



# Effet d'un programme d'activité physique en entreprise auprès de salariés du secteur tertiaire

Pauline Genin

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Thèse présentée en vue de l'obtention du grade de

**Docteur de l'Université Clermont Auvergne**

Ecole doctorale des Sciences de la Vie, Santé, Agronomie, Environnement

Discipline : Médecine

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par

**Pauline GENIN**

**Soutenue le 2 Novembre 2018**

Devant le jury composé de:

Professeur Barbara Charbotel (PU-PH)  
Professeur Frédéric Dutheil (PU-PH)  
Docteur Joffrey Beaujouan (PhD)  
Docteur Yolande Esquirol (MCU-PH)  
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## Publications scientifiques relatives à la thèse

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Genin PM, Dessenne P, Finaud J, Pereira B, Thivel D, Duclos M (Juillet 2018). "Health and fitness benefits but low adherence rate: effect of a 10-month onsite physical activity program among tertiary employees". Journal of Occupational and Environmental Medicine, epub.

Genin PM, Dessenne P, Finaud J, Pereira B, Dutheil F, Thivel D, Duclos M. "Effect of work-related sedentary time on overall health profile in active vs inactive office workers". Frontiers in Public Health 1;6:279.

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## Liste des abréviations en Français et en Anglais



6MWT: Six Minute Walk test.

ANOVA: Analyze of Variance.

ANSES : Agence Nationale de Sécurité Sanitaire de l'Alimentation, de l'Environnement et du Travail.

ASM: Association Sportive Montferrandaise.

ATA: American Thoracic Society.

AVC: Accident Vasculaire Cérébral.

BIA: Bioelectrical Impedance Analysis.

BMI: Body Mass Index.

BMJ: British Medical Journal.

BP: Bipodal.

CIFRE : Convention Industrielle de Formation par le Recherche.

CMJ: Counter Movement Jump.

CON : groupe Contrôle.

CPP: Comité de Protection des Personnes.

ENNS : Etude Nationale Nutrition Santé.

ESS: Epworth Sleepiness Scale.

ESTEBAN : Etude de Santé sur l'Environnement, la Bio surveillance, l'Activité Physique et la Nutrition.

EXP: groupe Expérimenté.

FFM: Fat Free Mass.

FM: Fat Mass.

FMDA: Factorial Mixed Data Analysis.

HC: Hip Circumference.

HD: Hand Dominant.

HDL: High Density Lipoprotein.

HG: Handgrip.

HIIT: High Intensity Interval Training.

HND: Hand No Dominant.

HP: Health Perception.

HR: Heart Rate.

IMC : Indice de Masse Corporelle.

INCA : Etude Individuelle Nationale des Consommations Alimentaires.

INSERM : Institut National de la Santé et de la Recherche Médicale.

IPAQ: the International Physical Activity Questionnaire.

ISI: Insomnia Severity Index.

KW: Kruskal-Wallis.

MCA: Multiple Correspondence Analysis.

MET: Metabolic Equivalent of Task.

MVPA: Moderate to Vigorous Physical Activity.

NC: Neck Circumference.

NHS: National Health Service.

NOV : groupe Novice.

NPAP: National Physical Activity Plan.

O2 : groupe Oxygène.

OMS : Organisation Mondiale de la Santé.

ONAPS : Observatoire National de l'Activité Physique et de la Sédentarité.

PA: Physical Activity.

PAG: Plan d'Action Gouvernemental.

PAL: Physical Activity Level.

PSQI: Pittsburgh Sleep Quality Index.

SBRN: Sedentary Behavior Research Network.

SD: Standard Deviation.

SEC: Seconds.

UK: United Kingdom.

UP: Unipodal.

USA: United States of America.

WC: Waist Circumference.

WHO: World Health Organization.

WHR: Waist to Hip Ratio.

## I. Contextualisation

La santé est un concept complexe, défini par l'Organisation Mondiale de la Santé (OMS) comme « Un état complet de bien-être physique, mental et social, qui ne consiste pas seulement en une absence de maladie ou d'infirmité ». Cette définition reposant en partie sur une perception individuelle, est aujourd'hui à l'origine de l'orientation et de la conception de nos politiques de santé publique. La hiérarchisation des priorités de santé publique repose aujourd'hui à la fois sur une évaluation objective de l'état de santé de la population, déterminant alors les axes et objectifs des plans nationaux, mais aussi sur l'identification des méthodes et contextes nécessaires à la bonne conduite et à l'efficacité de nos stratégies de santé.

Si une très grande part de l'augmentation de la prévalence des maladies chroniques est due au vieillissement de la population et à l'accroissement de l'espérance de vie (Organisation Mondiale de la Santé 2017), la sédentarité, l'inactivité physique, le surpoids, l'obésité ou encore le tabagisme parmi bien d'autres, vont composer de réels facteurs de risques tout au long de la vie.

Une meilleure identification et compréhension de ces facteurs de risques est nécessaire afin que les politiques de santé publique puissent élaborer des stratégies adaptées et ainsi réduire les risques à tous les âges.

Un des axes majeurs de lutte contre le développement des maladies chroniques non transmissibles comme l'obésité ou encore le diabète de type 2, repose sur la promotion de l'activité physique et la lutte contre la sédentarité. La littérature scientifique, ainsi que les rapports nationaux et internationaux, mettent clairement en avant la nécessité de créer de nouvelles stratégies de santé publique, pour enrayer à la fois le déclin constant du niveau

d'activité physique à tous les âges, et la progression alarmante du temps passé à des comportements sédentaires (Enquête Esteban 2017).

D'après un récent rapport de l'Organisation Mondiale de la Santé (OMS), avec 7889 pas par jour en moyenne,  $\frac{3}{4}$  des Français ont un niveau d'activité qui reste encore loin des recommandations (10000 pas quotidiens) à atteindre pour se maintenir en forme et préserver sa santé (même s'il est important de garder à l'esprit que ce seuil de 10000 pas correspond plutôt à 60 minutes d'activité physique modérée) (Tudor-Locke, Craig et al. 2011). De plus, en 2016, plus d'un Français sur deux estime que le temps passé devant les écrans se fait au détriment des Activités Physiques ou Sportives (Organisation Mondiale de la Santé 2018). Il semble donc aujourd'hui nécessaire d'approfondir les efforts permettant une promotion efficace de l'activité physique d'une part mais également la réduction des comportements sédentaires.

L'automatisation de l'industrie depuis la fin du XIXe siècle, ainsi que la tertiarisation du milieu professionnel contribuent à ce déclin du niveau d'activité physique quotidien de la population, favorisant simultanément un temps passé assis et devant un écran, toujours plus important.

En effet, la prévalence des professions sédentaires a augmenté de 20% aux Etats-Unis entre 1960 et 2008, avec un déclin concomitant des professions actives (Church, Thomas et al. 2011). En France, les adultes qui travaillent passent environ 10 heures par jour assis les jours travaillés (avec au moins 4,17 heures au travail), et 7,58 heures par jour assis les jours non travaillés, avec une association évidente entre le temps passé sédentaire au travail et les comportements sédentaires en dehors du travail (INCA 3 2017).

Alors que déjà dans les années 50, les travaux de Jerry Morris auprès des chauffeurs de bus britanniques soulignaient sans équivoque la nécessité de considérer l'activité physique

professionnelle et ses effets sur la santé, le milieu de l'entreprise apparaît aujourd'hui comme un levier d'action et un terrain d'intervention idéal pour encourager et soutenir la promotion de l'activité physique quotidienne (Morris and Raffle 1954).

Si les quinze dernières années ont vu se développer un nombre important d'initiatives cherchant à réduire les comportements sédentaires et à favoriser l'activité physique auprès d'employés de divers secteurs, ce travail de Doctorat (CIFRE), réalisé au carrefour du milieu de l'entreprise (ASM/Michelin) et du milieu académique (Université Clermont Auvergne), se propose d'évaluer la faisabilité et l'efficacité de programmes d'activité physique structurés, mis en place au sein même de l'entreprise, sur des indicateurs de santé d'employés du secteur tertiaire, particulièrement concernés par un temps conséquent dédié à des comportements sédentaires.

## **II. Revue de littérature**

### **1. Activité physique, inactivité et santé**

Bien que la plupart du temps associée par la population générale à la pratique sportive uniquement (certainement par manque d'information et de communication), l'activité physique concerne l'ensemble des activités humaines quotidiennes, des tâches domestiques aux transports actifs, en passant par l'activité professionnelle ou encore les activités de loisirs. Dès 1985, Caspersen et al. définissent l'activité physique comme l'ensemble des mouvements corporels produits par la mise en action des muscles squelettiques et entraînant une dépense énergétique supérieure au métabolisme de repos (Caspersen, Powell et al. 1985). Cette définition a encore été récemment rappelée par l'OMS (Organisation Mondiale de la Santé 2018). L'activité physique possède de très nombreuses

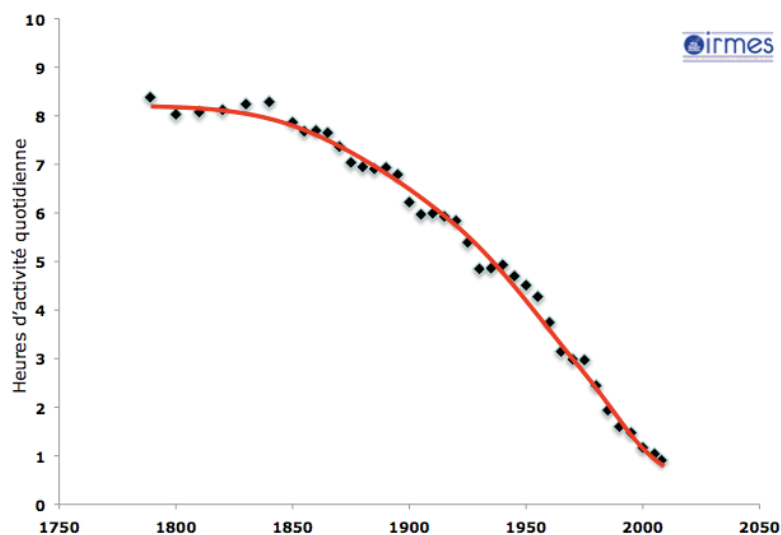
vertus et constitue un excellent moyen de se prémunir contre les maladies chroniques. Les bénéfices à court, moyen et long termes résultent d'adaptations systémiques, hormonales, métaboliques, dont les effets préventifs concernent l'ensemble des composantes de la santé (physique, mentale, vie sociale). Les données scientifiques démontrent aujourd'hui clairement les effets favorables de l'activité physique en matière de prévention de pathologies chroniques (maladies cardiovasculaires, diabète de type 2, cancers etc.) (ANSES 2016). Selon l'Observatoire Régional de la Santé du Nord-Pas-de-Calais, l'activité physique est bénéfique pour la santé indépendamment de l'âge et du poids du pratiquant, ce qui signifie que ses effets sont bénéfiques sur la population générale (Observatoire régional de la santé 2015). Il a de plus été démontré qu'une activité physique régulière est associée à une diminution des risques de diabète de type 2, d'hypertension artérielle ou de cancer du côlon et du sein, ainsi qu'à une diminution de la mortalité cardio-vasculaire et de la mortalité toutes causes confondues (ANSES 2016; PAG 2018).

Outre ses effets sur la santé physique, l'activité physique est aujourd'hui reconnue pour ses bénéfices sur la santé mentale, avec plusieurs études montrant que l'engagement dans une activité régulière peut réduire les symptômes de dépression et d'anxiété, pouvant aussi améliorer l'humeur et aider à la gestion du stress (Fox 1999; Paluska and Schwenk 2000; Blake, Mo et al. 2009).

Malgré ces bénéfices de santé reconnus, plusieurs études conduites dans divers pays d'Europe soulignent que seule une petite proportion d'adultes s'engagent dans des niveaux suffisants d'activité physique (Dugdill 2008). Une étude menée dans toute l'Union européenne a par exemple récemment estimé que les deux tiers de la population adulte n'atteignent pas les niveaux d'activité physique recommandés (Malik, Blake et al. 2014). Dans le même sens, les données du Royaume-Uni révèlent que seuls 39% des hommes et

29% des femmes répondent aux recommandations gouvernementales concernant l'activité physique (activité physique mesurée par questionnaire) (NHS 2008). Promouvoir l'exercice régulier est donc crucial pour la santé de la société et le bien-être des populations, mais également au regard des bénéfices médico-économiques associés à un mode de vie actif (INSERM 2008), ceci en faisant donc une préoccupation de santé publique majeure pour les gouvernements du monde entier.

La littérature scientifique reste cependant unanime, établissant le constat d'un trop faible niveau d'activité physique des populations au niveau mondial. En effet, les enquêtes montrent en France une réduction de la pratique physique régulière (figure 1), avec moins de la moitié des Français de 15 à 78 ans aujourd'hui considérés comme actifs (INSERM 2008), réduction touchant particulièrement les femmes, et s'intensifiant avec l'âge (ANSES 2016; Enquête Esteban 2017).



**Figure 1. Evolution du niveau d'activité physique pour la population française (Etude IRMES 2013).**

Selon le même rapport, près de 23% des adultes de 18 ans et plus n'étaient pas suffisamment actifs en 2010 au niveau mondial (hommes 20% et femmes 27%), 26% des

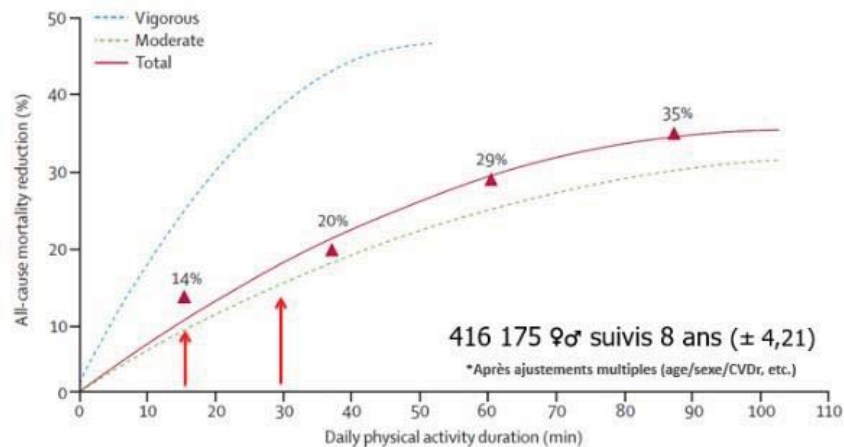
hommes et 35% des femmes au sein des pays à revenu élevé contre 12% et 24% respectivement dans les pays à revenu faible (rapport mettant en avant une association entre la progression du produit national brut et la réduction du niveau d'activité physique) (ANSES 2016).

Selon l'Agence Nationale de la Sécurité Sanitaire de l'Alimentation, de l'Environnement et du Travail (ANSES), la réduction de l'engagement physique lors des activités de loisirs et professionnelles ainsi que l'accroissement des modes de transports passifs (au détriment des transports actifs) contribuent grandement à cette réduction du niveau d'activité physique total de la population et à la progression du niveau de sédentarité (ANSES 2016).

Pourtant, la recherche indique que la santé et la qualité de vie s'améliorent de façon importante lorsque la population inactive adopte un mode de vie plus actif physiquement (Safiyari-Hafizi, Taunton et al. 2016). En effet, faire 20 minutes d'activité physique par jour d'intensité modérée permettrait de diminuer la mortalité globale de 16 à 30% (Wen, Wai et al. 2011). Par exemple, ajouter à son mode de vie 15 minutes de marche tous les jours diminue la mortalité de 14%, que l'on soit jeune ou âgé, un homme ou une femme, en bonne santé cardiovasculaire ou non, hypertendu ou non, obèse ou non, diabétique ou non... (Arem, Moore et al. 2015). Une récente étude a aussi montré que 25 à 30% des infarctus du myocarde et des accidents vasculaires cérébraux (AVC) sont évitables par une activité physique régulière (Safiyari-Hafizi, Taunton et al. 2016). Pratiquer une activité physique régulière permettrait aussi de diminuer l'incidence du diabète de type 2 de 50% chez les sujets pré-diabétiques et de 30% dans la population générale (Duclos, Oppert et al. 2013). La littérature a montré en parallèle que 15 minutes par jour ou 90 minutes par semaine d'exercice d'intensité modérée pourrait être bénéfique, même pour les personnes à



risque de maladie cardiovasculaire (Wen, Wai et al. 2011) et que chaque 15 minutes supplémentaires d'exercice quotidien permettait encore de réduire la mortalité toutes causes confondues de 4% (figure 2).

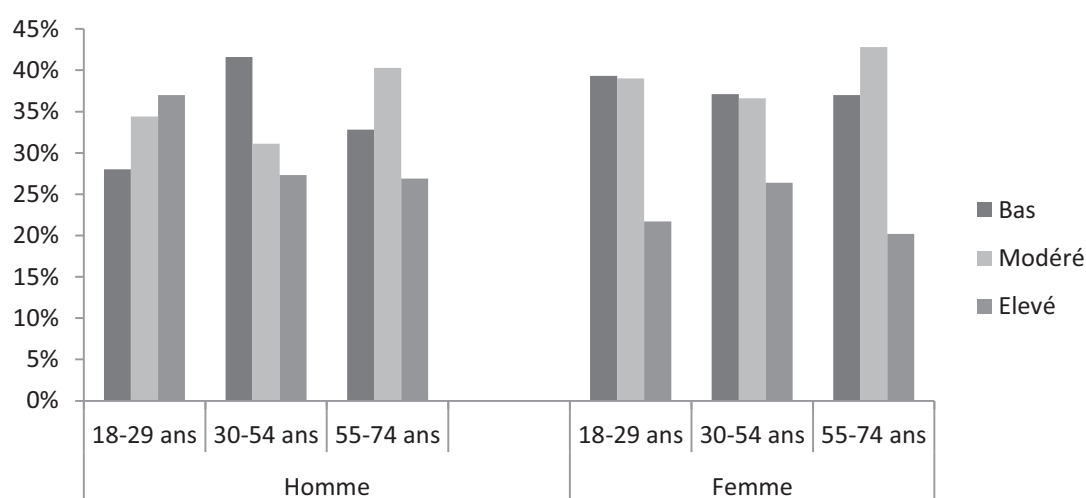


**Figure 2. Quantité minimale d'activité physique pour réduire la mortalité et prolonger l'espérance de vie (Pang Wen et al., 2011).**

Les données les plus récentes mettent en avant que cette réduction du niveau d'activité physique conduit aujourd'hui moins de 30% de la population mondiale (Organisation Mondiale de la Santé 2018) au respect des recommandations, 50% en France (figure 3) (ENNS 2006; INCA 3 2017), laissant ainsi place à une progression inquiétante de l'inactivité physique.

Il apparaît aujourd'hui essentiel de clarifier les définitions respectives de l'activité physique et de l'inactivité physique (comme nous le ferons plus tard pour la sédentarité) de manière à lever toute confusion et éviter toute mauvaise interprétation. Si l'activité physique correspond bien à l'ensemble des activités humaines favorisant une dépense énergétique (au-delà de celle de repos comme défini ci-dessus), le terme d'inactivité physique est lui

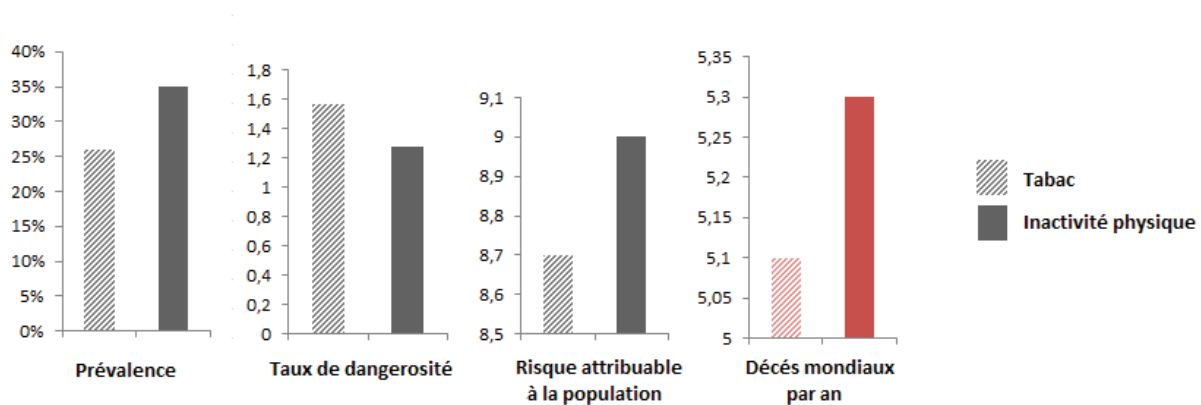
défini aujourd'hui comme la non atteinte des recommandations en activité physique (Tremblay, Colley et al. 2010; Tremblay, Aubert et al. 2017). La progression de cette inactivité physique est aujourd'hui plus que préoccupante puisque responsable de plus de 5.3 millions de décès par an dans le monde et 10% des décès en Europe, dépassant ainsi le taux de mortalité dû au tabac (figure 4) (Organisation Mondiale de la Santé 2018).



**Figure 3. Adultes de 18 à 74 ans selon le niveau d'activité physique, le sexe et l'âge en 2006 (en %) (Etude ENNS 2006).**

Selon les estimations de l'OMS, l'inactivité physique est la cause de 5% des cardiopathies coronariennes, de 7% des diabètes de type 2, de 9% des cancers du sein et de 10% des cancers du côlon (Organisation Mondiale de la Santé 2017). L'inactivité d'une part importante de la population est d'autant plus inquiétante que la littérature scientifique incrimine aujourd'hui clairement le manque d'activité régulière dans le développement de maladies chroniques évitables (maladies chroniques non transmissibles) telles que les maladies coronariennes, les AVC et le diabète de type 2 (Fine, Philogene et al. 2004; Jeon, Lokken et al. 2007; Mora, Cook et al. 2007). Dans le même sens, l'inactivité physique serait

associée à un indice de masse corporelle (IMC) plus élevé, mais aussi et surtout à un niveau de stress plus important (Sampasa-Kanyinga and Chaput 2017).



**Figure 4. Prévalence, taux de dangerosité, risque attribuable à la population et part des décès dans le monde entre le tabac et l'inactivité physique (adaptée de l'étude WHO, 2011).**

Sur le plan médico-économique, une récente étude considérant 142 pays soit 93% de la population mondiale met en avant un coût de santé lié à l'inactivité physique de plus de 67,5 milliards de dollars (61 milliards d'euros) en 2013 (Ding Ding 2016) ; 53,8 milliards de dollars seraient liés à des dépenses directes de santé alors que 13,7 milliards de dollars correspondraient à une perte de productivité. A noter que les auteurs n'ont inclus dans leur analyse que les cinq grandes maladies associées à l'inactivité physique : maladie coronarienne, AVC, diabète de type 2, cancer du sein et du côlon ; ce qui doit nous conduire à les considérer à la hausse au regard des multiples autres complications sanitaires qui y sont associées.

Toutes ces données doivent conduire aujourd'hui au développement de stratégies de santé publique permettant de réduire l'ampleur de l'inactivité à travers la promotion de la pratique physique. Alors qu'il est nécessaire de divulguer et rendre accessible au plus grand

nombre les recommandations en vigueur, ces stratégies de santé publique doivent impérativement adopter une démarche progressive. En effet, l'atteinte à court terme de ces recommandations chez des sujets inactifs peut être contreproductive et accroître la résistance et l'instauration de barrières à la pratique physique chez ces derniers (de Souto Barreto 2015). Parue début 2015 dans le British Medical Journal (BMJ), l'analyse du Dr De Souto Barreto met en effet en garde contre une démarche uniquement centrée sur la promotion directe des recommandations. Dans cette publication, l'auteur souligne cet impact pervers potentiel mettant en avant le fait que la promotion d'un accroissement progressif de l'activité physique permet à la fois des effets sanitaires significatifs rapides et une pérennisation de l'engagement des individus (Warburton, Charlesworth et al. 2010).

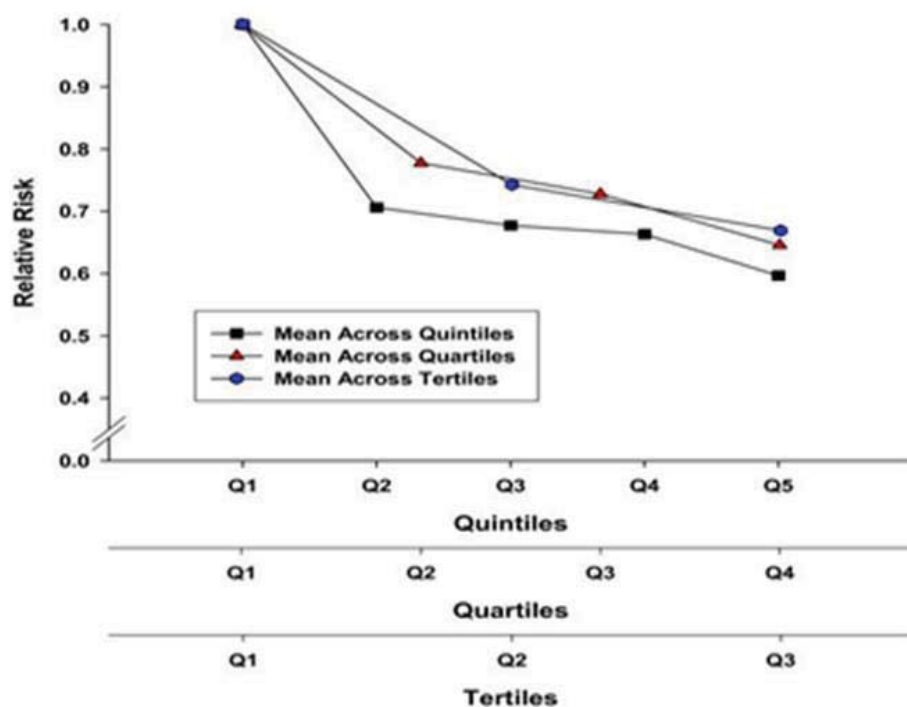


Figure 5. Réduction du risque relatif moyen de mortalité toutes causes confondues dans différentes catégories d'activité physique (Warburton et al., 2010).

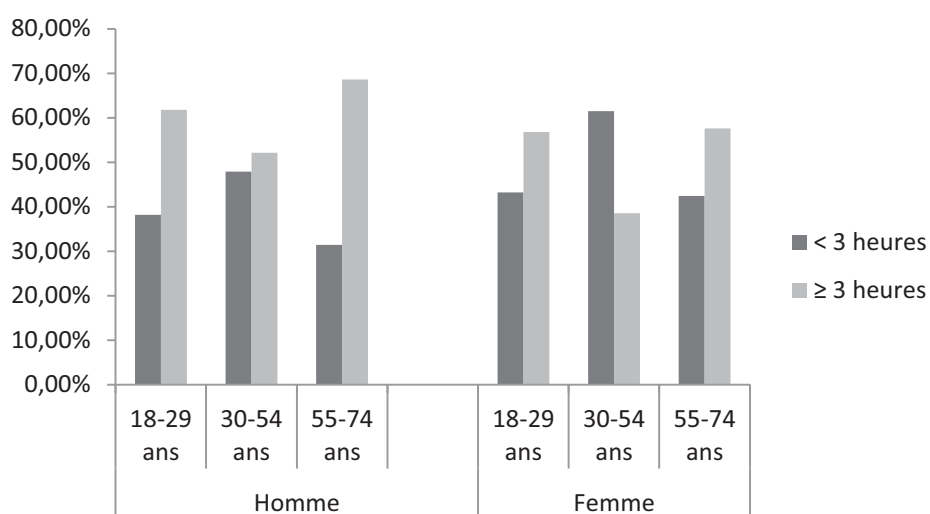
En effet, comme illustré par la Figure 5, l'analyse de Warburton et al. met en évidence une relation dose réponse. Ils mettent en avant que même avec une progression faible du niveau d'activité physique, le risque relatif de mortalité est réduit de 30%.

Non seulement les efforts doivent se porter sur la promotion de l'activité physique, mais ils doivent aussi s'attacher à la lutte contre la sédentarité. En effet, bien que le plus souvent confondus avec l'inactivité physique, les comportements sédentaires sont aujourd'hui prédominants au sein de nos sociétés et de nos modes de vie.

## **2. Comportements sédentaires, quelle définition, quels impacts, quelles stratégies ?**

Alors que la notion de sédentarité devient de plus en plus présente dans la littérature scientifique à la fin des années 90, Epstein et collaborateurs décrivent alors la présence de « sedentary alternative » entre les activités quotidiennes (Epstein, Roemmich et al. 2004). C'est en 2010 que le Sedentary Behavior Research Network (SBRN) propose une première définition consensuelle des comportements sédentaires, définition actualisée en 2017 (Tremblay, Colley et al. 2010; Tremblay, Aubert et al. 2017). Ainsi, selon le SBRN, la sédentarité se définit par une situation d'éveil caractérisée par une faible dépense énergétique, inférieure à 1,5 Mets (équivalent métabolique) en position assise ou allongée. Aujourd'hui au centre de nombreuses études scientifiques et enquêtes de santé, la sédentarité est principalement évaluée à travers le temps passé assis et le temps passé devant un écran.

La sédentarité est un des maux du siècle. En effet, comme rapporté dans le récent tableau de bord de l'Observatoire National de l'Activité Physique et de la Sédentarité (ONAPS), le seul fait d'être assis plus de trois heures par jour est déjà responsable de 3,8% des décès en France, toutes causes confondues et ce quel que soit le niveau d'activité physique en parallèle (Rezende, Sa et al. 2016). Ce seuil de trois heures passées assis est malheureusement très largement dépassé dans le quotidien de la population générale et ne cesse de croître (Figure 6). Pour exemple, chez les quadragénaires, le temps passé assis (dans les transports, au bureau, devant les écrans etc.) est estimé à 12 heures lors d'une journée de travail et 9 heures lors d'une journée non travaillée en France, avec plus de 70% de la population de l'hexagone passant plus de huit heures assis chaque jour (INCA 3 2017).



**Figure 6. Adultes de 18 à 74 ans selon le temps quotidien moyen passé devant un écran, selon le sexe et l'âge en 2006 (%) (Enquête Esteban 2015).**

Ces chiffres sont tout aussi alarmants chez nos homologues américains et britanniques avec un temps consacré à des comportements sédentaires (durant et hors du temps de travail) qui est passé de 26 à 38 heures par semaine entre 1965 et 2009 et de 30 à 42 heures entre

1960 et 2005, progression qui devrait se poursuivre au moins jusqu'en 2030 (Ng and Popkin 2012).

Les risques liés à ces comportements sédentaires et à leur place toujours plus importante sont loin d'être négligeables. En effet, au-delà de 4 heures quotidiennes passées en position assise, chaque nouvelle heure augmente la mortalité de 2%, et au-delà de 10 heures par jour, elle est même majorée de 34% (Mackenzie, Goyder et al. 2015). Ainsi, le simple fait de passer de la position assise à debout, un quart du temps de la journée, diminue d'environ 21% la mortalité cardio-vasculaire (Mackenzie, Goyder et al. 2015). Le fait d'être sédentaire augmente les facteurs de risques cardiovasculaires classiques comme le surpoids, le diabète ou encore l'hypertension artérielle (Rezende, Sa et al. 2016). En Australie, Dunstan et al. ont montré que le temps prolongé passé devant la télévision, était associé à un risque accru de mortalité (Dunstan, Barr et al. 2010). En effet, plus de 4 heures de télévision par jour augmenterait de 80% le risque de mortalité lié aux maladies cardiovasculaires et de 46% le risque de mortalité toutes causes confondues, par rapport aux personnes qui regardent la télévision moins de 2 heures par jour. Selon certaines études, le taux de mortalité est augmenté de 2% pour chaque heure passée assise et peut atteindre jusqu'à 8% lorsque le temps consécutif total passé assis est supérieur à 8h par jour (Chau, Grunseit et al. 2013).

S'il semble évident qu'il faille informer et éduquer la population sur ces méfaits du temps passé à des comportements sédentaires, il apparaît aussi nécessaire de proposer des alternatives à cette sédentarité. En effet, si comme cité préalablement, Epstein et collaborateurs mentionnaient dans les années 90 la présence de « sedentary alternative », il a récemment été mis en avant la nécessité aujourd'hui de recréer dans une société toujours plus sédentaire ce que Thivel et al appellent des « active alternative » (Thivel D 2018, en cours). Ceci apparaît d'autant plus important que la mutation de notre système économique

a favorisé la tertiarisation du milieu professionnel, augmentant drastiquement le temps passé assis et devant un écran.

### **3. Milieu professionnel : quel rôle et quels enjeux pour la santé des employés?**

#### **a. Impact sur la santé, milieu du travail**

Automatisation des chaînes de travail, robotisation des tâches manuelles, progrès technologiques industriels, accroissement des activités de service (...), cette importante modernisation du milieu professionnel a conduit à une très large tertiarisation de notre société, favorisant le temps quotidien passé à des comportements sédentaires et l'inactivité physique.

Ceci s'illustre par exemple par une augmentation de 20% de la prévalence des professions sédentaires aux Etats-Unis entre 1960 et 2008, avec un déclin concomitant de professions physiquement actives (Church, Thomas et al. 2011). En France, de récents résultats mettent en avant que les adultes occupant une activité professionnelle passent environ 10 heures par jour assis lors des jours travaillés (avec au moins 4,17 heures au travail) et 7,58 heures assis par jour, les jours non travaillés, soulignant une association nette entre le temps sédentaire passé au travail et les comportements sédentaires en dehors du travail (Saidj, Menai et al. 2015). Ainsi, nous passons un tiers de notre temps journalier à des activités sédentaires, soit plus de la moitié de notre temps éveillé. Il est maintenant bien démontré que le temps passé à des activités sédentaires chez l'adulte est principalement d'origine professionnelle, caractérisé par des périodes prolongées et ininterrompues de temps passé assis (Ryan 2011). Par exemple, il s'avère, qu'en moyenne sur une journée de travail



complète, les salariés du secteur tertiaire passent environ 77% du temps assis, 18% debout et seulement 5% à faire différents déplacements (Wick, Faude et al. 2016).

Outre ce temps passé assis, la sédentarité est également aujourd'hui liée à un « usage massif » des écrans qui s'intensifie dans la population française et partout dans le monde. Cette tendance est particulièrement importante dans la population féminine puisqu'une femme sur cinq cumule sédentarité et inactivité physique (INCA 3 2017).

En 1994, 12% des employés restaient 20 heures ou plus par semaine devant un écran. Ce chiffre est passé à 23% en 2010, sachant que cette proportion est bien plus forte chez les cadres et les employés administratifs (étude SUMER, DARES). Depuis 2006, la durée quotidienne moyenne de temps passé devant les écrans chez les adultes a augmenté de 53% (+44% pour les hommes et +66% pour les femmes). Ce temps devant les écrans est passé en moyenne de 3h10 par jour à 5h07 et la proportion d'adultes passant 3 heures ou plus devant leur écran, en dehors de leur activité professionnelle a ainsi atteint 80% en 2015 (Enquête Esteban 2017).

Cette combinaison d'un temps passé assis toujours plus important, associé à des durées d'exposition aux écrans qui ne cessent de progresser, ne peut qu'être délétère sur le plan sanitaire, favorisant le développement de pathologies chroniques et métaboliques associées. Certaines données américaines montrent par exemple que plus de 37% des travailleurs sont actuellement en surpoids (indice de masse corporelle [IMC]  $\geq 25\text{kg/m}^2$ ) et au moins 29% présentent un Indice de Masse Corporelle supérieur à  $30\text{ kg/m}^2$  (Garfinkel 1986). Plus récemment, Drenowatz et collaborateurs ont montré une association positive entre le temps de sédentarité et la composition corporelle (masse grasse) dans une cohorte de plus de 320 salariés du secteur tertiaire (Drenowatz, DeMello et al. 2016).

Il est important de souligner que les comportements sédentaires sont associés à des résultats de santé négatifs différents de ceux de l'inactivité physique (Drenowatz, DeMello et al. 2016; Albawardi, Jradi et al. 2017). En effet, l'activité physique ne protège pas des effets délétères de la sédentarité sur la santé. Par exemple, il a été montré que regarder la télévision pendant au moins 3 heures par jour était associé à une augmentation de la mortalité indépendamment de l'activité physique, sauf dans le quartile le plus actif, où la mortalité était significativement augmentée seulement chez les personnes qui regardaient la télévision pendant 5 heures ou plus (Ekelund, Steene-Johannessen et al. 2016). C'est la raison pour laquelle les objectifs de santé publique sont, d'une part, d'augmenter le temps d'activité physique et sportive et, d'autre part, de diminuer le temps passé à être assis.

Non seulement ce temps passé assis va avoir une incidence sur la corpulence et la composition corporelle, mais il va également favoriser l'apparition et le développement de maladies cardiovasculaires et chroniques (Ekelund 2012). En effet, une récente méta-analyse de 34 études a montré qu'indépendamment de l'activité physique, la durée totale du temps passé assis et du temps passé devant les écrans est associé à un risque accru de plusieurs maladies chroniques majeures (Patterson, McNamara et al. 2018).

Par répercussion, la progression de ces pathologies chroniques liées à un temps de sédentarité trop important chez les employés tertiaires, associée à un risque plus important d'anxiété et de dépression par rapport à des employés ayant une activité professionnelle plus physique (Kang, Park et al. 2016), va favoriser l'augmentation de l'absentéisme, mais aussi la perte de productivité (Hertz, Unger et al. 2004; Neovius, Johansson et al. 2009).

Au-delà des bénéfices sanitaires, la promotion de l'activité physique et la lutte contre la sédentarité vont également avoir des répercussions importantes sur le plan économique, à

travers à la fois la réduction du coût combiné de traitements des différentes maladies évitables et celle du nombre d'arrêts de travail et d'absences pour cause de maladies ou blessures (ministère de la Santé, 2009) (Katzmarzyk and Janssen 2004; Oldridge 2008).

On sait que le lieu de travail est désormais identifié comme un élément clé dans la promotion de la santé mais les auteurs soulignent aussi qu'il existe un besoin important de reconsidérer aussi bien la nature de l'activité professionnelle que les comportements pendant les temps de loisirs, qui sont souvent identifiés comme une routine quotidienne moins structurée associée à une gestion du poids négative (Drenowatz, DeMello et al. 2016).

La littérature actuelle nous montre aujourd'hui clairement que la diminution du niveau d'activité physique de la population, associée à une augmentation toujours plus importante du temps passé à des activités sédentaires, a de réels impacts sur la santé. La progression importante ces dernières décennies du secteur tertiaire a fortement participé à cette conjoncture, favorisant un temps quotidien passé assis devant un écran conséquent. Face à cette tertiarisation de notre société, le milieu du travail se présente désormais comme un lieu propice au développement et à la mise en place de nouvelles stratégies de promotion de l'activité physique et de lutte contre ce temps de sédentarité.

#### **b. Réduction du temps de sédentarité et promotion de l'activité physique auprès des employés du secteur tertiaire : quelles stratégies ?**

Alors qu'une grande majorité des employés occupe aujourd'hui une activité tertiaire et passe en moyenne 7 à 8 heures par jour sur son lieu de travail, l'entreprise a été récemment suggérée comme une nouvelle opportunité stratégique pour promouvoir l'activité physique (Green 1988). En effet, si la littérature met en exergue le manque de temps et de proximité des installations sportives comme principales barrières exprimées à la pratique physique

(Dugdill 2008), la promotion de cette pratique au sein même de l'entreprise apparaît nécessaire.

Les politiques de santé publique du monde entier ont souligné la nécessité de créer une culture qui est propice à l'activité physique régulière (The National Physical Activity Plan 2010). Spécifiquement, les employeurs sont encouragés à jouer un rôle clé dans la promotion de la santé et le bien-être des adultes en âge de travailler (ministère de la Santé, 2008; Centre d'information du NHS, 2008; Organisation mondiale de la Santé / Forum économique mondial, 2008). Pour l'employeur, il a été montré qu'une intervention permettant d'améliorer la santé de ses employés induit une réduction de l'absentéisme, des arrêts maladie et, par conséquent, une productivité accrue (Kuoppala, Lamminpaa et al. 2008). Il semble aujourd'hui clair que des interventions *in situ* (sur le lieu de travail) soient nécessaires aussi bien pour favoriser la progression du niveau d'activité physique des employés que pour réduire leur temps dédié à des comportements sédentaires. Cette nécessaire complémentarité entre promotion de l'activité physique et lutte contre la sédentarité dans cette population est très clairement appuyée par de récentes données montrant que chez des employés de bureau passant au moins 7h assis par jour (principalement devant un écran), certains indicateurs de santé (tels que le tour de taille, l'indice de masse corporelle ou encore la masse grasse) ne sont pas améliorés chez les actifs par rapport aux inactifs (au regard des recommandations d'activité physique), suggérant ainsi le potentiel impact négatif de ce temps sédentaire indépendamment du niveau d'activité physique (Genin, Dessenne et al. 2018).

Au-delà des indicateurs de santé physique les plus souvent utilisés, la promotion de l'activité physique et la lutte contre la sédentarité en milieu professionnel apparaissent également nécessaires pour la santé mentale et sociale des employés. En effet, à l'heure où de nombreux cadres sont confrontés au risque de burnout, la mise en place d'activités physiques sur le lieu de travail apporte un premier élément de prévention. Parmi les études réalisées sur l'apport de l'activité physique en entreprise, le rapport préparatoire de la commission Prévention, Sport et Santé, réalisé en 2008 indique qu'éliminer ne serait-ce qu'un seul des facteurs de risques pour la santé peut réduire l'absentéisme d'au moins 2% (Brown, Gilson et al. 2011). Cependant, le chemin est encore long.

En France, si 48% des salariés pratiquent une activité physique au moins une fois par semaine, seulement 13% le font sur leur lieu de travail (Organisation Mondiale de la Santé 2018). Aux yeux des autorités sanitaires, la pratique physique, vecteur de bien-être, est plus que jamais considérée comme un outil efficace de lutte contre des pathologies qui n'épargnent plus le monde du travail (stress, troubles musculo-squelettiques, cancers...). En Grande-Bretagne, l'absentéisme a reculé de 30 à 40% chez les employeurs ayant mis en place des politiques de santé pour leurs travailleurs, incluant l'exercice physique régulier. Le turnover s'en trouve même réduit de 25% (Lee, Shiroma et al. 2012). Il est suggéré qu'un employé physiquement actif aurait une productivité augmentée de 12% par rapport à un employé inactif (Santé Canada 2017).

Promouvoir l'activité physique sur le lieu de travail, associée à la lutte contre le temps sédentaire, semble donc pouvoir à la fois aider à maintenir les employés en bonne santé, tout en réduisant les coûts médico-économiques (Golaszewski 2000).

### **c. Quelles stratégies sont mises en place pour lutter contre la sédentarité ?**

Plusieurs stratégies sont mises en place depuis quelques années dans l'objectif de lutter contre la sédentarité. En effet les employeurs ont essayé de réduire le temps de sédentarité de leurs employés à travers différentes interventions, mettant par exemple en place la divulgation de conseils ou de messages incitatifs, à travers l'instauration de stations de travail assis-debout, ou encore grâce à de courtes phases d'interruption du temps passé assis (communément appelées dans la littérature « breaks »). Le Tableau 1 présente les principales études ayant mis en place et évalué les effets de ce type d'interventions basées sur la motivation/incitation à rompre le temps passé assis chez des employés du secteur tertiaire.

**Tableau 1. Interventions mises en place sur le lieu de travail afin de lutter contre la sédentarité (par ordre de publication dans la littérature).**

Références	Type d'intervention	Fréquence	Durée	Résultats
<i>Anderson et al., 2009</i>	Stratégies d'informations pour influencer l'activité physique	Libre	6 à 12 mois	Diminution poids, IMC
<i>Barr-Anderson et al., 2011</i>	Intégration de courtes phases d'activité physique	10-15min/jour	1 an	Avantages modestes sur la santé globale
<i>Carr et al., 2012</i>	Pédalier de bureau	5*20min/semaine	4 semaines	Diminution temps passé assis
<i>Taleb et al., 2012</i>	Contrôle vs intervention (station debout)	Libre	3 mois	Diminution temps passé assis
<i>Alkhajah et al., 2012</i>	Station debout	Libre	3 mois	Diminution temps passé assis
<i>Freak Poli et al., 2013</i>	Intervention avec podomètre	Tous les jours	4 mois	Augmentation niveau activité physique
<i>Neuhaus et al., 2014</i>	Station debout	Libre	/	Diminution temps passé assis
<i>Mackenzie et al., 2015</i>	Conseils, recommandations pour être "moins assis" (réunions de marche/debout)	Libre	1 mois	Diminution temps passé assis; stress; amélioration concentration
<i>Wollseiffen et al., 2015</i>	Courte phase d'exercice intensif	3min/jour	/	Amélioration performances neurocognitives
<i>Hendriksen et al., 2016</i>	Réunions et groupe de travail	Libre	5 mois	Diminution temps passé assis
<i>Bergouignan et al., 2016</i>	6h assis (SIT) vs SIT + 30min AP modérée vs 6h assis + 6*5min de marche/h	Libre	3 jours	Amélioration humeur; diminution fatigue, fringales
<i>Carr et al., 2016</i>	Station debout + e-mails	Libre	4 mois	Diminution temps passé assis
<i>Altassalo et al., 2017</i>	Groupe de motivation: réunions et groupe de travail	3*4h de réunion	1 an	Diminution temps passé assis
<i>Puig Ribera et al., 2017</i>	Contrôle vs groupe avec application mobile (sms persuasifs)	Libre	5 mois	Diminution du temps passé assis
<i>Torbeyns et al., 2017</i>	Vélo de bureau	8*25min/semaine	5 mois	Augmentation confiance en soi; réduction fatigue
<i>Guitar et al., 2017</i>	Trackers d'activité pour interrompre le temps passé assis	8h-5jours/semaine	8 semaines	/
<i>Winkler et al., 2018</i>	Messages motivationnels + coaching individuel	Libre	12 mois	Diminution du temps passé assis, poids, % masse grasse, tour de taille
<i>Gurd et al., 2018</i>	Courte phase d'activité: interval training avec sprint	2 à 4*8 à 20sec/semaine	12 semaines	Amélioration de la condition physique
<i>Nelson et al., 2018</i>	Position assise vs debout vs en équilibre sur une plateforme	3*30min	/	Réduction des douleurs musculo-squelettiques
<i>Lin et al., 2018</i>	Newletters vs intervention pour marcher plus	Libre	3 mois	Augmentation niveau d'activité physique; réduction poids, tour de taille
<i>Hallam et al., 2018</i>	10000 pas/jour: challenge avec newletters et messages motivationnels	5j/semaine	100 jours	Amélioration santé mentale et bien-être
<i>Zhu et al., 2018</i>	Messages motivationnels vs station debout + messages motivationnels	Libre	4 mois	Augmentation temps passé debout
<i>Tarraf et al., 2018</i>	Stations passives vs stations actives	Une fois	/	Augmentation de la productivité
<i>Haslam et al., 2018</i>	Contrôle vs informations sur mesure vs informations standards	Libre	2 ans	Diminution IMC, tour de taille
<i>Mansfield et al., 2018</i>	Réunions debout	Trois fois	/	Gêne et obstacles importants à cette pratique
<i>Baker et al., 2018</i>	Station debout	2 h/jour	/	Augmentation de l'inconfort; diminution de l'état thymique

/ : pas de durée imposée ; aucun résultat significatif

### *Approches informatives et incitatives basées sur des conseils*

Les premiers travaux conduits dans le domaine ont essayé de réduire le temps passé assis à travers l'utilisation d'ateliers éducatifs, informatifs ou la diffusion de conseils et d'incitations à rompre ce temps assis. Une récente étude conduite pendant un an auprès de salariés de 12 entreprises différentes a par exemple centré son intervention sur l'organisation régulière de réunions d'informations et d'ateliers faisant la promotion d'un niveau d'activité physique plus important et présentant les risques de la sédentarité. Bien qu'ils aient observé une réduction de l'activité physique de loisir de leurs participants, les auteurs ont pu montrer une légère diminution du temps passé assis (Aittasalo, Livson et al. 2017). Cette réduction du temps passé assis par les employés en réponse à des réunions d'informations et des ateliers éducatifs a également été observée par Hendriksen et collaborateurs après 5 mois de sensibilisation aux bienfaits de l'activité physique (Hendriksen, Bernaards et al. 2016). D'autres travaux utilisant cette fois-ci des messages motivationnels accompagnés d'un coaching individuel ayant pour objectif d'être moins assis et de bouger plus, ont permis au bout de 12 mois une diminution de la pression artérielle systolique, une diminution du poids, du pourcentage de masse grasse, du tour de taille et des concentrations plasmatiques de triglycérides, en rapport avec une diminution du temps passé assis au travail (Winkler, Chastin et al. 2018). Une récente étude de 2 ans a quant à elle comparé un groupe contrôle avec un groupe de salariés ayant des conseils standards et avec un groupe de salariés ayant des conseils individualisés. A la fin de l'étude, les salariés ayant bénéficié de conseils individualisés ont réduit significativement leur IMC et leur tour de taille ; et les deux groupes de salariés avec des conseils (standards et individualisés) ont démontré une motivation/satisfaction au travail nettement supérieure (Haslam, Kazi et al. 2018).



### *Stations assis-debout : nouvelles solutions de travail ?*

D'autres stratégies d'interventions basées sur la modification du poste de travail ont été développées de manière à diminuer les comportements sédentaires. En effet, des postes de travail avec des bureaux « debout » ont été proposés pour essayer de rompre ce temps sédentaire. Ces stratégies se développent depuis quelques années puisqu'en effet même si ces stations permanentes restent inactives (au sens ici où elles ne mettent pas en mouvement l'individu), il a récemment été mis en avant que cette position debout permettait d'atteindre un équivalent métabolique de 2 MET, supérieur au seuil de 1,5 MET utilisé pour définir les comportements sédentaires, pouvant donc être considérée comme une activité physique de faible intensité (Tremblay, Aubert et al. 2017). Pourtant, même si ce coût énergétique de la position debout même passive repose sur un ensemble de preuves scientifiques solides, une étude récente a montré que cette position debout passive n'augmente pas systématiquement et significativement la fréquence cardiaque et la dépense énergétique au-dessus de celle de repos (Miles-Chan and Dulloo 2017). Selon les auteurs, les hausses de la fréquence cardiaque et de la dépense énergétique observées sont dues à la transition « assis-debout », avant de revenir ensuite aux valeurs de repos (Miles-Chan and Dulloo 2017). Cela pourrait expliquer pourquoi certaines études n'ont pas trouvé d'effets de l'allocation des stations debout par opposition aux positions assises classiques sur les profils métaboliques et la composition corporelle chez les employés du secteur tertiaire, comme pour cette étude de 3 mois réalisée avec des stations de travail debout pour les salariés avec un travail de « bureau », dont les résultats ne mettent en avant qu'une diminution du temps passé assis au travail, sans résultats significatifs des autres paramètres (Alkhajah, Reeves et al. 2012). Dans le même sens, une récente étude de 4 mois a comparé

un groupe intervention bénéficiant de soutiens motivationnels + station debout, avec un groupe contrôle (soutien motivationnel seul), et a seulement montré une augmentation du temps passé debout au travail pour le groupe intervention, soulignant qui plus est une diminution de la productivité de ces employés (Zhu, Gutierrez et al. 2018). Surtout une récente méta-analyse de 34 études montre que l'utilisation de stations actives entraînent une diminution du temps passé assis au travail comparativement aux stations passives, alors que les différentes stratégies d'informations ou de conseils n'engendrent aucun résultat significatif sur le temps passé assis au travail (Shrestha, Kukkonen-Harjula et al. 2018).

Cela pourrait aussi expliquer pourquoi il a été démontré que les interruptions régulières du temps passé assis améliorent la santé par rapport aux stations debout qui sont passives de manière permanente (Chastin, Dontje et al. 2018). De plus, une étude récente a montré sur 20 salariés du secteur tertiaire que deux heures de travail en station debout dans une journée entraîneraient des effets négatifs aigus sur la santé tels qu'une augmentation de l'inconfort global, une diminution de l'état mental, le gonflement des membres inférieurs ou encore une augmentation des douleurs dans le bas du dos (Baker, Coenen et al. 2018). Ces mêmes auteurs ont donc mis l'accent sur la prudence à avoir quant à l'utilisation des stations debout.

Bien qu'il faille plus de recherches sur les effets exacts des stations debout, il semble plus pertinent de promouvoir l'adoption de stations de travail dites « actives », comme des bureaux de marche, ou des vélos bureau ; ou alors l'instauration de ce que l'on appelle les « active breaks », initiant une mise en activité comme de la marche ou de petits exercices simples à intervalles réguliers au cours de la journée de travail pour rompre avec la position assise, et ce quel que soit le niveau d'activité physique des employés (Tremblay, Aubert et al. 2017).

## *Des stations passives aux stations actives*

Plusieurs études se sont centrées sur l'utilisation de stations dites « actives » comme par exemple cette récente étude de faisabilité qui a comparé chez 99 volontaires d'une université l'utilisation d'une station debout (station passive) par rapport à une machine d'exercice avec pédales portables (station active) et a révélé une appréciation et une productivité plus importante pour la station active (Bastien Tardif, Cantin et al. 2018). Les résultats de cette étude sont une première étape pour mieux comprendre la faisabilité et l'acceptabilité des postes de travail actifs. Bien que d'autres investigations soient nécessaires ici aussi, certains résultats prometteurs démontrent déjà l'effet bénéfique des bureaux actifs impliquant la marche ou le pédalage sur la santé globale, le bien-être et les performances cognitives liées au travail chez les salariés du secteur tertiaire comme par exemple cette étude de 2017 qui a demandé à 22 salariés du secteur tertiaire de réaliser 8 fois 25 minutes par semaine de vélo de bureau pendant 5 mois et qui a relevé à la fin de l'étude une meilleure santé générale avec principalement une réduction de la fatigue, une augmentation de la confiance en soi ainsi qu'une amélioration des relations professionnelles (Torbeyns, de Geus et al. 2017).

Une méta-analyse de 2014 a dans le même sens montré que travailler sur des stations permettant la mobilité ou le mouvement, permettrait de réduire le temps de sédentarité sans compromettre la performance au travail (Neuhaus, Eakin et al. 2014), même si des études à plus grande échelle et à plus long terme sont encore nécessaires à ce sujet. Ceci se confirme avec les résultats de l'étude de Nelson et al. dans laquelle 30 salariés du secteur tertiaire ont été évalués sur trois positions différentes de travail : position assise, debout et en équilibre sur une plateforme (planche conçue pour imiter l'amplitude de mouvement

qu'un individu éprouve habituellement en marchant). Les résultats ont montré que si la consommation d'oxygène, la fréquence cardiaque et la dépense d'énergie augmentent en position debout, elles augmentent d'autant plus en position d'équilibre. De manière importante, les auteurs soulignent une réduction des douleurs musculo-squelettiques lors de la position d'équilibre à l'inverse de la position debout (Nelson, Casanova et al. 2018). La plateforme d'équilibre serait donc une alternative efficace pour augmenter la dépense énergétique sans interférer avec la productivité dans un environnement professionnel (Nelson, Casanova et al. 2018).

### *Les « active breaks » : solution efficace pour interrompre le temps de travail assis ?*

En parallèle, la littérature scientifique montre depuis quelques années une évolution des interventions visant à interrompre le temps passé assis au travail à travers l'introduction de « breaks » actifs, consistant en des interruptions régulières du temps assis par l'instauration de petits exercices physiques. Une étude récente de 30 employés de bureau a récemment comparé trois conditions expérimentales de manière randomisée : i) 6 heures passées assis sans interruption (SIT) ; ii) 6 heures passées assis auxquelles viennent s'ajouter 30 minutes de marche sur tapis roulant à intensité modérée le matin (ONE) ; iii) et 6 heures assis plus six fois 5 minutes de marche sur tapis roulant toutes les heures à intensité modérée (MICRO) (Bergouignan, Legget et al. 2016). Les résultats montrent une amélioration de l'énergie (évaluée à l'aide d'échelles visuelles analogues) pour les conditions ONE et MICRO, accompagnée d'une amélioration de l'humeur, d'une diminution de la fatigue et des fringales à la fin de la journée pour la condition MICRO par rapport aux deux autres. Ces interruptions actives (« active breaks ») et au sens plus large l'activité physique, semblent

donc bien bénéfiques, mais cela reste à instaurer à long terme et à inscrire dans les habitudes des employés.

L'introduction de ce genre de courtes périodes d'activité au cours de la journée de travail des employés du secteur tertiaire est une approche prometteuse pour améliorer le bien-être général au travail sans nuire à la performance cognitive (Bergouignan, Legget et al. 2016). Par exemple, des auteurs ont montré que plusieurs périodes courtes d'exercices intenses pendant la journée de travail avaient un effet positif sur les performances neurocognitives (Wollseiffen, Ghadiri et al. 2016). Dans le même sens, une revue systématique a montré qu'intégrer au temps de travail de courtes périodes d'activité physique entraînaient des avantages modestes mais constants sur la santé globale (Barr-Anderson, AuYoung et al. 2011). En effet, une étude de 2012 a proposé une intervention de quatre semaines avec la mise à disposition d'un pédalier dans le but d'interrompre le temps passé assis ; ils ont observé au bout d'un mois d'intervention une diminution du temps de sédentarité au travail mais aucun changement de qualité de vie ou de productivité (Carr, Walaska et al. 2012). Dans le même sens, une récente étude a montré sur 12 semaines, qu'une phase de sprint de 8 à 20 secondes, réalisée 2 à 4 fois par semaine permettait une amélioration de la condition physique et de la mobilité chez des employés de bureau (Gurd, Patel et al. 2018). Récemment, une étude avec 25 salariés du secteur tertiaire a été réalisée en demandant sur trois réunions différentes de rester debout pendant ce temps de travail. Les résultats ont principalement montré de nombreux obstacles à travers une gêne et un mal être important (Mansfield, Hall et al. 2018). Cette étude montre surtout qu'il existe encore de nombreuses barrières à ce genre de pratique et souligne l'importance de suggérer des stratégies pour s'acclimater à ce type de comportement.

De nombreuses stratégies peuvent donc être développées et mises en place sur le lieu de travail afin de lutter contre la sédentarité. Si ces interventions semblent permettre de réduire le temps passé à des comportements sédentaires, ceci ne se traduit pas par une augmentation du niveau d'activité physique des employés. Même s'ils sont plus rares, certains travaux ont quant à eux tenté de promouvoir la pratique physique de ces employés à travers la promotion de cette pratique physique, voire même l'instauration de programmes d'activité physique au sein même des entreprises.

#### **d. Promotion de l'activité physique**

Depuis plusieurs années, quelques auteurs ont cherché à démontrer les bienfaits de l'activité physique sur le lieu de travail. Pour cela, différentes interventions ont été mises en place. Comme pour la sédentarité, certains auteurs ont centré leurs travaux sur la promotion de la santé et du bien-être à l'aide de messages motivationnels, de conseils ou encore de groupes de travail. Le Tableau 2 recense les principales études faisant la promotion d'un mode de vie actif auprès d'employés du secteur tertiaire.

Tableau 2. Interventions mises en place sur le lieu de travail afin d'augmenter le niveau d'activité physique (par ordre de publication dans la littérature).

Références	Type d'intervention	Fréquence	Durée	Résultats
<i>Muto et al., 2001</i>	Séminaires de promotion de la santé	6 sessions	1 an	Amélioration de la composition corporelle
<i>Mackenzie et al., 2015</i>	Vidéos éducationnelles	Libre	4 semaines	Diminution du temps passé assis, du stress; amélioration de la concentration
<i>Johnson et al., 2016</i>	Conseils hebdomadaires + challenge	Libre	6 mois	Augmentation du niveau d'activité physique
<i>Shafieinia et al., 2016</i>	Contrôle vs groupe exercice (programme éducationnel + sms persuasifs)	4*90min sessions d'ex	3 mois	/
<i>Fournier et al., 2017</i>	Programme d'AP + sms motivationnels	Libre	1 an	Augmentation du niveau d'activité physique
<i>Lowensteyn et al., 2018</i>	Programme de bien-être au travail	Libre	6 semaines	Diminution stress, fatigue; amélioration sommeil
<i>Bort-Roig et al., 2017</i>	1h de marche/jour avec l'aide d'une application mobile	1h/jour	/	Diminution temps passé assis
<i>Lin et al., 2018</i>	Intervention éducationnelle avec challenge de pas	Libre	12 mois	Diminution poids, tour de taille; augmentation niveau d'activité physique
<i>Niederer et al., 2018</i>	Programme d'AP vs tâches cognitives	15 minutes	1 fois/condition	Amélioration performance cognitive

/ : pas de durée imposée ; aucun résultat significatif

## *Une approche informative pour augmenter le niveau d'activité physique*

Les premiers travaux conduits dans le domaine ont commencé par questionner les bienfaits d'une approche informative, basée sur de l'éducation à l'activité physique (parfois couplée à de l'éducation nutritionnelle) à travers différents séminaires, sur le niveau d'activité physique d'employés. Ceci a conduit au développement et à l'évaluation de nombreux programmes de promotion de la santé au travail. En effet, il apparaît que ces programmes peuvent améliorer la santé globale, augmenter l'activité physique (Proper, Koning et al. 2003; Conn, Hafdahl et al. 2009; Hutchinson and Wilson 2012), améliorer le statut pondéral et avoir des effets positifs potentiels sur le comportement alimentaire (Maes, Van Cauwenberghe et al. 2012). De plus, ce type de programme pourrait diminuer les arrêts maladie (Proper, Koning et al. 2003; Kuoppala, Lamminpaa et al. 2008) et augmenter la productivité au travail (Brown, Gilson et al. 2011; Cancelliere, Cassidy et al. 2011). Muto et al. ont par exemple montré une amélioration du profil biologique ainsi que de la composition corporelle des salariés grâce à l'intervention de professionnels lors de séminaires d'informations. Les auteurs expliquent les bienfaits de leurs interventions par une modification du style de vie des employés (augmentation du niveau d'activité physique et meilleures habitudes alimentaires), mais ces paramètres n'ont pas été évalués ce qui montre l'importance de la réalisation d'études aux designs plus élaborés, aussi bien en ce qui concerne les méthodes d'évaluation que la composition de l'intervention elle-même (Muto and Yamauchi 2001).

Dans un autre registre, une récente étude a proposé un défi en ligne de 6 semaines à 314 salariés, défi proposant aux participants de confronter leur niveau d'activité physique à l'aide de modules éducatifs mais aussi de comparer leurs pertes de poids induites



(Lowensteyn, Berberian et al. 2018). Leurs résultats mettent en avant une amélioration générale de la santé physique et mentale des employés, avec principalement une diminution du stress et de la fatigue, mais aussi une meilleure qualité de sommeil (Lowensteyn, Berberian et al. 2018). En 2016, une étude de 6 mois a été menée en proposant des conseils hebdomadaires, des carnets de bord à compléter par les employés, ainsi que deux défis (compétitions amicales entre les salariés à l'aide d'outils comme par exemple des podomètres pour aider au suivi de l'activité physique) créant une sorte de «compétition interne», ce qui a conduit à une augmentation significative du niveau d'activité physique hebdomadaire de ces derniers (Johnson, Stolp et al. 2016).

Une récente méta-analyse comportant 138 études d'interventions d'activité physique (renforcement de la motivation, éducation cognitivo-comportementale, conseils...) en milieu de travail (Hutchinson and Wilson 2012) a montré un effet significatif de l'augmentation du niveau d'activité physique sur les marqueurs physiologiques (cholestérol, HDL (high density lipoprotein), rapport entre les deux) ainsi que de la condition physique des employés, mais ce de manière encore trop modeste, soulignant ainsi la nécessité de continuer à développer ces interventions pour en optimiser les résultats (Conn, Hafdahl et al. 2009).

Associer ce type d'éducation thérapeutique à un programme d'activité semble d'autant plus important que quelques travaux ont montré que les employés montrant les moins bonnes habitudes de vie sont aussi ceux présentant une moins bonne productivité au travail et le plus d'arrêts maladie (Proper, van den Heuvel et al. 2006; Alavinia, Molenaar et al. 2009; Robroek, van den Berg et al. 2011; Williden, Schofield et al. 2012). Par exemple, associer des sms en plus d'un programme d'activité physique permettrait de modifier plus rapidement et de manière plus durable les habitudes en terme d'activité physique (Fournier, d'Arripe-Longueville et al. 2017). En effet, Mackenzie et al. ont réalisé une étude de 4 semaines où ils

ont associé des vidéos éducatives à des réunions de marche, ce qui a permis à la fin de l'intervention, de diminuer le temps passé assis au travail, diminuer le stress, mais aussi améliorer la concentration (Mackenzie, Goyder et al. 2015). De plus, une récente étude conduite auprès de 28 salariés du secteur tertiaire a comparé leur efficacité cognitive suite à une séance d'exercice physique (renforcement musculaire, coordination, etc.) ou suite à une séance d'exercice de développement cognitif (Niederer, Engeroff et al. 2018). D'après leurs résultats, l'exercice physique permet d'obtenir chez ces salariés une performance cognitive aussi importante qu'à la suite de la réalisation de ces tâches attentionnelles et cognitives.

En parallèle, certaines études ont quant à elles, plutôt mis l'accent sur la mise en place de réunions actives comme les réunions en marchant (walking meetings), des sorties de groupe ou encore des objectifs à atteindre en terme de nombre de pas par exemple. Une récente étude de 12 mois a évalué deux différents groupes : un groupe avec une intervention éducative et un groupe avec cette même intervention plus des challenges (pas sur la journée, parcours de marche dans les environs de l'entreprise ou encore outils de motivation). Les résultats ont montré une diminution du poids, du tour de taille et une augmentation du niveau d'activité physique pour le groupe avec l'intervention combinée (Lin, Hong et al. 2018). Dans le même sens, une étude de 100 jours avec un challenge de 10000 pas/jour a été réalisée afin d'évaluer les effets sur le bien-être général. Les résultats montrent un effet positif faible mais constant sur différents paramètres (dépression, anxiété, stress, bien-être) pendant toute la durée de l'étude. Ces résultats soulignent donc l'amélioration générale de la santé mentale et du bien-être chez les salariés qui entreprennent d'atteindre les recommandations des 10000 pas/jour (Hallam, Bilsborough et al. 2018). Récemment, une nouvelle étude a été menée en intégrant une heure de marche (à

différentes intensités) dans une journée de travail dans le but de comparer un podomètre face à une application smartphone, mais les principaux résultats ont uniquement montré une diminution du temps passé assis grâce à cette intervention (Bort-Roig, Puig-Ribera et al. 2017).

En plus de ces stratégies développées pour réduire le temps de sédentarité ou favoriser la mise en activité des employés, certaines entreprises ont montré leur intérêt pour l'intégration au sein de leur site, d'espaces dédiés à la pratique sportive, voire même de réelles structures de pratique libre ou encadrée sur le lieu de travail.

#### **e. Programmes d'activité physique en entreprise**

Nous avons donc fait le constat au fil des années d'une diminution du niveau d'activité physique, accompagnée d'une augmentation du nombre de comportements sédentaires. La population du secteur tertiaire est particulièrement touchée ; en effet, comme mis en avant précédemment, les employés passent environ 7 à 8 heures par jour sur leur lieu de travail. Nous avons détaillé jusqu'alors les stratégies incitatives de promotion de l'activité physique et de la rupture des comportements sédentaires, mais rompre cette sédentarité ne veut pas dire rendre actif, distinction importante au regard de la littérature pointant du doigt les effets de cette sédentarité sur certains paramètres de santé, quel que soit le niveau d'activité physique des individus (Thivel, Tremblay et al. 2018).

Passant au minimum la moitié de leur journée de travail assis, et la moitié de leur journée sur leur lieu de travail, la mise en place de programmes d'activité physique en entreprise apparaît être une opportunité et une stratégie efficace pour rompre les barrières à l'activité physique des salariés (Dishman, Oldenburg et al. 1998). Plus que des incitations et des

ruptures des comportements sédentaires, la mise en place de programmes d'activité physique structurés et sur site apparaît aujourd'hui essentielle, la faisabilité et l'efficacité de ce type d'intervention *in-situ* étant au cœur de ce travail de Doctorat.

Le tableau 3 synthétise les principales études conduites auprès d'employés du secteur tertiaire et qui ont proposé des programmes d'activité physique en entreprise. Dans ce contexte, plusieurs articles publiés ont examiné l'efficacité de la promotion de la santé en milieu de travail. Les auteurs ont suggéré que les études interventionnelles plus récentes devraient être mieux conçues (programmes plus calibrés, designs adaptés, taille d'échantillon plus importante, etc.) et ont souligné la nécessité de conduire d'autres études plus élaborées et sur plus long terme. En outre, la majorité des études déjà publiées sur le sujet ont jusqu'à présent été jugées de mauvaise qualité scientifique (Dishman, Oldenburg et al. 1998).

**Tableau 3. Programmes d'activité physique en entreprise (par ordre de publication dans la littérature).**

Références	Type d'intervention	Fréquence	Durée	Résultats
<i>Pedersen et al., 2009</i>	Entraînement de résistance vs exercice complet	3*20min/semaine	1 an	Diminution % masse grasse, douleurs
<i>Bredahl et al., 2014</i>	Entraînement en force	3*20min/semaine	5 mois	Nombreux freins à la pratique
<i>Grande et al., 2014</i>	Exercices de stretching	3*5min/semaine	3 mois	Augmentation niveau d'activité physique; diminution % masse grasse
<i>Vilela et al., 2015</i>	Contrôle vs groupe exercice	5*10min/semaine	4 mois	Amélioration composition corporelle, souplesse, force membres supérieurs
<i>Jakobsen et al., 2015</i>	Exercices à la maison vs au travail + coaching pour la motivation	5*10min/semaine	10 semaines	Activité physique au travail plus efficace
<i>Dalager et al., 2016</i>	1-h AP haute intensité supervisée + 6*30-min AP modérée	1-h+6*30min/semaine	1 year	Amélioration de la condition physique; diminution IMC
<i>Boudet et al., 2017</i>	Différents programmes d'AP avec différentes intensités	4j/semaine	3 semaines	Motivation plus importante sur l'intensité modérée
<i>Justesen et al., 2017</i>	Exercices de haute intensité	1h/semaine	1 an	Amélioration productivité, diminution absentéisme
<i>Corbett et al., 2018</i>	Entraînement en endurance + force	3*60min/semaine	12 semaines	Diminution IMC
<i>Fang et al., 2018</i>	Programme d'AP d'intensité modérée	3*60min/semaine	12 semaines	Amélioration condition physique, qualité de vie au travail
<i>Rowland et al., 2018</i>	Contrôle vs exercice	1/semaine	12 semaines	Amélioration condition physique; diminution risques cardio-vasculaires
<i>Hunter et al., 2018</i>	Programme d'AP supervisé vs non supervisé	2/semaine	8 semaines	Amélioration capacités cardio-respiratoires, force musculaire maximale
<i>Kinnafick et al., 2018</i>	Entraînement HIIT	3 à 5*25min/semaine	10 semaines	Faible augmentation du niveau d'activité physique

Une méta-analyse d'Abraham & Graham-Rowe révèle que dans l'ensemble, les bienfaits observés des interventions menées jusqu'alors en entreprise restent faibles (Abraham 2009). Pourtant, une revue systématique a par exemple montré que des interventions (programmes de marche et conseils d'activité physique) conduites en entreprise (dans plusieurs pays d'Europe, en Australie, Nouvelle-Zélande et au Canada) ont une incidence positive sur le comportement face à l'activité physique (Dugdill 2008). Les efforts pour prévenir la prise de poids en ciblant à la fois l'activité physique et le comportement alimentaire sur le lieu de travail ont augmenté au cours des dernières décennies. Plusieurs revues systématiques ont été réalisées et ont trouvé des effets favorables sur l'activité physique, le comportement alimentaire ou les deux (Proper, Koning et al. 2003) ainsi que sur le statut pondéral (Dishman, Oldenburg et al. 1998; Dugdill 2008). En parallèle, Proper et al ont montré une diminution de l'absentéisme et du niveau de stress au travail grâce à un programme d'activité physique en endurance, mais aucune modification de la productivité au travail n'a été observée (Proper, Koning et al. 2003).

Une des premières études utilisant un design plus structuré et adapté a été conduite par l'équipe de Pedersen et a montré qu'une heure par semaine d'exercices (marche nordique, boxe, step, renforcement musculaire, etc.) pendant un an, permettait une diminution du pourcentage de masse grasse ainsi qu'une diminution des douleurs au niveau du dos et des épaules (Pedersen, Blangsted et al. 2009). D'autres paramètres de santé ont été évalués, mais aucun résultat significatif n'a été trouvé, ce qui peut s'expliquer par la subjectivité de certaines mesures, reposant en majorité sur l'utilisation de questionnaire.

En effet, une méta-analyse publiée (Verweij, Coffeng et al. 2011) a trouvé des preuves modestes d'effet des interventions d'activité physique et de nutrition en milieu de travail en faveur du groupe «intervention» avec une baisse de seulement -1,3 kg par rapport au

groupe «contrôle» à 6 ou 12 mois de suivi (Anderson, Quinn et al. 2009). Néanmoins, ces résultats ont été limités à des études publiées jusqu'en 2005 et comprennent des études visant la perte de poids essentiellement. Bien que l'objectif central de la plupart des études incluses n'ait pas été amélioré, l'accent sur la prévention primaire et secondaire est plus important que la prévention basée sur le gain de poids de la population et peut se révéler plus efficace dans la lutte contre l'obésité. Dans le même sens, une étude a montré qu'environ 20 minutes de vélo par jour en milieu de travail permettait de réduire la sédentarité, le temps passé assis, néanmoins sans changement significatif de productivité au travail (Carr, Walaska et al. 2012).

Quelques années plus tard, une étude de 4 mois a comparé un groupe contrôle avec un groupe intervention (15 minutes d'endurance musculaire, 5 fois par semaine) et les résultats principaux ont montré pour le groupe intervention une amélioration de la composition corporelle, de la souplesse ainsi qu'une amélioration de la force des membres supérieurs (Vilela, Benedito Silva et al. 2015). Mais seuls ces trois paramètres ont été évalués. Dans le même sens, une étude d'un an a été menée chez des salariés qui devaient réaliser 6 fois 30 minutes d'activité physique par semaine en entraînement personnel adossées à 1 heure par semaine d'activité supervisée ; cette programmation a permis à la fin de l'année d'intervention d'obtenir une augmentation de la VO<sub>2</sub> max ainsi qu'une diminution de l'indice de masse corporelle (Dalager, Justesen et al. 2016). En parallèle, des preuves cohérentes démontrent que les interventions d'activité physique en milieu de travail réduisent considérablement les douleurs musculo-squelettiques générales mais aussi et surtout les douleurs au niveau du cou et des épaules (Moreira-Silva, Teixeira et al. 2016). Ici aussi, seuls ces paramètres de santé ont été évalués. Il est tout de même important de noter qu'il peut exister des facteurs influents de soutien social et de l'environnement qui

pourraient accentuer ou non la participation des différents employés aux programmes d'activité physique, comme par exemple le niveau d'éducation ou encore, le soutien social des familles (Huang and Hung 2016).

Parallèlement, une récente étude a quant à elle évalué les effets d'une heure d'activité physique intense par semaine pendant les heures de travail, couplée à des recommandations d'activité physique de loisirs sur les paramètres de santé au travail pendant un an ; elle a montré que ce programme permettait de diminuer l'absentéisme, mais aussi d'améliorer la productivité (Justesen, Sogaard et al. 2017). Cette fois ci, ce sont les paramètres de condition physique et de santé globale qui n'ont pas été évalués.

Plus récemment, une étude de 12 semaines avec 3 fois 60 minutes d'activité physique par semaine (exercice aérobic + renforcement musculaire) a montré une diminution de l'IMC ; cette étude s'est seulement centrée sur l'évaluation des indices anthropométriques et des indices de pressions artérielles (Corbett, Fennell et al. 2018). Dans le même sens, une récente étude a montré qu'un programme d'activité physique d'un an (3 séances/semaine de 60 minutes) chez des salariés en surpoids permettait de réduire les facteurs de risques du syndrome métabolique, mais améliorait aussi la condition physique globale, les relations au travail, la satisfaction professionnelle ainsi que la qualité de vie (Fang, Huang et al. 2018). Une fois de plus, l'étude menée par Shaw et al. a montré que les interventions d'activité physique (en particulier quand elles sont combinées avec des interventions sur les comportements alimentaires) sont efficaces pour diminuer les risques de maladies cardiovasculaires, la pression artérielle ou encore la glycémie, alors qu'aucune perte de poids n'a été relevée (Shaw, Farris et al. 2018).

En parallèle, une étude de 3 mois a montré qu'un programme d'activité physique (2 séances par semaine) sur le lieu de travail entraînait une amélioration de la composition corporelle,



une diminution du pourcentage de masse grasse ainsi qu'une augmentation du niveau d'activité physique (Grande, Silva et al. 2014). Une récente étude de 12 semaines conduite auprès de femmes uniquement a évalué les effets de séances d'activité physique de groupe + prescription d'exercices (par comparaison avec un groupe contrôle sans intervention) et a mis en évidence une amélioration de la condition physique accompagnée d'une diminution des risques cardiovasculaires pour le groupe intervention (Rowland, Berg et al. 2018). D'autres travaux ont quant à eux comparé les effets d'un programme d'activité physique supervisé vs. non supervisé, montrant que la capacité cardiorespiratoire et la force musculaire maximale ont été significativement améliorées, quel que soit le groupe (Hunter, Gordon et al. 2018). Un suivi à 15 mois des deux groupes a en revanche montré que les effets bénéfiques n'avaient pas été maintenus au long terme. Kinnaïck et al. ont quant à eux montré qu'un programme d'entraînement HIIT (high intensity interval training) de 10 semaines ne permettait qu'une très faible augmentation du niveau d'activité physique, non maintenue sur le long terme (Kinnaïck, Thogersen-Ntoumani et al. 2018) ; de manière importante, si leurs participants ont exprimé leur satisfaction au regard du programme proposé, ils ont tout de même émis le souhait d'intensités d'exercices plus faibles (Kinnaïck, Thogersen-Ntoumani et al. 2018).

Compte tenu de la place prépondérante que prend aujourd'hui le lieu de travail dans la promotion de la santé, et les bénéfices reconnus de l'activité physique sur cette dernière, il semble aujourd'hui important de mieux comprendre comment intégrer l'activité physique au sein des entreprises pour optimiser les stratégies de promotion d'un mode de vie actif. Il faut cependant faire attention car les bénéfices engendrés par les programmes d'activité

physique peuvent rapidement disparaître si cette pratique physique est interrompue (Skogstad, Lunde et al. 2018).

Alors que le milieu de travail a été récemment identifié comme un nouveau cadre idéal pour promouvoir l'activité physique, la complexité des activités tertiaires qui, par définition, favorisent la sédentarité, combinée à l'effet indépendant du temps sédentaire et de l'activité physique sur la santé, doit amener les acteurs et les praticiens à mener des interventions individualisées favorisant non seulement l'activité physique, mais aussi luttant contre la sédentarité. Il est important de noter que des interruptions du temps sédentaire remplacées par des activités physiques de faibles intensités sont le début de la mobilité humaine chez des sujets inactifs.

Bien que le nombre d'études sur la mise en place de programmes d'activité physique au travail ait augmenté rapidement dans les dernières années, la littérature souligne aujourd'hui la nécessité de travaux méthodologiquement mieux conçus. Sont également nécessaires des comparaisons directes de programmes avec et sans installations sportives et ou permettant des activités physiques sur le lieu de travail, afin de déterminer si le coût des installations sur place est justifié par l'amélioration de la santé et la productivité des employés. De plus, des études ciblant les sujets à risque permettraient de déterminer si les interventions doivent être adaptées à des sous-groupes particuliers de salariés (Conn, Hafdahl et al. 2009).

### III. Objectifs

Au regard de la littérature scientifique détaillée ci-dessus, il semble aujourd'hui nécessaire d'approfondir les connaissances dans le milieu de l'entreprise. En effet, compte tenu de la place prépondérante que prend aujourd'hui le lieu de travail dans la promotion de la santé, et les bénéfices reconnus de l'activité physique sur cette dernière, il est aujourd'hui important de mieux comprendre comment intégrer l'activité physique au sein des entreprises pour optimiser les stratégies de promotion d'un mode de vie actif.

Ainsi, ce travail de thèse CIFRE a eu pour objectif principal de déterminer la faisabilité et l'efficacité d'un programme d'activité physique en entreprise auprès de salariés du secteur tertiaire. Cet objectif s'est décliné en différents objectifs secondaires :

- I. Etudier la faisabilité d'un protocole de recherche permettant d'évaluer les effets d'un programme d'activité physique de 5 mois en entreprise auprès de salariés du secteur tertiaire, et ses effets sur les paramètres de santé, bien-être et condition physique (étude 1).
- II. Evaluer les effets d'un programme d'activité physique structuré de 10 mois mis en œuvre sur le lieu de travail, sur les indicateurs de santé globaux chez les employés tertiaires (étude 2).

- III. Comparer les indicateurs de santé globaux chez des employés du secteur tertiaire, physiquement actifs et inactifs présentant un haut niveau de sédentarité, et évaluer les effets d'un programme d'activité physique de cinq mois en milieu de travail sur ces indicateurs de santé entre les employés sédentaires actifs et les employés nouvellement actifs (étude 3).
- IV. Observer le taux d'adhésion durant les programmes d'activité physique en milieu de travail et suggérer de nouvelles stratégies pour favoriser l'activité physique chez les employés, compte tenu du profil accrocheurs/décrocheurs (étude 4).

Les objectifs 3 et 4 ont été déterminés compte-tenu des résultats obtenus après les études 1 et 2.

Si ce travail de thèse a été effectué dans le cadre d'une CIFRE avec l'ASM/Michelin (présentation de l'entreprise et de ses activités en annexe), avec donc une phase expérimentale au sein de l'entreprise Michelin, le déroulement et les difficultés rencontrées lors de cette phase nous ont amené à inclure un autre site d'expérimentation, la Caisse Primaire d'Assurance Maladie, afin de pouvoir répondre à nos objectifs.

## **IV. Contributions Personnelles**

## 1. Etude I

Effect of a 5-month worksite physical activity program on tertiary employees  
overall health and fitness

Genin PM, Degoutte F, Finaud J, Pereira B, Thivel D, Duclos M.

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## a. Résumé

**Objectif:** Cette étude pilote a pour objectifs de déterminer les effets d'un programme d'activité physique sur la santé et la condition physique d'employés du secteur tertiaire.

**Méthode :** 95 employés ont été randomisé en trois groupes : Contrôle (CON), Novice (NOV) et Expérimenté (EXP). Les groupes NOV et EXP ont suivi un programme d'activité physique en entreprise de 5 mois (au moins 2 séances/semaine). La composition corporelle, le niveau d'activité physique, la condition physique, les habitudes alimentaires, la perception de la santé, la qualité du sommeil, la douleur et la qualité de vie ont été évalués.

**Résultats :** Le pourcentage de masse a diminué pour les groupes NOV et EXP ; la distance parcourue au test du 6 minutes marche, les pompes et les squats jump ont augmenté pour les groupes NOV et EXP. Le niveau d'activité physique, la perception de la santé, la qualité du sommeil et les habitudes alimentaires se sont améliorés pour le groupe NOV.

**Conclusion :** Cette étude souligne pour la première fois les effets bénéfiques de tels programmes en entreprise chez les salariés du secteur tertiaire sur la santé globale ; mais aussi la faisabilité de sa conception.

**Mots clés :** activité physique, santé au travail, condition physique, santé.

## **b. Abstract**

**Objective:** This pilot study questions the effects of a worksite physical activity program on health and fitness in tertiary employees.

**Methods:** 95 employees were randomly assigned to: Control (CON); Novice (NOV); Experienced group (EXP). The NOV and EXP groups followed a 5-month worksite physical activity program (at least 2 sessions/week). Body composition, physical activity level and physical fitness, eating habits, health perception, sleep quality, pain and quality of life were assessed.

**Results:** Fat mass decreased in NOV and EXP; the distance covered during the 6-min walking test, push-ups, squat jump increased for NOV and EXP group. Physical activity level, health perception, quality of sleep and eating habits were improved in NOV.

**Conclusion:** This study underlines for the first time the beneficial effects of such worksite programs among tertiary employees on overall health and the feasibility of its design.

**Key words:** physical activity, occupational health, physical fitness, health.



### **c. Introduction**

It is estimated that physical inactivity contributes to almost one in ten premature deaths (based on life expectancy estimates for world regions) from coronary heart disease and one in six deaths from any cause (Lee, Shiroma et al.). Sedentary behavior is associated with poor health on any age range, independently of the level of physical activity (Biswas, Oh et al. 2015). Sedentary behavior may not be only defined by lack of physical activity. People can achieve recommended levels of physical activity, and yet spend large amounts of remaining time inactive (Patel, Bernstein et al. 2010; Leon-Munoz, Martinez-Gomez et al. 2013). These long periods of sedentary behavior increase risk of cardiovascular diseases, type 2 diabetes, cancers, obesity (Biswas, Oh et al. 2015), even in individuals with activity in the recommended levels.

Regular physical activity is key in the primary prevention of at least 35 chronic conditions (Booth, Roberts et al. 2011). Nowadays, exercise is the first-line treatment of 26 chronic diseases (Pedersen and Saltin 2015).

Besides its effects on health-related physical fitness, physical activity is now recognized for its benefits on mental health, with many studies showing that regular physical activity reduces depression and anxiety symptoms, improves mood and helps with stress management (Fox 1999; Paluska and Schwenk 2000; Blake, Mo et al. 2009; Blake, Mo et al. 2009).

French public health recommendations include a minimum of 150 minutes of moderate to vigorous exercise per week, however less than half of 15-78 years old population is

considered as active (report 2008). In addition, French working adults spent an average of 9,96h/day sitting on workdays (whose 4,17h/day in work sitting); and 7,58h/day sitting on non-workdays (Saidj, Menai et al. 2015). The same study reported that being sedentary at work was associated with more sedentary behavior outside of work.

Worldwide, public health policies underline the urgent necessity to create a suitable culture of regular physical activity (NPAP 2010; Health 2011) where employers are encouraged to play a key role in the promotion of health and well-being among adults of working age (Prevention 2012).

Workplaces represent today an ideal opportunity for new initiatives to promote physical activity. Workplaces could indeed reduce some barriers identified to limit the engagement into physical activity, such as lack of time and proximity (Dugdill, Brettle et al. 2008). Due to the difficulty of changing the population habits and to engage them in activity on usual contexts (such as associations, gymnasiums, etc.), worksite programs might provide a great way to incite employees to increase their activity, especially due to the time people spend at the workplace (Green 1988).

Increasing the level of employees physical activity might maintain them healthy, reducing health care costs (Golaszewski 2000). Moreover, more than 37% of USA workers are currently overweight (body mass index [BMI]  $\geq 25\text{kg/m}^2$ ), at least 29% are obese (BMI  $\geq 30\text{kg/m}^2$ ) (Garfinkel 1986), and this is associated with an increased rate for absenteeism and lost productivity (Hertz, Unger et al. 2004; Neovius, Johansson et al. 2009).

This illustrates the important economic benefit associated with regular physical activity, reducing the combined cost of different treatments for avoidable diseases and reducing the number of sick leave due to diseases or wounds (Katzmarzyk and Janssen 2004; Oldridge 2008).

Some previous studies have indeed shown that interventions conducted to improve employees' health induce a reduction in absenteeism and sick leave, and favor increased productivity (Proper, Koning et al. 2003; Kuoppala, Lamminpaa et al. 2008).

It seems then that workplace-based physical activity interventions can improve global health, physical activity level (Proper, Koning et al. 2003; Conn, Hafdahl et al. 2009; Hutchinson and Wilson 2012), weight status (Ni Mhurchu, Aston et al. 2010), and may have positive effects on eating behavior (Maes, Van Cauwenberghe et al. 2012). However, a recent systematic review identified a low effect of such physical activity programs implemented on worksites (Rongen, Robroek et al. 2013). This low effect might be due to a large heterogeneity in the individual effects. Moreover, these studies mainly focused their analysis on lifestyle improvements (physical activity increased in everyday life, outside of workplace) (Proper, Koning et al. 2003; Conn, Hafdahl et al. 2009), and long term outcomes like productivity on workplace and sick leave.

Although there is a growing interest in the scientific literature concerning workplace physical activity interventions, most of the studies conducted so far focused specifically on health indicators (weight status, body composition, physical activity level, pain). The aim of this pilot study is to question the multidimensional effects of a workplace-implemented physical

activity program on overall health using a large number of physical and psychological indicators.

#### **d. Material and methods**

##### ***Population and Design***

Ninety-five office employees (tertiary sector workers) aged  $44 \pm 9.9$  years took part in this experimental study (62 males and 33 females). Participants were approached through the manufacture internal network.

All the participants received information sheets and signed consent forms as requested by ethical authorities (Local Human Protection Committee).

After a medical visit to ensure the ability of the participants' to complete the entire protocol, they were stratified into three subgroups: i) Control group (CON n=22; engaged in less than 150 minutes moderate physical activity per week for at least one year, according to the IPAQ short-form questionnaire) and not motivated to start the worksite physical activity program, ii) Novice group (NOV= 37; participants unsupported by physical activity and who started the worksite physical activity program at the beginning of the study), iii) participants engaged in the worksite physical activity program for the last 2 years at least (minimum of 2 45 minutes sessions per week) (Experienced (EXP) n=36). A first visit (V1) was realized in January 2016 in which the participants were asked to fill in several questionnaires (Quality of Life, Physical Activity Level, Sleep Quality, Somnolence, Insomnia, Eating Behaviors, Health Perception, and Pain), anthropometric measurements were performed, their body composition was

assessed and their physical fitness was evaluated using different physical tests. This visit was done by the same experimenter (PG) at worksite and during work time.

All these measurements were also performed at the end of study (V2), five months later.

### *The Worksite Physical Activity Program*

EXP and NOV group were requested to take part in two training sessions per week, within their worksite training program. Each session should last 45 minutes minimum, alternating between muscle strengthening and cardio respiratory exercise (one of each per week), supervised by a professional for a duration of 5 months (from February to Jun 2016). Their worksite facilities propose eighteen free different physical activities distributed in groups, such as muscle strengthening, stretching, cardiorespiratory or team sport. Each activity lasts around 45 minutes. Thus, the participants can choose the activities they want in these categories: muscle strengthening (weights machines) or cardiorespiratory (latino dance, step, bike, fight exercise...). The compliance was controlled by the computerized access to the sport facilities. Participants were also allowed to add a third weekly session, choosing among collective activities, (i.e. Pilates or stretching).

### *Anthropometric measurements and body composition*

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Both mass and height were obtained at the same time of the day for the same subject, and not in the fasting state. Body Mass Index (BMI) was calculated as body mass (kg) divided by height squared ( $m^2$ ).

Body Composition was assessed by bioelectrical impedance analysis, performed with the Tanita MC780 multi frequency segmental body composition analyzer. This analyzer consists in a stand-alone unit where the subject has to step on bare foot (standard mode). Information concerning the subject (age, gender and height) is entered by the experimenter. Once body mass has been assessed by the scale, the subject has to take grips with both hands (alongside his body) during the impedance measure (Hand to foot BIA). A full segmental analysis is performed in less than 20 sec. Segmental fat mass and fat-free mass values are indicated by the end of the analysis on the digital screen (trunk, left and right arms and legs); as well as total body fat, fat-free mass and water. Total fat and fat-free mass were reported by the researcher into an excel sheet for statistical treatment. The newly developed BIA analyzer has been recently validated in healthy adults (Verney, Schwartz et al. 2015).

#### *Physical activity level (short version of the International Physical Activity Questionnaire IPAQ-SF)*

This questionnaire consists of six questions asking participants to recall aspects of their physical activity over the last 7 days (in this work, total physical activity does not include sitting time). The IPAQ-SF encompasses the amount of time spent sitting (in this work, total sitting time and the time spend seated during screen activities have been considered separately), walking and participating in moderate-to-vigorous physical activities for at least ten minutes at a time in the last 7 days. The participants' physical activity level was expressed in MET/h/week (Craig, Marshall et al. 2003).

## *Well-being, Quality of Life and Health Perception*

Well-being and quality of life at work were assessed using a newly developed questionnaire ("worksite well-being and quality of life questionnaire") especially designed for occupational health studies. The participants were asked to rate statements describing well-being state at work using visual analogue scales ranging from "not at all" to "absolutely" (i.e. "I'm actually feeling distressed while at work").

This questionnaire has been recently validated in a similar population (Carton 2015).

All participants were also demanded to complete a short self-administered questionnaire specifically designed to explore their perception of health ("health perception scale"). Six criteria were investigated: (1) perceived physical fitness, (2) perceived ideal weight, (3) perceived healthy balanced diet, (4) perceived sleep quality, (5) perceived stress level, and (6) perceived general health. A 10-point scale from 1 (not at all) to 10 (very much) was used to assess each item. The six individual scores were computed to obtain a global score for health perception.

This questionnaire has been previously validated in adults (Garnier, Gaubert et al. 2013).

## *Sleep*

### ***Sleep quality***

The Pittsburgh Sleep Quality Index (PSQI) is a self-rated questionnaire assessing sleep quality and disturbances over a 1-month time interval. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum

of scores for these seven components yields one global score. Clinical and clinimetric properties of the PSQI were assessed over an 18-month period with "good" sleepers and "poor" sleepers (Buysse, Hall et al. 2008).

### ***The Insomnia Severity Index (ISI; Morin, 1993)***

The Insomnia Severity Index (ISI) assesses subjective symptoms and consequences of insomnia, and the degree of anxiety or distress caused by sleep difficulties (Morin, Belleville et al. 2011). The ISI is composed of seven items measuring the severity of sleep discordance (difficulty initiating sleep, difficulty maintaining it, waking too early in the morning), satisfaction with current sleep, disruption of daily functioning, perception of entourage about the apparent deterioration of the quality of life and degree of worry or concern about sleep difficulties. Each item is rated on a scale from 0 to 4 and the total score ranges from 0 to 28. Typically, the total score at the ISI used to classify individuals according to the severity of their insomnia: absence of insomnia (0-7), mild insomnia (8-14), moderate insomnia (15-21), severe insomnia (22-28).

### ***Somnolence scale : Epworth (Johns 1992)***

The Epworth Sleepiness Scale (ESS) is a self-administered eight-item questionnaire that has been proposed as a simple method for measuring daytime sleepiness in adults (patients with various sleep disorders). This brief questionnaire asks subjects to rate on a 0 to 3 scale the chance that, over "recent times" they would have dozed in eight specific situations that are commonly met in daily life (0= would never doze; 3= high chance of dozing). Thus, subjects are asked to retrospectively characterize, part of their usual behavior in a variety of situations that are more or less soporific.



Subjects are asked to distinguish dozing behavior from feeling of tiredness. The ESS score is the sum of eight item-scores and can range from 0 to 24.

### *Pain*

Pain was evaluated using the Nordic questionnaire that is a standardized and validated questionnaire usually used by occupational health practitioners to detect musculoskeletal pain (Roquelaure, Ha et al. 2006). The questions concentrate on symptoms most often encountered in an occupational setting focusing on work-activities specific musculoskeletal symptoms. The questions are forced choice variants that might be either self-administered or used in interviews, and in the present work the questionnaire was self-administrated (Kuorinka, Jonsson et al. 1987).

Pain was also assessed using the Quick DASH questionnaire. This is an 11-item disability scale. Participants are asked to indicate the amount of difficulty performing activities, the amount of limitation, or the extent of interference with activities (ranging the difficulty from 1 to 5 with 1 indicating the least impairment and 5 indicating the most). Items inquiring about the extent of arm, shoulder, and hand pain and tingling are rated from 1 (none) to 5 (extreme).

Scores are summed and averaged, and the value is transformed to a score from 0 to 100 by subtracting 1 from the average and multiplying by 25. Higher scores indicate greater disability (Giladi, McGlinn et al. 2014).

### *Eating Behaviors*

Eating habits were collected using a self-administrated questionnaire (“eating habits questionnaire”) commonly used in clinical routine and research. Emphasis was placed on frequency of breakfast, snacking, tendency for extra helping during meals, and the type of beverages consumed. One question was asked in relation to each of these specific eating habits. Each item was clearly explained, and all the questions were followed by predetermined responses to facilitate comprehension (i.e., “Do you eat breakfast? Every Day – Often - Sometimes – Never”; “Do you snack between meals? Every Day– Often - Sometimes – Never”; “Do you have tendency to have extra-helping during meals? Every Day – Often- Sometimes –Never”; “Which kind of drink do you consume when you are thirsty? Water - Sugar-sweetened beverage”). This questionnaire was adapted from validated eating habits questionnaire (Pradhan, Taylor et al. 2013; Thivel, Aucouturier et al. 2013).

### *Physical fitness*

*Aerobic fitness.* The patients were asked to perform a 6-minute Walking Test that was performed on an indoor 20-m corridor, following the recommendations from the American Thoracic Society (ATA). The subjects were instructed to walk the longest distance in 6 min. After 6 min, the distance covered was measured to the nearest meter by an investigator. Participants were asked to wear a heart rate monitor (Polar Electro Inc, Lake Success; USA) during the test and heart rate was recorded at the end of the 6 minutes. This test has been found reliable in healthy subjects (Kervio, Carre et al. 2003) and it is highly reproducible (Beriault, Carpentier et al. 2009).

*Muscle capacities.* Upper limbs muscle strength was assessed using the handgrip method, using the dominant and non-dominant hand, as non-invasive marker of muscle strength of upper extremities, well suitable for clinical use (Norman, Stobaus et al. 2011). The participants were also asked to perform a maximal number of push-ups (knees on the floor) respecting an imposed frequency. The test stopped once they were not able to maintain this rhythmicity anymore or has difficulty to maintain the imposed position (Hwang, Kwon et al. 2015; Marcolin, Petrone et al. 2015). Lower limb muscle strength was assessed during both a squat and a counter movement jump using the Optojump technology (*Microgate SRL, Rome, Italy*), (Kockum and Heijne 2015). The Shirado test was used to assess the static endurance of the abdominal muscles (Fransoo 2009) and the Sorensen test to assess back strength and the endurance of all the muscles involved in extension of the trunk (Demoulin, Vanderthommen et al. 2006).

*Balance and Flexibility.* The Sit-and-Reach test was used to evaluate the participants' flexibility (Mayorga-Vega, Merino-Marban et al. 2014) while their balance was assessed using the Flamingo test (Oja 1995).

#### **e. Statistical considerations**

All analyses were performed using Stata software (version 13, StataCorp, College Station, TX) and R softwares. Statistical analyses were done for a two-sided type I error of  $\alpha=5\%$ . Baseline subject's characteristics were presented as the mean  $\pm$  standard deviation (SD) or the median (interquartile range) for continuous data (assumption of normality assessed by using the Shapiro-Wilk test) and as the number of patients and associated percentages for categorical parameters. Quantitative variables were compared between independent groups

(CON, NOV and EXP) by ANOVA or Kruskal-Wallis (KW) tests if conditions of ANOVA were not respected (normality and homoscedasticity analyzed using Bartlett test). When appropriate ( $p < 0.05$ ), post-hoc test for multiple comparisons was applied to a type I-error correction: Tukey-Kramer post ANOVA and Dunn post KW. Comparisons between independent groups were done by Chi-squared or when appropriate by Fischer-exact test for categorical variables. To analyze repeated correlated data, random-effects models were performed to study fixed effects as group, time-points evaluation and their interaction taking into account between and within subject variability. The normality of residuals was checked for all models. Finally, multidimensional analyses as factorial mixed data analysis (FMDA) were performed for T0 data to complete these analyses. These statistical methods were useful for analyzing assets as elements of qualitative and quantitative variables in order to (1) uncover the underlying relationships and structures of the measured variables (latent constructs) and (2) to aggregate subjects into clusters such that each cluster represents a topic. When quantitative and categorical data are studied together, the usual methodology is to transform quantitative variables, categorizing them so as to submit these new variables in an exploratory multiple correspondence analysis (MCA). This methodology is relatively easy to implement and can be used when sample sizes are sufficient ( $n > 100$ ). Otherwise, the MCA could give unstable and non-robust results. It is interesting to use the FMDA approach in two particular situations: (1) when the number of categorical variables is very small compared to the quantitative variables and (2) when the sample size is low. According to the limited literature on this subject, it appeared difficult to estimate an optimal sample size in order to question the multidimensional effects of a workplace-implemented physical activity program on overall health and fitness. Also, sample size has been estimated according to Cohen's recommendations [Statistical power analysis for the behavioral sciences (2nd Ed.). New

Jersey: Lawrence Erlbaum, 1988] who has defined effect-size bounds as: small (ES: 0.2), medium (ES: 0.5) and large (ES: 0.8, “grossly perceptible and therefore large”). We calculated that a minimum of 22 workers per group would allow to highlight an effect size equal to 1 for a type I error  $\alpha=0.018$  (two-tailed with correction due to multiple comparisons) and statistical power of 80%. Considering possible to follow-up, we finally chose to include a minimum of 25 workers per group.

Since no difference was found depending on the number of exercise session per week, all the participants have been grouped. A sensibility analysis was performed to measure the possible impact of missing data (notably imputation of missing data). Results and practical conclusions were analogous (data not shown).

## f. Results

**Table 1.** Baseline and evolution of anthropometry and body composition parameters by group.

	CON			NOVICE			EXP			Mixed model	ANOVA $\Delta$	Posthoc $\Delta$
	T0	T1	$\Delta$	T0	T1	$\Delta$	T0	T1	$\Delta$			
Weight (kg)	74,1 $\pm$ 19,7	79,5 $\pm$ 16,3	5,4 $\pm$ 3,4	77,3 $\pm$ 16,3	72,8 $\pm$ 13,1	-4,5 $\pm$ 3,2	72,6 $\pm$ 14,5	71,5 $\pm$ 13,9	-0,64 $\pm$ 1,38	ns	ns	
BMI (kg/m <sup>2</sup> )	25 $\pm$ 5,4	26,3 $\pm$ 4,5	0,01 $\pm$ 0,26	25,8 $\pm$ 4,5	24,2 $\pm$ 2,9	-0,35 $\pm$ 0,66	23,7 $\pm$ 3,3	23,8 $\pm$ 3,4	-0,22 $\pm$ 0,47	ns	ns	
WC (cm)	93,6 $\pm$ 16,7	97,1 $\pm$ 13,1	0,04 $\pm$ 1,04	96,1 $\pm$ 14,6	90,7 $\pm$ 10,7	-1,74 $\pm$ 1,88	89,5 $\pm$ 12,9	88 $\pm$ 12,6	-2,65 $\pm$ 2,22	CON-NOV** CON-EXP**	**	CON-NOVICE* CON-EXP*
HC (cm)	103 $\pm$ 10,3	104,4 $\pm$ 9	-0,29 $\pm$ 1,18	105,6 $\pm$ 8,4	101,7 $\pm$ 5,6	-2 $\pm$ 1,63	102,2 $\pm$ 6,1	100,4 $\pm$ 6,3	-1,75 $\pm$ 1,46	CON-NOV** CON-EXP*	**	CON-NOVICE* CON-EXP*
WHR (cm)	0,9 $\pm$ 0,1	0,9 $\pm$ 0,1	0 $\pm$ 0,01	0,9 $\pm$ 0,09	0,9 $\pm$ 0,1	0 $\pm$ 0,02	0,9 $\pm$ 0,1	0,9 $\pm$ 0,1	-0,01 $\pm$ 0,02	ns	t	CON-EXP* NOVICE-EXP*
NC (cm)	37,5 $\pm$ 5,1	39,4 $\pm$ 4,2	0,18 $\pm$ 0,26	37,5 $\pm$ 4	37,1 $\pm$ 4,1	-0,19 $\pm$ 0,3	36,8 $\pm$ 3,7	37,1 $\pm$ 3,5	0,08 $\pm$ 0,13	CON-NOV*** NOV-EXP**	**	CON-NOVICE* NOVICE-EXP**
FM (%)	24,1 $\pm$ 7,1	23,6 $\pm$ 7,8	-1,28 $\pm$ 0,77	25 $\pm$ 7,6	21,4 $\pm$ 5,5	-1,47 $\pm$ 1,37***	21,2 $\pm$ 5,7	19,7 $\pm$ 6,3	-1,58 $\pm$ 1,31***	ns	ns	
FFM (kg)	53 $\pm$ 13,3	57,5 $\pm$ 12,5	0,95 $\pm$ 0,76**	54,6 $\pm$ 10,3	54,4 $\pm$ 10,2	0,39 $\pm$ 0,86	54,4 $\pm$ 10,7	54,3 $\pm$ 9,9	0,38 $\pm$ 0,89	ns	ns	
Central Adiposity Index	7,5 $\pm$ 4,9	8,4 $\pm$ 3,5	-0,36 $\pm$ 0,46	6,7 $\pm$ 4,1	6,8 $\pm$ 3,2	0,67 $\pm$ 1,75	5,9 $\pm$ 3,5	6,4 $\pm$ 3,6	0,08 $\pm$ 0,82	ns	ns	

\*p<0.05 ; \*\*p<0.01 ; \*\*\*p<0.001 ; t : tendency; BMI : Body mass index ; WC : waist circumference ; HC : hip circumference ; WHR : waist to hip ratio ; NC : neck circumference ; FM : fat mass ; FFM : fat free mass; ANOVA: Analyze of Variance;  $\Delta$ : Delta (value T1 – value T0, considering participants with full data collection at both T0 and T1 only). Results adjusted on age and gender.

Table 1 details the results for anthropometric characteristics and body composition of the employee.

No significant change in weight was observed during the study. By contrast, the two groups NOV and EXP significantly lost fat mass between T0 and T1. Some of this fat mass loss was central fat mass as waist circumference decreased. The mixed model shows a significant difference for waist circumference between CON and NOV ( $p \leq 0.05$ ) and between CON and EXP ( $p \leq 0.01$ ). The waist circumference delta was significantly higher ( $p \leq 0.05$ ) in the NOV group ( $-1.74 \pm 1.88 \text{ cm}$ ) compared to the CON group ( $0.04 \pm 1.04 \text{ cm}$ ). Similar results were observed for hip circumference: the delta was higher in the NOV group compared to the CON group ( $p \leq 0.01$ ) and higher in the EXP group compared to the CON group ( $p \leq 0.05$ ).

**Table 2.** Baseline and evolution of functional tests results by group.

	CON				NOVICE				EXP				Mixed model	ANOVA $\Delta$	Posthoc $\Delta$
	T0	T1	$\Delta$	T0	T1	T0	T1	$\Delta$	T0	T1	$\Delta$	$\Delta$			
6WT distance (m)	570,7 $\pm$ 51,2	617,9 $\pm$ 67,4	49,6 $\pm$ 46,5*	598,3 $\pm$ 62,7	648,5 $\pm$ 74	44,9 $\pm$ 53,2**	644,9 $\pm$ 63,3	698,3 $\pm$ 78,8	58,5 $\pm$ 58,9***				ns	ns	
6WT HR (bpm)	122,8 $\pm$ 18,7	123,3 $\pm$ 22,9	5,1 $\pm$ 18,8	136,1 $\pm$ 26,2	124,8 $\pm$ 21,7	-8,5 $\pm$ 19,4	128,2 $\pm$ 26,5	133,5 $\pm$ 18,6	6,2 $\pm$ 21,9				NOV-EXP*	ns	NOVICE-CON <sup>t</sup>
Shirado (sec)	185 $\pm$ 87,4	147,2 $\pm$ 80,7	-27,1 $\pm$ 58,9	160,3 $\pm$ 87,6	197,8 $\pm$ 102	15,5 $\pm$ 72,3	236,1 $\pm$ 65,7	221,8 $\pm$ 93,3	-10,8 $\pm$ 47,4				CON-NOV*	ns	
Sorensen (sec)	58,4 $\pm$ 39,1	62 $\pm$ 35,3	11,8 $\pm$ 10	78,8 $\pm$ 48,6	87,3 $\pm$ 38,4	1,3 $\pm$ 32,9	96,1 $\pm$ 52,2	97,4 $\pm$ 50,3	-7,9 $\pm$ 24				ns	ns	
Puch ups (rep)	17,5 $\pm$ 10,7	24,1 $\pm$ 18,8	5,4 $\pm$ 7,5	21,2 $\pm$ 9,7	28,6 $\pm$ 10,3	5,7 $\pm$ 5,1***	36,5 $\pm$ 17,1	42,7 $\pm$ 16,8	5,3 $\pm$ 7**				ns	ns	
HG HD (kg)	38,2 $\pm$ 10,7	40,4 $\pm$ 12,2	0,8 $\pm$ 4	42,2 $\pm$ 11,1	44,2 $\pm$ 10,7	1,2 $\pm$ 2,4t	41,7 $\pm$ 11,5	40,8 $\pm$ 8,7	1,4 $\pm$ 2,9t				ns	ns	
HG HND (kg)	34,5 $\pm$ 10,8	38,9 $\pm$ 11,6	2,5 $\pm$ 3,2t	38,9 $\pm$ 10,6	40,4 $\pm$ 10,2	1 $\pm$ 3,1	38,9 $\pm$ 11	40,8 $\pm$ 8,7	2,5 $\pm$ 3,6*				ns	ns	
Squat Jump (cm)	20,2 $\pm$ 6,1	22,1 $\pm$ 7,2	0,8 $\pm$ 1,7	21,1 $\pm$ 5,5	24 $\pm$ 5,6	2,6 $\pm$ 2,2***	22,7 $\pm$ 5,9	25 $\pm$ 6,8	1,6 $\pm$ 2,2**				CON-NOV <sup>t</sup>	ns	
CMJ (cm)	25,6 $\pm$ 7,6	26,4 $\pm$ 8,8	-0,2 $\pm$ 1,5	26,4 $\pm$ 5,9	28,8 $\pm$ 5,9	1,8 $\pm$ 2,2	29,6 $\pm$ 7,4	30,3 $\pm$ 8,3	0,3 $\pm$ 2,2				CON-NOV* NOV-EXP <sup>t</sup>	t	CON-NOVICE* NOVICE-EXP <sup>t</sup>
Flexibility (cm)	25,2 $\pm$ 15,1	31,4 $\pm$ 13,4	2,8 $\pm$ 9,7	23 $\pm$ 13,7	26,9 $\pm$ 12,1	3,5 $\pm$ 5,8*	28,7 $\pm$ 11,7	29,2 $\pm$ 12,9	1,2 $\pm$ 4,8				ns	ns	
Balance open right (sec)	77,5 $\pm$ 59,5	100,1 $\pm$ 79,8	32,1 $\pm$ 54,7	124,1 $\pm$ 81,7	165,9 $\pm$ 75,7	29,2 $\pm$ 63	160,3 $\pm$ 85,2	207,2 $\pm$ 103,1	50 $\pm$ 53,9**					ns	
Balance open left (sec)	83 $\pm$ 66,2	109,9 $\pm$ 87,5	52 $\pm$ 78,3t	114,8 $\pm$ 74,9	187,7 $\pm$ 68,8	60,9 $\pm$ 66**	160,7 $\pm$ 93,6	199 $\pm$ 102,7	41,4 $\pm$ 56,9*					ns	
Balance close right (sec)	7,6 $\pm$ 8,8	8,7 $\pm$ 8	1,9 $\pm$ 6,3	16,9 $\pm$ 21,6	34,2 $\pm$ 49,3	14,9 $\pm$ 31,9	17,6 $\pm$ 25,2	22,2 $\pm$ 20,7	3,5 $\pm$ 17,5					ns	
Balance close left (sec)	10,4 $\pm$ 19,2	9,1 $\pm$ 10,2	4,6 $\pm$ 5,4	17 $\pm$ 19,3	14,1 $\pm$ 14	-3,6 $\pm$ 14,4	12,8 $\pm$ 14,6	17,8 $\pm$ 17,1	4,8 $\pm$ 13,2					ns	

\*p<0.05; \*\*p<0.01; \*\*\*p<0.001; t : tendency; ANOVA: Analyze of Variance;  $\Delta$ : Delta; 6WT: six minute walk test; HR: heart rate; HG: hand grip; HD: hand dominant; HND: hand no dominant; CMJ: counter movement jump



There is a time effect on the distance walked in the 6 minute walk test between T0 and T1 with a significant increased distance in the three groups (table 2), but no difference in the distance gained between each group.

The mixed model shows a significant difference for Shirado test between CON and NOV ( $p \leq 0.05$ ), and a significant difference between CON and NOV for counter movement jump. A time effect was depicted between T0 and T1 with a significant progression for the push-ups and the squat jump for NOV and EXP.

NOV increased their flexibility between T0 and T1 with a time effect.

Concerning balance, there is a time effect between T0 and T1 for balance open right for EXP and for balance open left for NOV and EXP.

Table 3 details the results for the different questionnaires.

The mixed model shows a significant difference for health perception between NOV and EXP ( $p \leq 0.001$ ). The health perception delta was significantly higher in NOV compared to EXP ( $p \leq 0.01$ ). Moreover, there was a time effect between T0 and T1 for CON and NOV.

Concerning physical activity level, a time effect was depicted between T0 and T1 for CON and NOV, with both groups increasing their physical activity level. However, either at T0 or at T1, the EXP is the group with higher physical activity level. The mixed model for this questionnaire showed a significant difference between CON and NOV (NOV > CON,  $p \leq 0.05$ ) and between NOV and EXP ( $p \leq 0.01$ ). And the delta was significantly higher ( $p \leq 0.05$ ) in the NOV group compared to the EXP. This was not associated with decreased time spent sitting.

**Table 3.** Baseline and evolution of self-reported physical activity, health perception, sleep, wellbeing, eating habits and pain by group.

	CON			NOVICE			EXP			Mixed model	ANOVA $\Delta$	Posthoc $\Delta$
	T0	T1	$\Delta$	T0	T1	$\Delta$	T0	T1	$\Delta$			
Physical activity level (METs)	1008,8 $\pm$ 59,6	1177,5 $\pm$ 809,2	237,8 $\pm$ 330,5*	714,9 $\pm$ 516,4	1548,4 $\pm$ 858,8	887,5 $\pm$ 795,3**	1678,1 $\pm$ 860,1	1706 $\pm$ 653,1	-62,6 $\pm$ 665,8	CON-NOV* NOV-EXP**	*	NOVICE-EXP**
Sedentary (screen h/d)	49,9 $\pm$ 8,2	55,2 $\pm$ 6,9	4,9 $\pm$ 9,4	56,2 $\pm$ 9,7	50,9 $\pm$ 9,1	-6,4 $\pm$ 9,4	53,7 $\pm$ 9,1	53,1 $\pm$ 9,5	-1,5 $\pm$ 11		ns	
Sedentary (total h/d)	62,8 $\pm$ 7,7	62,7 $\pm$ 5	-0,08 $\pm$ 8,9	70,3 $\pm$ 9,7	65,6 $\pm$ 9,3	-7,9 $\pm$ 12,9	66 $\pm$ 8,6	63,8 $\pm$ 10,3	-2,9 $\pm$ 12,2		ns	
Health perception	47,4 $\pm$ 13,5	56,6 $\pm$ 13,5	7,9 $\pm$ 10*	45,9 $\pm$ 12,7	61,8 $\pm$ 12,3	13,4 $\pm$ 12,5***	63,4 $\pm$ 13,8	64,9 $\pm$ 11	2,5 $\pm$ 7,9	NOV-EXP***	*	NOVICE-EXP**
Sleep (insomnia)	8,9 $\pm$ 4,9	7,7 $\pm$ 4,6	-0,5 $\pm$ 3	9,1 $\pm$ 4,7	6,1 $\pm$ 3,8	-3 $\pm$ 3,5***	6,3 $\pm$ 3,4	52 $\pm$ 3,4	-1,3 $\pm$ 2,6t		ns	
Sleep (somnia)	7,5 $\pm$ 3,3	8,6 $\pm$ 3,6	0,5 $\pm$ 2,5	8 $\pm$ 3,2	7 $\pm$ 2,7	-0,7 $\pm$ 2,5	6,5 $\pm$ 3,4	6,3 $\pm$ 3,4	-0,4 $\pm$ 2,7		ns	
Bad eating habits	1,2 $\pm$ 0,8	0,5 $\pm$ 0,5	-0,2 $\pm$ 0,4	1 $\pm$ 0,9	0,5 $\pm$ 0,6	-0,5 $\pm$ 0,7**	0,9 $\pm$ 0,6	0,6 $\pm$ 0,6	-0,4 $\pm$ 0,6**		ns	
Worksite well-being	7,4 $\pm$ 1	7 $\pm$ 1,2	0 $\pm$ 1,3	7,3 $\pm$ 1,1	7,4 $\pm$ 1,1	0 $\pm$ 1,4	7,4 $\pm$ 1,1	7,3 $\pm$ 0,9	-0,3 $\pm$ 1		ns	
Pain	0,8 $\pm$ 0,9	0,5 $\pm$ 0,5	-0,2 $\pm$ 0,5	1 $\pm$ 1	0,6 $\pm$ 0,7	-0,2 $\pm$ 0,5	0,5 $\pm$ 0,6	0,4 $\pm$ 0,4	-0,2 $\pm$ 0,6		ns	

\*p<0.05; \*\*p<0.01; \*\*\*p<0.001; t: tendency; ANOVA: Analyze of Variance;  $\Delta$ : Delta

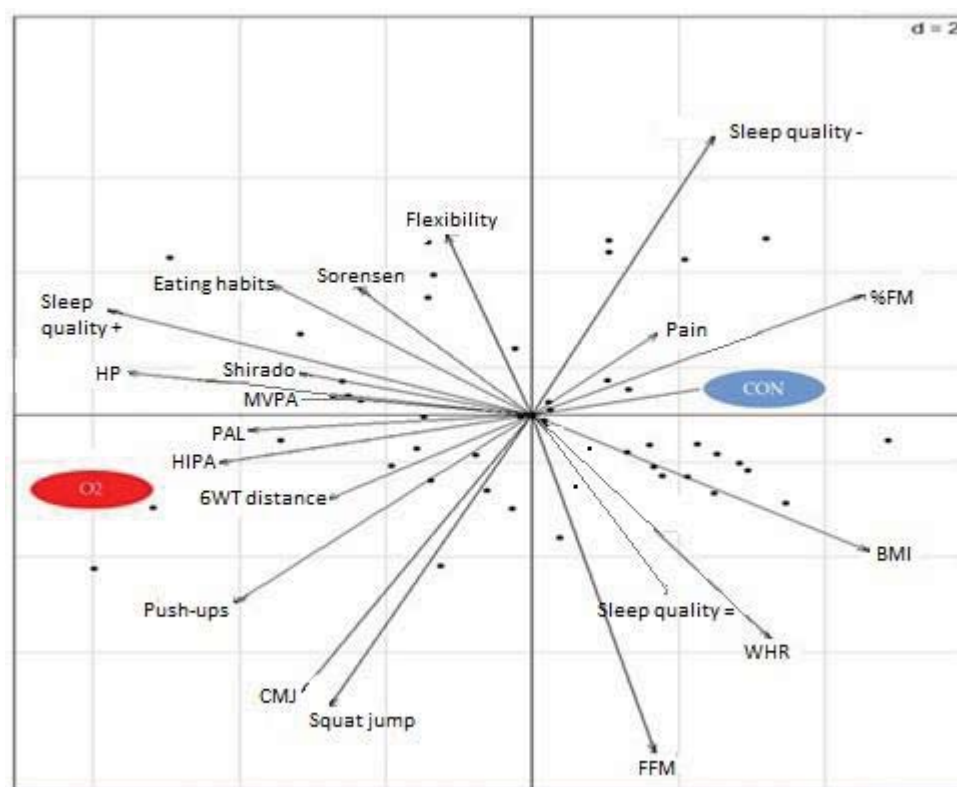


Figure 1: Multidimensional analysis of mixed data

(O2: Oxygen group; CON: Control group; FFM: fat free mass; WHR: waist hip report; BMI: body mass index; FM: fat mass; HP: health perception; PAL: physical activity level; MVPA: moderate to vigorous physical activity; HIPA: high intensity physical activity; 6WT distance: 6 minute walk test; CMJ: counter movement jump; Sleep quality +: good quality of sleep; Sleep quality =: moderate quality of sleep; Sleep quality -: poor sleep quality; Eating behaviors: good eating habits ).

The multidimensional analysis (Figure 1), illustrates the associations between the different parameters studied. As mentioned in the statistical description, T0 only was considered in this analysis (where the NOV and CON groups are computed).

According to this approach, it appears that being part of the EXP group is strongly associated with better performance during functional tests (Shirado and Sorensen, 6MWT, push-ups or vertical jumps). The EXP also shows good sleep quality, good health perception and higher level of physical activity. Conversely, participants in the CON group show higher values of fat

mass, BMI, waist to hip ratio/hip circumference, but also more severe pain and poor sleep quality.

#### **g. Discussion**

While public health policies encourage higher physical activity level and try to reduce sedentary behaviors at any age, workplaces have been pointed out as pertinent and interesting settings to favor physical activity (Dugdill, Brettle et al. 2008). Studies remain however contradictory with some authors showing positive effects of physical activity programs implemented inside companies (Katzmarzyk and Janssen 2004; Oldridge 2008; Anderson, Quinn et al. 2009); while others obtained less convincing results (Rongen, Robroek et al. 2013). According to a recent meta-analysis, such discrepancies between studies can be explained by a deep lack of methodological quality, making any definitive conclusion difficult (Dishman, Oldenburg et al. 1998). Moreover, most of the studies conducted so far in this area focused their analysis on specific health indicators and we were not able of finding any work questioning the impacts of workplace interventions on overall health.

The main aim of the present pilot work was to question the efficacy of an in-site physical activity program, and its evaluation among tertiary employees, comparing experienced and novice participants (including a control group with no intervention). Interestingly, this is the first study to assess the effects of such an intervention on overall health using a large number of physical and psychological indicators.

Although the present results indicate that a 5-month in-site physical activity program improves overall health among tertiary employees, it also showed that most of the health

indicators under study were still improved in experienced participants. Interestingly, the CON group also shows a significant increase of its physical activity level, Fat-Free Mass, 6MWT performance and health perception, which might suggest the ability of such studies to make all the participants (even the CON group) concerned about their health and cause a change on their daily habits.

The results for anthropometric measurements and body composition through mixed models showed significant differences in waist circumference between the CON and NOV group and between CON and EXP. Regarding fat mass, a time effect between T0 and T1 with a significant difference for NOV and EXP has been found. These results agree with the current literature. It has been repeatedly shown that a regular physical activity practice could be associated with a reduction in waist circumference (Dishman, Oldenburg et al. 1998; Dugdill, Brettell et al. 2008; Anderson, Quinn et al. 2009; Verweij, Coffeng et al. 2011). Furthermore, Verweij et al have shown that worksite intervention whose main aim was to increase employees' physical activity level was able to reduce waist circumference (Verweij, Coffeng et al. 2011). However, body composition was not measured in the majority of these studies. Body composition measurement is a strength of the present protocol, especially since we used a BIA device that has been recently shown to provide satisfactory results compared with DXA in adults (Verney, Schwartz et al. 2015). On the other hand, Verney et al. showed that the adiposity index proposed by this device was not a reliable proxy to assess central adiposity (Verney, Schwartz et al. 2015), which is a measure of particular interest due to its implication in the development of metabolic complications. Waist circumference was however assessed to estimate central body fat. Although no significant results were achieved for most of these parameters, our multidimensional analysis emphasizes the positive association between these anthropometric and body composition indicators and the

control group, suggesting the beneficial effect of the intervention on these parameters. Moreover, it has already been shown that a multi-week physical activity program (24 weeks with a regular program) and seminar about general health education can reduce principally waist circumference and body mass index (Atlantis, Chow et al. 2006).

Our analysis also revealed better performances in the NOV and EXP group for most of the functional tests. The distance covered during the 6-minute walk test, performance during the Sorensen test, Shirado test, jump tests and the number of push-ups realized were higher on NOV and EXP groups. There was however not significant difference for the handgrip test, flexibility or balance test between groups. Once more, these results confirmed that engaging in a regular physical activity program has beneficial effects on physical fitness and motor skills; as previously shown in the literature. Tammelin et al. (Tammelin, Nayha et al. 2002) compared two groups of workers (sedentary employees and less sedentary employees), and shown that the least sedentary employees presented better physical abilities (Tammelin, Nayha et al. 2002). However, it remains important to consider the exact nature for each employee job. In fact, in 2003, Ruzic et al., showed that the physically hardship of job and fatigue could be a limiting factor in the improvement of physical capacity business (Ruzic, Heimer et al. 2003). Again, our multidimensional analysis confirms these results as it shows that most of the performed functional tests are positively associated with the engagement in the EXP group (association in the same half of the graph, and sometimes even the same quarter).

Regarding the questionnaire, physical activity level was increased for CON and NOV with a greater significance for NOV. These results are mainly explained by the activities proposed within the intervention. Certainly, the delta parameter was significantly higher in the NOV

group compared with the EXP group, which is explained by the introduction of physical activity in the NOV group. Significant differences between the two groups for the level of physical activity corresponded essentially to the different activities proposed as part of the Oxygen program. This explain why the level of total physical activity was significantly higher before intervention in EXP than CON and NOV, the difference being associated with achieving or not the Oxygen sessions according to the groups. These results agree with the literature which has repeatedly shown that physical activity programs at workplace help to raise the level of total physical activity (Dishman, Oldenburg et al. 1998; Conn, Hafdahl et al. 2009; Hutchinson and Wilson 2012), which has been clearly underlined by Dishman et al. in their meta-analysis (Dishman, Oldenburg et al. 1998). Interestingly, our result show not groups difference of intervention effect in terms of sedentary time. While the use of a self-reported questionnaire might in part explain such a result, the fact that our study only enrolled tertiary workers that by definition spend a large part of their time seated might also explain this lack of difference. Further studies are then needed using better methods to assess sedentary behaviors in such a population.

The present work is to our knowledge the first to question the effect of physical activity on health perception until now. According to our results, individuals who practice a regular physical activity present a better perception of their health. This is consistent with the study by Chen et al., 2015 who showed a reduced stress and anxiety level in response to a physical activity intervention in employees of state agencies (Chen, Hannon et al. 2015).

Mixed models have not showed significant difference in terms of eating habits. However, the literature has already shown that engagement in regular physical activity allowed a significant improvement in eating behaviors (Maes, Van Cauwenberghe et al. 2012). But this

last study compared the same group of subjects before and after a 6-month physical activity program while we compared different interventional groups (CON vs NOV vs EXP), which can contribute to explain our different results.

One of the main interests for companies in implementing on-site physical activity programs, it is to reduce risk-related pain. Using specific questionnaires, we also assessed pain felt by employees, with especial focus on back and neck, both areas are particularly relevant when it comes to tertiary employees. Although it does not reach level of significance, our results indicate lower scores for neck and back pain in people that have been engaged in the Oxygen program (both NOV and EXP) compared with people in the control group. This is confirmed by our multidimensional analysis showing a positive association between the CON group and the high values of pain: variables lying in the same quarter of the graph which shows the importance of the association. Again, this agrees with the current available evidences, that already showed the positive effect of such programs on pain management, and especially the intensity of the pain felt, on the workforce (Marchand, Myhre et al. 2015). The use of questionnaires to assess pain is certainly a methodological issue in the present work, making difficult to obtain specific and more detailed results.

Furthermore, it has been showed that physical activity can improve overall sleep quality (decrease sleep latency, early waking, insomnia, and increase quality of sleep) (Atkinson and Davenne 2007). The use of self-reported questionnaires (although validated) to assess sleep quality might also explain the lack of significant results. However, we can still observe rather pronounced differences between groups with better values for NOV and EXP. Once again, the fact that these results are no significant may be explained by the disparity that exists in our sample. Although, the sample size and heterogeneity don't allow to show statistically



significant differences, multidimensional analysis graphically illustrates very clearly the association between the practice of the Oxygen program and "good" sleep, unlike what it was observed in the CON group.

Interestingly, even though our results showed better performances or improvements in the two intervention groups (NOV and EXP), a particular focus has to be done on the control group. Indeed, individuals in the control group who show interesting improvements on some of the parameters, despite absence of intervention. For instance, we can see an increase of fat free mass, distance covered during the 6-minute walk test, level of physical activity and health perception. These positive effects remain modest compared with what has been found in the NOV or EXP groups but display interesting indications showing the impact of participation in a study. Many studies conducted over the last fifty years highlight the impact of the "placebo" process or the "CON" group. Similarly, there are psychological or psychophysiological effects accompanying a participation in a study. Usually, this reaction is favorable, which might explain, the improvement of participants in the CON group of our study. This clearly joins up with the previously described mere-measurement effect suggesting behavioral changes in individuals without intervention or specific advice, but just as they are part of measurements campaigns, which can explain the results observed in this work in the control group [62].

Although this is a pilot project, some limitations have to be considered when interpreting the results, such as low number of subjects, tools used and heterogeneity between and within groups (i.e. gender distribution in groups, study time). Moreover, even though we used validated field tests, more objective measurement of the physical activity level could have been used, i.e. using accelerometers. In addition, we could have taken measures on

different times and not just at 5 months. Importantly, although some participants gave up before the end of the program (as previously pointed), our complementary statistical approaches underline the accuracy of our results and reinforce our conclusions regarding such an intervention among tertiary employees.

## **h. Conclusion**

To conclude, this pilot study underlines the beneficial effects of work-site physical activity programs proposed to tertiary employees on overall health and the feasibility of its design. Although this is the first study to enroll both experimented and novice participants, further studies are now needed using larger sample sizes and more objective methods.

Moreover, it would be interesting and necessary to develop a theoretical model entailing and connecting some of the study behavioral and physiological outcomes in the context of workplace physical activity programs. This would require involving practitioners and researchers together in the design and elaboration of new studies and programs.

## 2. Etude 2

Health and fitness benefits but low adherence rate: effect of a 10-month onsite physical activity program among tertiary employees

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## a. Résumé

**Objectif:** Evaluer les effets d'un programme d'activité physique structuré de 10 mois en entreprise sur les indicateurs de santé globaux chez des salariés du secteur tertiaire.

**Méthode:** 224 employés ont suivi un programme d'activité physique de 10 mois sur le lieu de travail. La santé globale a été évaluée au départ, à 5 mois et à la fin de l'intervention.

**Résultats:** Le pourcentage de masse grasse a diminué significativement. Un effet temps a montré une amélioration pour les pompes, le gainage abdominal, la souplesse, la fréquence cardiaque après l'exercice, la fréquence cardiaque 30 secondes après et 60 secondes après la fin de l'exercice. L'anxiété, la dépression et les habitudes alimentaires se sont également améliorées. Au total, 45% des participants ont terminé le programme entièrement.

**Conclusion:** Bien qu'un programme d'activité physique structure en entreprise montre des indicateurs de santé améliorés, l'adhésion demeure une préoccupation et nécessite que des spécialistes élaborent de nouvelles stratégies.

**Mots-clés:** activité physique, santé au travail, condition physique, salariés tertiaires, entreprise.

## **b. Abstract**

**Objective:** To assess the effects of a 10-month structured physical activity intervention implemented within the workplace on overall health indicators among tertiary (office workers) employees.

**Methods:** In this quasi-experimental study, 224 employees followed a 10-month worksite physical activity program. Overall health was assessed at baseline, after 5 months and by the end of the intervention.

**Results:** Fat mass percentage decreased significantly. There was a time effect favoring push-ups, abdominal strength, flexibility, heart rate post exercise, heart rate +30 seconds and heart rate +60 seconds post-exercise. Anxiety, depression and eating habits also improved. In total, 45% of participants completed the whole intervention.

**Conclusion:** Although a structured on-site physical activity program supports improved health indicators, adherence remains a concern and requires specialists to develop new strategies.

**Key words:** physical activity, occupational health, physical fitness, tertiary employees, worksite.

### c. Introduction

Over the past century, our societies have faced increasing and worrying declines in population's physical activity levels, mainly due to an automation of our daily living and occupational activities (Ng and Popkin 2012). Despite the clearly recognized beneficial effects of physical activity on cardiovascular (Jeon, Lokken et al. 2007), functional (Genin, Degoutte et al. 2017), social and mental health (Blake, Mo et al. 2009); only a small proportion of adults engage in adequate physical activity (Dugdill 2008). Some European studies estimate that two-thirds of adult populations do not achieve the recommended physical activity levels (Malik, Blake et al. 2014).

Other data from the UK reveal that only 39% of men and 29% of women comply with government recommendations on physical activity (NHS 2008). While the lack of physical activity remains a public health concern, national and international strategies are required to create a conducive culture, encouraging regular physical activity.

The “tertiarisation” of our societies (relating to the increasing dominance of our tertiary sectors and declines in manual and physical occupations) has favored both physical inactivity (with the automation of occupational tasks reducing human efforts) and sedentariness (with an increasing time spent seated in front of a computer screen). Indeed, the prevalence of sedentary professions increased by 20% in the United States between 1960 and 2008, with a concomitant decline in physically active ones (Church, Thomas et al. 2011).

In France, working adults spend about 10 hours a day sitting on working days (with at least 4 hours at work) and approximately 7.5 sitting hours a day on non-working days; generating a positive association between the time spent sedentary at work and sedentary behaviors

outside work (Saidj, Menai et al. 2015). However, due to the important amount of time employees spend at work, workplaces have been recently suggested as a new strategic opportunity to promote daily physical activity and reduce sedentary behaviors. Moreover, Dugdill and colleagues suggested workplaces as ideal opportunities to tackle recurrent barriers to physical activity such as the lack of time and proximity (Dugdill 2008); facilitating physical activity access to individuals who might not be active in other settings (associations or gyms), and using peer networks and employers' incentives (Green 1988). While employers are increasingly encouraged to play a key role in the promotion of working adults' health and well-being (NHS 2008; World Health Organization 2010), it is possible that favoring employees' good health will also reduce a company's absenteeism, and ideally, increase workplace productivity (Kuoppala, Lamminpaa et al. 2008).

Collectively, these data promote the implementation of worksite interventions designed to increase individuals' physical activity levels and reduce the time spent in sedentary behaviors. However, the majority of the available evidence involves interventions that tend to reduce sedentary behaviors through the use of standing desks or active breaks (Bergouignan, Legget et al. 2016; Baker, Coenen et al. 2018).

There is also some social behavior theory evidence investigating sensitization methods to encourage physical activity (text messages, group discussions, among others) (Winkler, Chastin et al. 2018). Fewer studies have implemented on-site structured physical activity programs. Among these, was a one-year study, using motivation group strategies during meetings and workshops to promote physical activity among employees (Aittasalo, Livson et al. 2017). Other researchers have used communication strategies such as regular newsletters, to promote the beneficial effects of walking (Lin, Hong et al. 2018). More recently, studies aiming at replacing sedentary with more active time have been conducted.

Alkhajah et al., requested office workers aged 20 to 65 years to use sit-to-stand workstations during three months, with a goal of reducing sitting time (Alkhajah, Reeves et al. 2012). Although some studies have questioned the effects of structured physical exercise sessions implemented within workplaces (Justesen, Sogaard et al. 2017; Fang, Huang et al. 2018), there are often limitations to the evaluation of the interventions that include reduced sample size, limited number of measured outcomes, and short limited durations.

In 2009, Pedersen and colleagues conducted one of the first interventions targeting structured onsite physical activity to employees. The one-year intervention comprised one hour per week of various physical activity modalities (e.g. steppers, punch bags, Nordic walking). Results demonstrated decreased fat mass percentage and reduced back and shoulder pain among 549 office workers (Pedersen, Blangsted et al. 2009). More recently, Vileva et al. implemented a four-month onsite physical activity program comprising 15 minutes of muscular endurance that was performed five times a week. Similarly, results showed improved body composition and overall fitness among the employees who followed the program compared with a control group (Vilela, Benedito Silva et al. 2015). Also, fat mass percentage and physical activity levels showed improvements in workers who engaged in three 15-minute sessions per week of stretching exercises conducted within their workplace over a three month period (Grande, Silva et al. 2014). Lastly, two worksite sessions per week combining resistance and aerobic exercises (for 5 months) showed beneficial effects on body composition, overall fitness, health perception, sleep quality, pain, eating habits and physical activity level among office workers spending about 7 hours per day seated in front of a computer screen (Genin, Degoutte et al. 2017).

While studies targeting specific subgroups of employees at risk or concerned by chronic disease have been suggested as necessary (Conn, Hafdahl et al. 2009), Fang and



collaborators have recently pointed out that a one-year physical activity program comprising three sessions (of 60 minutes each) per week in overweight employees reduced their risk factors for metabolic syndrome; concomitantly improving their overall fitness, workplace relationships, job satisfaction and quality of life (Fang, Huang et al. 2018).

Although these studies collectively suggest the beneficial effects of onsite physical activity programs, their designs and methodological approaches could be improved due to limitations such as reduced sample size, short term interventions, lack of engagement monitoring, inadequate physical activity quantification, and limited rather than comprehensive health related outcomes (Conn, Hafdahl et al. 2009). Several systematic reviews and meta-analyses indeed report a weak effect of workplace health promotion programs; an important heterogeneity of the observed results, and a lack of statistical power due to relatively small sample sizes (Rongen, Robroek et al. 2013) (Proper, Koning et al. 2003; Conn, Hafdahl et al. 2009).

The aim of the present study was to assess the effects of a 10-month structured physical activity intervention implemented within the workplace on overall health indicators (fitness, quality of life, health perception, sleep, pain, anxiety and depression) in a large group of tertiary employees.

#### **d. Material and methods**

##### *Participants*

A total of 224 office employees (tertiary workers) from two local companies participated in the study (162 females, 60 males; mean  $\pm$  standard deviation age: 43.8 $\pm$ 10 years; body mass:

67.3±13.3 kg; BMI: 24±3.7 kg/m<sup>2</sup>). Participants were approached through their employers' internal network providing information via regular emails to all the employees. To be included the participants were required to: i) be office workers; ii) show no contraindications to physical activity; and iii) be free of any medication that could interfere with the study outcomes. All participants received information sheets and signed consent forms as requested by ethical authorities (Local Human Protection Committee, CPP Sud Est IV).

### *Design*

Prior to inclusion in the study, the volunteers' pending participation was approved by a physician in order to ensure their ability to complete the entire protocol. Then, a screening session occurred in September 2016 in which the participants were asked to complete several questionnaires (health perception, eating habits, worksite well-being, sleep quality, anxiety, depression and pain), anthropometric measurements were performed, their body composition was assessed and their physical fitness was evaluated. Screenings were conducted by the same experimenter at worksite and during work time. All these measurements were repeated at the mid-point of study five months later (February, 2017) and at the end, at ten months (June, 2017).

### *Anthropometric measurements and body composition*

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Both mass and height were obtained at the same time of the day for the same participant, and not in the fasting state. Body Mass Index (BMI) was calculated as body mass (kg) divided by height

squared (m<sup>2</sup>). All the anthropometric measures were performed in accordance with the Anthropometric Standardization Reference Manual (Lohman 1988). Body composition was estimated using bioelectrical impedance analysis, performed with the Tanita MC780 multi frequency segmental body composition analyzer. This analyzer consists in a stand-alone unit onto which the participant stepped in bare feet using the standard mode. Information concerning the participant (age, gender and height) was manually entered by the researcher. Once body mass has been assessed by the scale, the participant had to hold fixed straps with both hands (alongside the body) during the impedance measure (Hand to foot BIA). A full segmental analysis was performed in less than 20 seconds.

Total body fat, total fat-free mass and body water were reported by the researcher into an excel sheet for statistical treatment. The newly developed BIA analyzer was recently validated in healthy adults (Verney, Schwartz et al. 2015).

### *Well-being, Quality of Life and Health Perception*

Well-being and quality of life at work were assessed using the Worksite Well-being and Quality of Life questionnaire, specifically designed and validated for occupational health studies (Carton 2015).

The participants were asked to rate statements describing well-being state at work (e.g. “I’m actually feeling distressed while at work”) using visual analogue scales ranging from “not at all” to “absolutely”.

All participants were also asked to complete the Health Perception Scale that is a short self-administered questionnaire designed to explore their perception of health (Garnier, Gaubert et al. 2013). Six criteria healthy balanced diet, (4) perceived sleep quality, (5) perceived

stress level, and (6) perceived general health. A 10-point scale from 1 (not at all) to 10 (very much) was used to assess each item. The six individual scores were computed to obtain a global score for health perception.

### *Sleep quality*

The Pittsburgh Sleep Quality Index (PSQI) is a self-rated questionnaire assessing sleep quality and disturbances over a 1-month period. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction.

The sum of scores for these seven components yields one global score. Previously, clinical and clinimetric properties of the PSQI were assessed over an 18-month period with "good" sleepers and "poor" sleepers (Buysse, Hall et al. 2008).

### *Pain*

Pain was evaluated using the Nordic questionnaire that is a standardized and validated questionnaire typically used by occupational health practitioners to detect musculoskeletal pain (Roquelaure, Ha et al. 2006). The questions concentrate on symptoms most often encountered in an occupational setting focusing on work-activities specific musculoskeletal symptoms. The questions are forced choice variants that might be either self-administered or used in interviews, and in the present study, the questionnaire was self-administrated (Kuorinka, Jonsson et al. 1987).

### *Eating Behaviors*

Eating habits were collected using the self-administrated Eating Habits Questionnaire” (Pradhan, Taylor et al. 2013; Thivel, Aucouturier et al. 2013), commonly used in clinical routine and research.

Emphasis was placed on the frequency of breakfast, snacking, tendency for extra helping during meals, and the type of beverages consumed.

One question was asked in relation to each of these specific eating habits. Each item was clearly explained, and all the questions were followed by predetermined responses to facilitate comprehension (i.e., “Do you eat breakfast? Every Day –Often - Sometimes – Never”; “Do you snack between meals? Every Day– Often - Sometimes – Never”; “Do you have tendency to have extra-helping during meals? Every Day – Often- Sometimes –Never”; “Which kind of drink do you consume when you are thirsty? Water - Sugar-sweetened beverage”).

### *Anxiety and depression*

Anxiety and depression were evaluated using a self-assessment scale that was found to be a reliable instrument for detecting states of depression and anxiety (Zigmond and Snaith 1983).

The anxiety and depressive subscales were also shown to be valid for the measurement of the severity of emotional disorders. Both the Depression and Anxiety scales provide scores from 0 to 21, with 0 representing the absence of depression or anxiety and 21 representing a very high level for both.

### *Aerobic fitness*

The step test was performed on a stool that had a height of 16.25 inches (41.3 cm) for men and 11.8 inches (30cm) for women. Stepping up and down was required for a total duration of 6 minutes at the rate of 24 cycles per minute, which was set by a metronome. Participants were asked to wear a heart rate monitor (Polar Electro Inc, Lake Success; USA) during the test and heart rate was recorded at the end of the 6 minutes, 30 seconds and 1 minute after the end of the test. This test has been found reliable in healthy individuals and it is highly reproducible (Chatterjee, Chatterjee et al. 2004).

### *Muscle function*

Upper limb muscle strength was assessed using a handgrip dynamometer on the dominant hand, as a non-invasive estimate of muscle strength of upper limbs, well suitable for clinical use (Norman, Stobaus et al. 2011). The participants were also asked to perform a maximal number of push-ups (knees on the floor) while simultaneously complying to an imposed frequency. The test stopped once they were unable to maintain this cadence or had difficulty to maintain the correct position (Marcolin, Petrone et al. 2015; Hwang, Kwon et al. 2017). Lower limb muscle strength was assessed using a Counter Movement Jump (CMJ) using the Optojump technology (Microgate SRL, Rome, Italy) (Kockum and Heijne 2015). The Shirado test was used to assess the static endurance of the abdominal muscles (Fransoo 2009) and the Sorensen test to assess back strength and the endurance of all the muscles involved in extension of the trunk (Demoulin, Vanderthommen et al. 2006).

*Flexibility.* The sit and reach test is a common estimate of flexibility, and specifically measures the flexibility of the lower back and hamstring muscles (Mayorga-Vega, Merino-

Marban et al. 2014). This test involves sitting on the floor with legs stretched out straight ahead. Shoes should be removed. The soles of the feet are placed flat against the box. Both knees should be locked and pressed flat to the floor. Where appropriate, the tester may assist by gently holding the knees down. With the palms facing downwards, and the hands on top of each other or side by side, the participant reaches forward along the measuring line as far as possible. After some practice reaches, the participant reaches out and holds that position for at least one-two seconds while the distance is recorded. The tester also needs to ensure there are no jerky movements (Wells 1952).

*Balance.* A stabilometric platform was used to assess postural stability. Participants were asked to stand barefoot in a relaxed posture, on a bipedal standing position on the force platform with feet in a fixed and parallel position (the distance between their heels was fixed to the pelvis width). Four measurements were performed by participants in the following standing positions: two feet with open eyes, two feet with eyes closed, the dominant foot with open eyes and the dominant foot with eyes closed (Cimolin, Cau et al. 2017).

### *On-site physical activity intervention*

The intervention consisted of two training sessions per week for a total of 10 months. The intervention was conducted within the participants' worksite using physical activity facilities provided by the companies to their employees. The participants were free to choose between the eighteen different physical activities proposed, such as muscle strengthening, stretching, cardiorespiratory or team sport. However, they were asked to perform at least one muscle strengthening (weight machines) and one cardiorespiratory session (such as latino dance, step aerobics, cycling, boxercise) per week. Each session was supervised by a

professional and lasted 45 minutes. The participants had access to these facilities at any time of the day to facilitate their engagement. The attendance of the participants during the intervention was recorded using a computerized access to the sport facilities (each participant had to clock in each time).

#### **e. Statistical considerations**

All analyses were performed using Statview (version 4 for window). Statistical analyses were based on a two-sided type I error of  $\alpha=5\%$ . Baseline participants' characteristics were presented as the mean  $\pm$  standard deviation (SD). Assumption of normality was assessed by using the Smirnov-Kolmogorov test. To analyze repeated data collections, ANOVAs with repeated measures were used. When omnibus p-value was less than 0.05, a Tukey-Kramer post-hoc test was performed to take into account the multiple comparisons and the possibility of an inflated the type I error. When assumption of normality was not reached, random-effects models were performed taking into account between and within participant variability (as random-effect).



## f. Results

**Table 1.** Baseline and evolution of anthropometry, body composition parameters and functional tests.

	T0	T1	T2	ANOVA	T0 vs T1	T0 vs T2	T1 vs T2	Posthoc
Weight (kg)	66.1±12.7	66.3±13	66±12.8	ns	0,09 [-0,2;0,4]	0,14 [-1,9;0,5]	0,05 [-0,3;0,4]	
BMI (kg/m <sup>2</sup> )	23.5±3.5	23.5±3.6	23.4±3.6	ns	0,07 [-0,2;0,3]	0,15 [-0,2;0,5]	0,08 [-0,3;0,4]	
WC (cm)	84.1±11.3	84.6±11.4	84.4±11.5	ns	-0,008 [-0,3;0,3]	0,02 [-0,3;0,3]	0,03 [-0,3;0,4]	
FM (%)	24.3±7.5	23.9±7.7	23.5±8	*	0,09 [-0,2;0,4]	0,4 [0,09;0,7]	0,3 [-0,01;0,7]	T0-T2**
FFM (kg)	47.3±9.5	47.5±9.1	47.4±9.4	ns	0,07 [-0,2;0,4]	-0,02 [-0,3;0,3]	-0,09 [-0,4;0,25]	
Central adiposity Index	5.3±3.3	5.3±3.4	5.3±3.3	ns	0,05 [-0,2;0,3]	0,04 [-0,3;0,4]	-0,01 [-0,4;0,3]	
Rest heart rate (bpm)	69.9±11.7	70.1±11	69.9±10.7	ns	-0,1 [-0,4;0,1]	-0,003 [-0,3;0,3]	0,16 [-0,2;0,5]	
Heart rate (bpm)	146.5±19.1	138.3±15.5	129.9±18.9	***	0,5 [0,2;0,8]	0,8 [0,5;1,2]	0,3 [-0,05;0,6]	T0-T1*** / T0-T2*** / T1-T2***
Heart rate +30 (bpm)	126.9±20.5	119.4±17.3	112.4±20.6	***	0,3 [-0,02;0,6]	0,5 [0,1;0,8]	0,2 [-0,1;0,6]	T0-T1*** / T0-T2*** / T1-T2***
Heart rate +60 (bpm)	112.8±20.2	105.6±17.6	99.6±18.8	***	0,3 [0,01;0,6]	0,6 [0,2;0,9]	0,2 [-0,01;0,6]	T0-T1*** / T0-T2*** / T1-T2***
RPE	4.4±1.8	3.9±1.8	3.8±1.8	**	0,5 [0,2;0,8]	0,6 [0,2;0,9]	0,03 [-0,3;0,3]	T0-T1** / T0-T2***
CMJ (cm)	19.6±5.8	20±6.7	19.8±5.7	ns	-0,2 [-0,5;0,1]	-0,2 [-0,5;0,1]	-0,03 [-0,4;0,3]	
Handgrip (kg)	36.1±27.5	35.1±9.9	35.1±9.7	ns	-0,07 [-0,4;0,2]	-0,2 [-0,5;0,1]	-0,1 [-0,4;0,2]	
Puch-ups (rep)	26.5±18.2	30.1±17.6	30.2±17.8	***	-0,16 [-0,4;0,14]	-0,3 [-0,6;0,03]	-0,15 [-0,5;0,2]	T0-T1** / T0-T2***
Shirado (sec)	170.9±23.2	170.9±26.3	176.2±19.7	*	-0,07 [-0,3;0,2]	-0,4 [-0,7;-0,09]	-0,4 [-0,7;-0,03]	T0-T2* / T1-T2*
Sorensen (sec)	173.6±19.1	176.5±18.4	175.3±17.5	ns	-0,1 [-0,4;0,1]	-0,3 [-0,6;0,07]	-0,09 [-0,4;0,25]	
Flexibility (cm)	1.9±8.7	4.3±9.4	3.8±8.6	***	-0,3 [-0,6;0,003]	-0,3 [-0,6;0,5]	0,02 [-0,3;0,4]	T0-T1*** / T0-T2***
Romberg index (dp)	165±113.4	177.3±125.8	162.6±185.3	ns	0,02 [-0,2;0,2]	0,09 [-0,1;0,3]	0,1 [-0,1;0,3]	
Romberg index (up)	1213.9±1028.3	925.4±889.1	990±832.2	ns	0,3 [0,1;0,5]	0,3 [0,06;0,5]	-0,03 [-0,3;0,2]	

\*p<0.05; \*\*p<0.01; \*\*\*p<0.001, BMI: Body Mass Index; WC: Waist Circumference; CMJ: Counter Movement Jump; T0: baseline; T1: middle of the 10-month program; T2: end of the 10-month program; bpm: beats per minute; rep: repetition; sec: seconds; up: unipodal; bp: bipodal.

The Table 1 details the results for anthropometric characteristics, body composition and functional tests of the employees. No significant changes in body mass, BMI, waist circumference, fat free mass and central adiposity index were observed during the study. In contrast, the ANOVA showed a loss of fat mass percentage with decreases between T0 and T2 ( $p \leq 0.01$ ). Among the results for functional tests, no change was observed for CMJ, handgrip, back strength and for the Romberg index (balance) ( $p > 0.05$ ). Other physical test results showed a time effect for push-ups, abdominal strength and flexibility. The post-hoc analysis results identified respective improvements between T0-T1 ( $p \leq 0.01$ ) and T0-T2 ( $p \leq 0.001$ ) for push-ups, T0-T2 ( $p \leq 0.05$ ) and T1-T2 ( $p \leq 0.05$ ) for abdominal strength and T0-T1 ( $p \leq 0.001$ ) and T0-T2 ( $p \leq 0.001$ ) for flexibility.

Results from the aerobic fitness showed a significant time effect for heart rate post exercise, specifically, decreases in heart rate +30 seconds and heart rate +60 seconds after exercise ( $p \leq 0.001$ ), but without a change in resting heart rate.

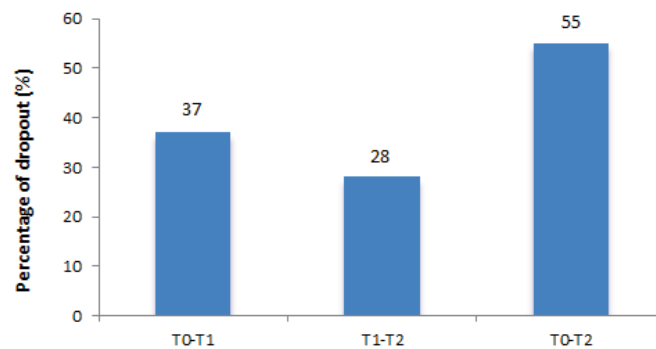
The Table 2 details the results for health perception, sleep, wellbeing, eating habits, anxiety, depression and pain by group. No significant effect of the physical activity (PA) worksite intervention was observed on well-being, pain and sleep quality. Nonetheless, the results showed a significant decrease for total health perception ( $p \leq 0.001$ ), which was attributed to the decrease in the score of item 4 (rest) between T1 and T2 ( $p \leq 0.05$ ). Participants' physical fitness perception was improved between T0-T1 ( $p \leq 0.05$ ) and T0-T2 ( $p \leq 0.05$ ). None of the other items relating to health perceptions generated significance.

The ANOVA showed a time effect for anxiety and depression with a decrease between T1-T2 ( $p \leq 0.001$ ) and T0-T2 ( $p \leq 0.001$ ). Finally, there was a time effect for eating habits denoting improvements between T0-T1 ( $p \leq 0.01$ ) and T0-T2 ( $p \leq 0.001$ ).

**Table 2.** Baseline and evolution of self-reported health perception, sleep, wellbeing, eating habits, anxiety, depression and pain by group.

	T0	T1	T2	ANOVA	T0 vs T1	T0 vs T2	T1 vs T2	Posthoc
Health perception (total)	5.8±1.3	5.9±1.2	4.2±3	***	-0,1 [-0,4;0,13]	-0,1 [-0,4;0,2]	0,009 [-0,3;0,3]	T0-T2*** / T1-T2***
Item 1 (physical fitness)	6.1±1.7	6.5±1.4	6.6±1.8	*	-0,2 [-0,5;0,07]	-0,3 [-0,7;-0,03]	-0,2 [-0,5;0,1]	T0-T1* / T0-T2*
Item 2 (physical appearance)	4.2±1.9	4.3±1.9	4.3±2.1	ns	0,02 [-0,3;0,3]	-0,02 [-0,3;0,3]	-0,04 [-0,4;0,3]	
Item 3 (balanced diet)	6.3±1.9	6.1±1.8	6.4±1.9	ns	-0,03 [-0,3;0,2]	-0,2 [-0,5;0,1]	-0,1 [-0,5;0,2]	
Item 4 (rests)	6.1±2.1	6.5±2.1	5.9±2.4	*	-0,2 [-0,5;0,08]	0,03 [-0, 3;0,3]	0,2 [-0,09;0,6]	T1-T2*
Item 5 (stress)	5.9±2.2	5.9±2.2	5.7±2.4	ns	-0,05 [-0,3;0,2]	0,007 [-0,3;0,3]	0,05 [-0,3;0,4]	
Item 6 (health level)	6.9±1.7	6.9±1.5	6.8±1.8	ns	-0,12 [-0,4;0,2]	-0,08 [-0,4;0,2]	0,04 [-0,3;0,4]	
Sleep quality	6.7±3.4	6.1±3.4	6.4±3.5	ns	0,2 [-0,05;0,5]	0,1 [-0,2;0,4]	-0,09 [-0,4;0,2]	
Eating habits	1.1±0.3	0.9±0.4	0.9±0.3	***	0,3 [0,04;0,6]	0,4 [0,09;0,7]	0,07 [-0,3;0,4]	T0-T1** / T0-T2***
Worksite well-being	7.2±1.3	7.5±1.3	7.3±1.4	ns	-0,08 [-0,4;0,2]	-0,04 [-0,4;0,3]	0,04 [-0,3;0,4]	
Anxiety	6.8±3.3	6.3±3.4	3.9±3.8	***	0,1 [-0,1;0,4]	0,8 [0,5;1,1]	0,7 [0,4;1]	T0-T2*** / T1-T2***
Depression	11.6±1.4	11.6±1.3	7.4±5.8	***	-0,02 [-0,3;0,3]	1 [0,7;1,4]	0,99 [0,7;1,3]	T0-T2*** / T1-T2***
Pain	1.8±1.7	1.7±1.8	1.9±1.9	ns	0,03 [-0,3;0,3]	-0,08 [-0,4;0,2]	-0,1 [-0,4;0,2]	

\*p<0.05; \*\*p<0.01; \*\*\*p<0.001



**Figure 1:** Percentage of dropout (%)

Thirty-seven per cent of participants stopped participating in the program between the first and second measurement times, while an additional 28% ceased before the final study measurement. In total, 55% of the participants did not complete the whole intervention (Figure 1).

#### **g. Discussion**

While public health policies encourage increased physical activity engagement and reduced sedentary behaviors at any age, workplaces are pertinent and interesting settings to promote health related outcomes from physical activity (Dugdill 2008). Currently, the literature is limited by relatively few well-designed and appropriately powered studies that examine the impact of onsite interventions (within-companies) with conflicting results about the physical activity interventions in the workplace with some showing positive (Katzmarzyk and Janssen 2004; Oldridge 2008; Anderson, Quinn et al. 2009) and less convincing results (Rongen, Robroek et al. 2013). A recent meta-analysis concluded that such discrepancies between studies can be explained by the lack of depth in methodological quality, making any

definitive conclusion difficult (Dishman, Oldenburg et al. 1998). Moreover, most of the studies conducted to date in this area have focused their analysis on specific health indicators without proposing a view of the employees' overall health. Available results in the field are somewhat limited to the effects of physical education sessions, encouragement and motivational strategies (Aittasalo, Livson et al. 2017; Puig-Ribera, Bort-Roig et al. 2017), walking meetings (Mackenzie, Goyder et al. 2015) or sedentary breaks (Bergouignan, Legget et al. 2016). Few studies have been custom built, implemented and evaluated the broader impacts of structured aerobic and resistance exercise sessions (Pedersen, Blangsted et al. 2009; Genin, Degoutte et al. 2017).

In this context, the aim of the present work was to assess the effects of a 10-month structured physical activity intervention implemented within the workplace on overall health indicators among tertiary employees. According to our results, two to three supervised sessions of physical exercise per week, performed within the worksite facilities, favor tertiary employees in multiple ways: a reduction in fat mass percentage, increased aerobic and anaerobic fitness parameters, improved habits in eating, rest and fitness, as well as desirable reductions in self-perceptions of depression and anxiety.

Our results showed no significant difference in total body mass and other anthropometric measurements. This result supports previous studies reporting unchanged anthropometric parameters after a one-year program (Lowensteyn, Berberian et al. 2018). However, our results showed maintenance of fat free mass over 10 months accompanied by a significant loss of fat mass percentage. Although favorable body composition results concur with previously published studies of a similar duration (Grande, Silva et al. 2014), Atlantis and colleagues however, found improved body weight and waist circumference after only 24

weeks of an exercise program (comprising aerobic exercise 20 minutes duration 3 days/week + weight-training 30 minutes 2-3 days/week) that was combined with health-related educational seminary among sedentary employees (Atlantis, Chow et al. 2006). This discrepancy can be explained by the fact that more than half of their participants were overweight or obese, while employees in the current study were lean. Also, our objective was more to promote overall health rather than to induce weight loss.

Indeed, our 10-month intervention favored improved overall fitness, particularly improved performances between baseline and T1 for push-ups and flexibility and a greater endurance of the abdominal muscles (using the Shirado test) by the end of the program. Similarly, our participants showed improved aerobic capacities with decreased maximal heart rate and reduced 30- and 60-second post-exercise heart rates by the end of the intervention. These results are in accordance with previously published papers (Vilela, Benedito Silva et al. 2015; Fournier, d'Arripe-Longueville et al. 2017). Vilela and collaborators for instance also showed better flexibility, along with improved sit-up and push-up test performances after a 4 month intervention among chemical plant employees (Vilela, Benedito Silva et al. 2015). Our results are further supported by Ruzic et al. who showed that work-based physical activity programs could favor improved physical fitness among employees with a low work index (as a proxy for the physical demand imposed by occupational tasks) such as tertiary workers, while such improvements remain limited among employees with high work index (Ruzic, Heimer et al. 2003). Others however, have been unable to report any modification of their participants' physical fitness in response to onsite physical activity interventions (Grande, Silva et al. 2014; Lowensteyn, Berberian et al. 2018). Importantly, although Grande and colleagues also conducted their study among tertiary employees, their participants presented challenging characteristics with a higher initial body weight (mean 73 kg) and a higher BMI (above 25

kg/m<sup>2</sup>) defining them as overweight, which could explain such discrepancies (Grande, Silva et al. 2014). Moreover, cardio-respiratory fitness and muscular strength were both demonstrated to be strong predictors of total mortality, cardiovascular mortality and incident cardiovascular disease in both general population and in subjects with chronic disease (Leong, Teo et al. 2015; Tikkanen, Gustafsson et al. 2018).

Alongside with physical fitness and fat mass, our employees also improved anxiety and depression. The available literature repeatedly shows that regular physical activity programs at workplaces help reduce stress and anxiety among employees (Chen, Hannon et al. 2015; Mackenzie, Goyder et al. 2015; Puig-Ribera, Martinez-Lemos et al. 2015; Hallam, Bilsborough et al. 2018; Lowensteyn, Berberian et al. 2018). Indeed, Hallam et collaborators for instance, found that a 100-day challenge of 10,000 steps a day favored a reduction in depression, anxiety and stress among 2000 employees (without describing the type of occupational activities contributing to the 10,000 steps) (Hallam, Bilsborough et al. 2018). In another study, a significant decrease in work stress was observed in response to the integration of short bouts of physical activity into organizational routine (Barr-Anderson, AuYoung et al. 2011). These studies however, relied on intervention that was composed of targeted psychological challenges or work time interruptions. Until the current study, to the best of the authors' knowledge, anxiety and depression had not been evaluated in response to a physical activity program implemented within the workplace.

In the current study, anxiety and depression were significantly reduced, despite the participants not changing their self-perceptions of work-related stress and work-related well-being. Although this might seem contradictory, this result might indicate that regular physical activity, even when implemented inside worksite, can improve overall well-being

without decreasing the employee's work-related stress and welfare. Regular physical activity might help individuals improve their daily well-being without reducing their work-specific related stress and pressure. Further studies seem then necessary to distinctly assess overall and work-specific well-being and comfort among employees. Although it has been shown that regular physical activity and increased quality of life are usually associated with better overall sleep quality (decrease sleep latency, early waking, insomnia, and increase quality of sleep) (Atkinson and Davenne 2007; Sampasa-Kanyinga and Chaput 2017), sleep was not improved in the present work. Despite some evidence of validation (Buysse, Hall et al. 2008), the use of a self-reported questionnaire imposes some limitations of this instrument that mask more objective measures of sleep quality. Our result could also be confounded by the fact that our participants reported a relatively great sleep quality at baseline; providing a plausible explanation for the lack of changes in response to our program.

The literature remains relatively limited in describing the effects of worksite-related physical activity programs on eating patterns. Based on established relationships between physical activity levels, appetite control and eating habits, targeting improved nutrition in sedentary individuals (such as tertiary employees) with uncontrolled appetite regulation and possibly higher daily intakes (Beaulieu, Hopkins et al. 2017) may be a challenge. However, when interventions also increase an individual's physical activity levels, favorable nutritional compensatory responses can be expected (Schubert et al., 2016; Donnelly et al., 2017). Nonetheless, it seems necessary to control eating habits when implementing physical activity intervention. Several studies have reported improved eating patterns in response to regular physical activity programs without focusing on tertiary employees (Ni Mhurchu, Aston et al. 2010; Maes, Van Cauwenberghe et al. 2012). In their work, Johnson et al. for



instance questioned eating habits among tertiary employees and found improved food-related behaviors in response to a web-based prevention program (Johnson, Stolp et al. 2016), details of the impact of physical activity on eating patterns among workers were unclear. Our results showed that eating habits improved after the first 4 months of intervention, without any additional improvement by the end of the 10 months. This result agrees with Johnson et al who also found improved eating patterns during the first 6 months of their intervention without any further modifications. Yet further studies are needed to investigate how regular physical activity can favor rapid adaptations of individuals' eating habits.

While most of the studies conducted to date have assessed pain among employees whose daily tasks require body motion and muscle work (Watanabe, Takahashi et al. 2018), few concern tertiary employees. Although these workers often lack manual tasks, they spend a considerable part of their time seated which might have important musculoskeletal implications, particularly at lumbar, back and neck sites. In their study, Pedersen et al conducted a one year randomized controlled trial with tertiary employees, examining the effects of resistance training and all-round physical exercise sessions performed within workplaces (Pedersen, Blangsted et al. 2009). Their results showed significant reductions of pain symptoms. Using questionnaires, we also assessed pain felt by employees, with a particular focus on the back and neck; both areas being particularly relevant to tertiary employees who spend a large proportion of their time seated. While we did not observe any pain improvement, the use of self-reported questionnaires may explain our results. However, similar to sleep responses the employees in the current study presented with a relatively low levels of pain at baseline. The initial lack of pain most likely explains why we

did not observe any significant changes (the highest pain score being observed within our sample being 3.8 out of 10, which remains indeed low). Once more, the results suggest that onsite physical activity interventions could more specifically consider the employees' profiles in order to maximize health benefits.

Our results also point out the necessity of strategies to target the employees' adherence rate to such programs. Indeed, 1 out of 2 participants did not complete the whole intervention. Adherence may become the key consideration by stakeholders and researchers investing in workplace interventions who must try to understand and address the potential underlying reasons for non-completion. The 55% dropout rate observed here agrees with what is rarely discussed, but usually observed in other similar studies. For example, in their study, Jakobsen et al. asked tertiary employees to exercise five times per week (10-minute sessions) for 10 weeks and observed a dropout rate of 22% (Jakobsen, Sundstrup et al. 2015). Moreover, during their 1-year trial, Pedersen et al. obtained a 48% dropout rate among office workers who exercised 3 times per week (Pedersen, Blangsted et al. 2009) and in another study, 30% of the enrolled participants were found to give up before the end of the intervention (Genin, Degoutte et al. 2017). While such high dropout rates are usually observed, the profile of these participants remains under-explored. In other words, even though most of the studies conducted so far emphasize the positive effects of physical activity among employees, the high dropout rates observed clearly question the reliability and feasibility of onsite structured physical activity programs. Many larger analyses should be conducted to better understand and identify the potential predictive indicators for tertiary employees' adherence to on-site physical activity programs.

Our results obviously have to be interpreted in light of some limitations. The sample size might be considered as one of the limitations, demonstrating the difficulty of recruiting volunteers for such interventions, and reinforcing the need for deeper explorations of the potential specific profile of employees interested in workplace physical activity programs. The use of field testing to assess employees' physical fitness might also be a limitation and more objective methods could be used such as ergometers and direct methods to assess their aerobic capacities (laboratory-based maximal aerobic testing). Obviously the use of BIA to assess body composition is not as accurate as other devices such as dual-x-ray absorptiometry; however BIA offers one of the best alternatives for studies enrolling large samples and remains a reliable and validated tool in healthy adults, as previously described (Verney, Schwartz et al. 2015). The lack of biological data collection might also be pointed out as a potential limitation. Indeed, while Pedersen and collaborators found similar results showing that a 60-minute onsite exercise session per week (training and all-round physical exercise) favored a significant improvement of tertiary employees' physical capacities, they also found improved cardiovascular and metabolic syndrome related-risk factors as an important metabolic health indicator (Pedersen, Blangsted et al. 2009). Finally, the European EPIC cohort study showed significant interactions between PA and BMI in relation to all-cause mortality, with a greater risk reduction due to increased PA level observed in those categorized as normal weight and abdominally lean, and with a markedly reduced risks (-15 to 30%) observed between individuals categorized as inactive and moderately active (Ekelund, Steene-Johannessen et al. 2016). Our participants were abdominally lean, of normal weight, but with a high level of sedentary time, which underlines the significance of our results from a preventive health perspective.

## **h. Conclusion**

While tertiary employees spend a considerable part of their time being sedentary, the current study highlights the beneficial effects of on-site physical activity programs on their overall health. Despite these benefits, it seems that such interventions suffer from a substantial drop-out rate that must lead occupational health specialists to develop new strategies promoting the employees' adhesion. Although the program was theoretically adapted to tertiary workers (on site, individualized, supervised, multi-activities), not all employees participated and about half of them dropped out during the 10-month intervention. Moreover, further studies should focus on addressing sedentary time and increasing light to moderate PA before and/or in addition to structured PA program.

### 3. Etude 3

Effect of work-related sedentary time on overall health profile in active vs  
inactive office workers

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Frontiers

## a. Résumé

**Objectifs :** Bien que des stratégies de santé publique soient développées pour lutter contre la sédentarité et promouvoir l'activité physique, certaines activités professionnelles, en particulier les activités tertiaires, ont été mises en avant pour leur caractère très sédentaire. Même si les entreprises proposent de plus en plus de programmes d'activité physique sur le lieu de travail à destination de leurs employés afin d'améliorer leur niveau d'activité physique, leur temps passé assis reste extrêmement élevé. L'objectif principal de ce travail était de comparer les indicateurs de santé entre les employés du secteur tertiaires actifs et inactifs avec un niveau élevé de sédentarité. Deuxièmement, nous nous sommes interrogés sur les effets d'un programme d'activité physique sur le lieu de travail de 5 mois sur les indicateurs de santé globaux parmi les employés du secteur tertiaire initialement actifs et inactifs.

**Méthode :** Les mesures anthropométriques, la composition corporelle (bioimpédancemétrie), la condition physique (cardiorespiratoire et musculaire), la qualité de vie et la perception de la santé (questionnaire auto-déclaré) ont été évaluées chez 193 employés tertiaires actifs et inactifs avant (T0) et après (T1) un programme d'activité physique de 5 mois sur le lieu de travail, composé de 2 séances d'activité par semaine.

**Résultats :** Les pompes ( $p < 0.001$ ), le gainage dorsal ( $p < 0.001$ ), la masse grasse ( $p < 0.01$ ) et le tour de taille ( $p < 0.05$ ) étaient significativement meilleurs chez les employés actifs au début mais aussi à la fin du programme. La perception de la santé ( $p < 0.001$ ) était significativement différente entre les groupes à T0 mais pas à T1. Aucune différence significative n'a été observée pour la masse maigre, l'IMC, le bien-être au travail, la force musculaire des membres inférieurs et supérieurs. Les variations entre T0 et T1 démontrent que si tous les

paramètres étudiés ont progressé positivement avec le programme de 5 mois, la perception de la santé ( $p<0.001$ ), le gainage dorsal ( $p<0.05$ ) et l'IMC (tendance) ont montré une meilleure progression chez le groupe inactif par rapport aux actifs.

**Conclusion :** Les indicateurs de santé pourraient ne pas être meilleurs chez les employés actifs du secteur tertiaire que chez les employés inactifs, ce qui pourrait être dû au niveau élevé de sédentarité caractérisant leur tâche professionnelle. Un programme d'activité physique structuré dans l'entreprise peut améliorer la santé des employés actifs et inactifs.

**Mots-clés :** employés tertiaires, activité physique, sédentarité, santé, condition physique.

## b. Abstract

**Objective.** While public health strategies are developed to fight sedentary behaviors and promote physical activity, some professional activities, and especially tertiary ones, have been pointed out for their highly sedentary nature. Although workplace physical activity programs are increasingly proposed by companies to their employees in order to increase their physical activity levels, sitting and screen time remain extremely high. The main aim of this work was to compare health indicators between active and inactive tertiary employees with similar high levels of sedentariness. Secondly, we questioned the effects of a 5-month workplace physical activity program on overall health indicators among initially active and inactive tertiary employees.

**Methods.** Anthropometric measurements, body composition (bio-impedance), physical fitness (cardiorespiratory and musculoskeletal fitness) and health-related quality of life and perception of health status (self-reported questionnaires) were assessed among 193 active and inactive tertiary employees before (T0) and after a 5-month workplace physical activity intervention (T1), composed of 2 physical sessions per week.

**Results.** Significant improvements were found in performance of push-ups ( $p<0.001$ ), back muscle strength ( $p<0.001$ ) fat mass ( $p<0.01$ ) and waist circumference ( $p<0.05$ ) in active compared with inactive employees both at baseline and at the end of the program.

Health perception ( $p<0.001$ ) was significantly different between groups at T0 but not at T1. However, no significant difference was observed for fat-free mass, BMI, workplace well-being and lower and upper limbs muscle strength. The variations between T0 and T1 demonstrate that, while all the studied parameters progressed positively during the 5-month program, health perception ( $p<0.001$ ), back muscle strength ( $p<0.05$ ) and BMI



(tendency) showed a significantly higher progression in the inactive compared with the active group.

**Conclusion.** Health indicators might not be improved among active tertiary employees compared with inactive ones, which might be due to the high level of sedentariness characterizing their occupational task. Structured on-site physical activity programs can improve health in both initially active and inactive employees.

**Key words.** Tertiary employees, physical activity, sedentariness, health, fitness.

### c. Introduction

Over the last decades, sedentariness has become one of the largest public health concerns, recognized as one of the main causes of preventable premature mortality. Diaz and collaborators recently highlighted that both the total volume of sedentary time as well as its accrual in prolonged, uninterrupted bouts are associated with increased all-cause of mortality (Diaz, Howard et al. 2017), which has been associated with poor health at all ages, independently of the level of physical activity (Biswas, Oh et al. 2015). It is crucial to clarify that sedentariness is not the same as lack of physical activity, as people can reach the recommended levels of physical activity for their age, yet spend a large amount of their time engaging in sedentary activities (Patel, Bernstein et al. 2010) (Leon-Munoz, Martinez-Gomez et al. 2013). Evidence suggests that the time dedicated to sedentary activities (leisure and work) has increased from 26 to 38 hours per week between 1965 and 2009 in the United States and from 30 to 42 hours between 1960 to 2005 in Great Britain, expressing alarming prospects for 2030 (Ng and Popkin 2012). According to the 2006 national nutrition and health survey (ENNS), 53% of adults aged 18 to 74 (59% of men and 48% of women) spend three hours or more per day (working days and holidays) in front of a screen (television or computer) outside of working hours. Importantly, this proportion progresses with age in both men and women.

When it comes to work-related sedentary time particularly, it appears that the prevalence of sedentary professions increased by 20% in the United States between 1960 and 2008, with a concomitant decline of more “physically active professions” (Ng and Popkin 2012). In France, working adults have been shown to spend on average 9.96h per day sitting on workdays (with at least 4.17h/day seated at work) and 7.58h/day sitting on non-workdays (Saidj,

Menai et al. 2015). Importantly, Saidj and colleagues reported clear associations between the sedentary time at work and the adoption of sedentary behaviors outside work.

Worldwide, public health policies underline the urgent need to create a suitable culture of regular physical activity (Department of Health 2011), where employers are encouraged to play a key role in the promotion of health and well-being among adults of working age (National Center for Chronic Disease Prevention and Health Promotion 2008).

Workplaces represent today an ideal opportunity for new initiatives to promote physical activity. Workplaces could indeed reduce some of the barriers that have been identified to limit the engagement in physical activity, such as lack of time and proximity (Dugdill 2008). Due to the difficulties in changing the habits of populations and to promote physical activity in usual settings (such as associations, gymnasiums, etc.), workplace-based programs might provide a great way to incite employees to increase their activity levels, especially due to the amount of time people spend at their workplace (Green 1988). There is clear evidence that increasing the employees' level of physical activity has beneficial effects on their health, concomitantly reducing health care costs (Golaszewski 2000) and the cost of different treatments for preventable diseases, and decreasing the number of sick leave due to diseases or injuries (Katzmarzyk and Janssen 2004) (Oldridge 2008). Some previous studies have indeed shown that interventions conducted to improve employees' health, may lead to reduced absenteeism and sick leave, while favoring increased productivity (Proper, Koning et al. 2003) (Kuoppala, Lamminpaa et al. 2008).

Although some controlled and well-designed studies have found that workplace-based physical activity interventions can improve general health, physical activity levels (Proper, Koning et al. 2003) (Conn, Hafdahl et al. 2009), weight status (Ni Mhurchu, Aston et al. 2010)

and may have positive effects on eating behavior among employees (Maes, Van Cauwenberghe et al. 2012); a recent systematic review identified some limitations of such interventions, due to large inter-individual heterogeneity (Rongen, Robroek et al. 2013). At the same time, a recent study conducted in 2017, underlined the beneficial effects of worksite physical activity programs proposed to tertiary employees on overall health (Genin, Degoutte et al. 2017). Although this pilot study was the first to our knowledge to enroll both experimented (active individuals, already regular users of their companies' physical facilities) and novice (inactive before the intervention) participants, further studies are now needed using larger sample sizes and more objective methods. Moreover, while the studies conducted so far mainly focused on increasing the level of physical activity of workers, tertiary employees remain highly sedentary due to the static nature of their work, which might have deleterious effects, independently of their physical activity levels. Some interesting studies effectively suggest that long periods of sedentary behaviors increase the risk of cardiovascular diseases, type 2 diabetes, some cancers and obesity, among other conditions, even in individuals reaching recommended levels of physical activity (Biswas, Oh et al. 2015).

While it remains evident that workplace interventions have to be conducted to favor healthy active living among tertiary employees, the sedentary nature of such professional activities must be considered. The first aim of the present study was to compare overall health indicators among physically active and inactive tertiary employees, showing a high level of sedentariness. Secondly, we assessed the effects of a 5-month physical activity workplace intervention on overall health indicators between sedentary previously active and newly active tertiary employees.

#### **d. Material and methods**

##### *Participants and design*

A total of 193 office employees (tertiary workers; 83 females, 110 males; age:  $44.2 \pm 9.8$  years; weight:  $72.6 \pm 14.7$  kg; BMI:  $24.5 \pm 3.8$  kg/m<sup>2</sup>) took part in this quasi-experimental study. Participants were approached and recruited through the manufacturer internal network, thanks to various informative announcements to the employees. After a medical inclusion to control for their ability to complete the whole study, anthropometric measurements and body composition were assessed, aerobic fitness, muscle capacities, well-being as well as quality of life and health perception were measured (T0). The participants followed then a 5-month on-site physical activity intervention and all these measures were replicated by the end of the intervention (T1). All the participants received information sheets and signed consent forms as requested by ethical regulations. To be included the participants had to: i) be tertiary employees; ii) show no contraindications to physical practices; iii) be free of any medication that could interfere with the study outcomes. Employees who showed a regular participation in their worksite physical activity program for the last 2 years were classified as active while the others were classified as inactive. Their physical activity level was also confirmed through a self-reported physical activity questionnaire (Lee, Macfarlane et al. 2011; Golubic, May et al. 2014) based on the World Health Organization's Physical activity guidelines (at least 150 minutes of moderate to vigorous activity per week) (World Health Organization 2010).

All the participants received information sheets and signed consent forms as requested by ethical procedures. This study has been reviewed and approved by our local ethical authorities (Local Human Protection Committee - CPP SUD EST VI / CNIL).

### *On-site physical activity intervention*

Active and inactive groups were requested to take part in two to three training sessions per week, within their worksite training program. Each session lasted 45 minutes minimum, alternating between muscle-strengthening and cardiorespiratory exercises (one of each per week), supervised by a professional for a duration of 5 months. The program proposed eighteen different physical activities such as muscle strengthening, stretching, cardiorespiratory or team sports.

The participants were asked to perform at least one muscle-strengthening (weights machines) and one cardiorespiratory session (Latin dance, step, bike, fight exercise...) per week. Compliance was controlled by a computerized access to the sport facilities.

### *Anthropometric measurements and body composition*

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Both body mass and height were obtained at the same time of the day for the same subject, and not in a fasting state. Body Mass Index (BMI) was calculated as body mass (kg) divided by height squared ( $m^2$ ).

Body Composition was assessed by bioelectrical impedance analysis, performed with the Tanita MC780 multi frequency segmental body composition analyzer. This analyzer consists in a stand-alone unit where the subject has to step on bare foot (standard mode). Information concerning the subject (age, gender and height) is entered by the researcher. Once body mass has been assessed by the scale, the subject has to take grips with both

hands (alongside his body) during the impedance measure (Hand to foot BIA). A full segmental analysis is performed in less than 20 sec. Total body fat, total fat-free mass and body water were reported by the researcher into an excel sheet for statistical treatment. The newly developed BIA analyzer has been recently validated in healthy adults (Verney, Schwartz et al. 2015).

### *Well-being, Quality of Life and Health Perception*

Well-being and quality of life at work were assessed using a newly developed questionnaire (“worksite well-being and quality of life questionnaire”) especially designed for occupational health studies. The participants were asked to rate statements describing their well-being at work using visual analogue scales ranging from “not at all” to “absolutely” (i.e. “I’m actually feeling distressed while at work”). This questionnaire has been recently validated in a similar population (Carton 2015).

All participants were also asked to complete a short self-administered questionnaire specifically designed to explore their perception of health (“health perception scale”). Six criteria were investigated: (1) perceived physical fitness, (2) perceived ideal weight, (3) perceived healthy balanced diet, (4) perceived sleep quality, (5) perceived stress level, and (6) perceived general health. A 10-point scale from 1 (not at all) to 10 (very much) was used to assess each item.

The six individual scores were computed to obtain a global score for health perception. This questionnaire has been previously validated in adults (Garnier, Gaubert et al. 2013).

### *Aerobic fitness*

The step test was performed on a stool of 16.25 inches (41.3 cm) for men and 11.8 inches (30cm) for women for a total duration of 6 minutes at the rate of 24 cycles per minute, which was set by a metronome. Participants were asked to wear a heart rate monitor (Polar Electro Inc, Lake Success; USA) during the test and heart rate was recorded at the end of the 6 minutes, 30 seconds and 1 minute after completion of the test. This test has been found reliable in healthy subjects and it is highly reproducible (Chatterjee, Chatterjee et al. 2004).

### *Muscle capacities*

Upper limbs muscle strength was assessed using the handgrip on the dominant hand, as a non-invasive marker of muscle strength of upper limbs, well suitable for clinical use (Norman, Stobaus et al. 2011). The participants were also asked to perform a maximal number of push-ups (knees on the floor) respecting an imposed frequency. The test stopped once they were not able to maintain this rhythmicity or showed difficulties to maintain the correct position (Hwang, Kwon et al. 2017) (Marcolin, Petrone et al. 2015).

Counter Movement Jump (CMJ) was used to assess lower limb muscle strength using the Optojump technology (Microgate SRL, Rome, Italy) (Kockum and Heijne 2015).

The Shirado test was used to assess the static endurance of the abdominal muscles (Fransoo 2009) and the Sorensen test to assess back strength and endurance for all the muscles involved in the extension of the trunk (Demoulin, Vanderthommen et al. 2006).



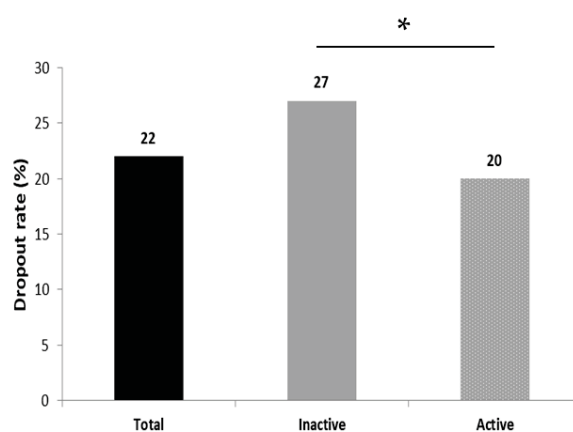
#### e. Statistical considerations

Sample size has been estimated in order to compare overall health indicators as fat mass percentage among physically active and inactive tertiary employees showing a high level of sedentariness. According to our previous work (Genin et al., 2017) and to Cohen's recommendations (Erlbaum 1988) who has defined effect-size bounds as: small (ES: 0.2), medium (ES: 0.5) and large (ES: 0.8, "grossly perceptible and therefore large"), we calculated that a minimum of 185 participants would allow to highlight an effect size equals 0.5 for a two-tailed type I error at 5%, a statistical power of 90% and a ratio 60%-40% for inactive/active employees. All analyses were performed using Stata software (version 13, StataCorp, College Station, TX). Statistical analyses were done for a two-sided type I error of  $\alpha=5\%$ . Baseline subject's characteristics were presented as the mean  $\pm$  standard deviation (SD) or the [median interquartile range] for continuous data (assumption of normality assessed by using the Shapiro-Wilk test) and as the number of patients and associated percentages for categorical parameters. Quantitative variables were compared (at each time-point evaluation T0 and T1) between independent groups (active vs. inactive tertiary employees) by Student t-test or Mann-Whitney test if conditions of t-test were not respected (normality and homoscedasticity analyzed using Fisher-Snedecor test). Comparisons between independent groups were done by Chi-squared or when appropriate by Fischer-exact test for categorical variables. To analyze repeated correlated data, the evolution of variations between the beginning and the end of the study was calculated for each parameter. Then, random-effects models were performed to study fixed effects as group (noted intergroup evolution of variations in Tables 1 and 2), time-points evaluation and their interaction taking into account between and within subject variability. The normality of residuals was checked

for all models. A sensibility analysis was performed to measure the possible impact of missing data (notably imputation of missing data). Results and practical conclusions were analogous (data not shown).

## f. Results

A total of 193 middle and upper classes office workers took part in the study; 84 females and 110 males with an average age of  $44.2 \pm 9.8$  years, an average weight and BMI of  $72.6 \pm 14.7$  kg and  $24.5 \pm 3.8$  kg/m<sup>2</sup> respectively. At baseline (T0) 98 and 95 participants composed the inactive and active groups respectively against 71 and 73 at T1.



**Figure 1.** Dropout rates to a 5-month workplace physical activity program between initially active and inactive tertiary employees ( $p \leq 0.05$ ).

The Figure 1 illustrates the dropout rate observed during the 5-month workplace program. 22% of all subjects dropped out before the end of the intervention, with a higher rate

observed in the initially active employees: 20% did not complete the whole study against 27% in the inactive sample ( $p<0.05$ ).

**Table 1.** Intra- and inter-group results for anthropometry and body composition.

		Inactive	Active	I vs A
Fat mass (%)	T0	24.8±7.5	21.7±7.1	$p=0.0032$
	T1	22.8±6.9	20.8±7.3	$p=0.0722$
	T0 vs T1	$p<0.001$	$p<0.001$	
Fat free mass (kg)	T0	52.5±11.3	53.6±10.7	<i>ns</i>
	T1	54.5±10.9	52.7±9.9	<i>ns</i>
	T0 vs T1	<i>ns</i>	<i>ns</i>	
BMI (kg/m <sup>2</sup> )	T0	25±4.6	24.1±3.2	<i>ns</i>
	T1	24.9±3.9	23.7±3.1	$p=0.0864$
	T0 vs T1	<i>ns</i>	<i>ns</i>	
WC (cm)	T0	92±15.3	87.5±12.3	$p=0.0264$
	T1	92±13.4	87±12.1	$p=0.0287$
	T0 vs T1	<i>ns</i>	<i>ns</i>	

BMI: Body Mass Index; WC: Waist Circumference; T0: baseline; T1: end of the 5-month program; I: Inactive; A: Active.

Table 1 details the results for anthropometric characteristics and body composition, while Table 2 presents the participants' functional characteristics, well-being and health perception. There was a statistically significant difference for push-ups ( $p\leq0.001$ ;  $p\leq0.01$  respectively), Sorensen test ( $p\leq0.001$ ), fat mass ( $p\leq0.01$ ; tendency respectively) and waist circumference ( $p\leq0.05$ ) between active and inactive at T0 but also at T1. Table 2 also highlights a significant difference for health perception at T0 between active and inactive participants ( $p\leq0.001$ ), but this difference no longer exists at T1. No significant change in worksite well-being, rest heart rate, CMJ, Shirado test, fat-free mass or BMI was observed during the study. There was a time effect for the inactive group which demonstrates

significant progressions between T0 and T1 for health perception ( $p \leq 0.001$ ), and CMJ ( $p \leq 0.01$ ). In contrast, the two groups significantly improved their results for handgrip ( $p \leq 0.01$ ), push-ups (inactive:  $p \leq 0.001$  and active:  $p \leq 0.05$ ), fat mass ( $p \leq 0.001$ ) and their heart rate post exercise (inactive:  $p \leq 0.01$  and active:  $p \leq 0.001$ ) between T0 and T1.

**Table 2.** Intra- and inter-group results for functional tests, health perception and well-being.

		Inactive	Active	I vs A
Health perception	T0	51.2±15.1	61.3±14.3	$p < 0.001$
	T1	59.1±14.7	62.5±12.7	<i>ns</i>
	T0 vs T1	$p < 0.001$	<i>ns</i>	
Worksite well-being	T0	7.34±1.4	7.3±1.3	<i>ns</i>
	T1	7.3±1.2	7.4±1.3	<i>ns</i>
	T0 vs T1	<i>ns</i>	<i>ns</i>	
Rest heart rate (bpm)	T0	71.3±11	67.2±11.6	<i>ns</i>
	T1	73.5±10.5	68.3±10.3	<i>ns</i>
	T0 vs T1	<i>ns</i>	<i>ns</i>	
Heart rate (bpm)	T0	150.4±20.2	147.9±19.9	<i>ns</i>
	T1	141.1±18.3	135.6±17.3	$p = 0.0698$
	T0 vs T1	$p = 0.0029$	$p < 0.001$	
Heart rate +30 (bpm)	T0	126±26.6	128.3±22	<i>ns</i>
	T1	127.8±19.3	116.9±19.2	$p = 0.0329$
	T0 vs T1	<i>ns</i>	$p < 0.001$	
Heart rate +60 (bpm)	T0	116±20.8	112.4±22.4	<i>ns</i>
	T1	111.3±21.3	103±18.4	$p = 0.0236$
	T0 vs T1	<i>ns</i>	$p < 0.001$	
CMJ (cm)	T0	24.6±7.7	23.6±7.1	<i>ns</i>
	T1	26.7±7.6	24.4±8.9	<i>ns</i>
	T0 vs T1	$p = 0.0256$	<i>ns</i>	
Handgrip (kg)	T0	24.6±7.7	23.6±7.1	<i>ns</i>
	T1	41.8±10.7	40.3±11.1	<i>ns</i>
	T0 vs T1	$p = 0.0035$	$p = 0.0082$	
Push-ups (rep)	T0	22.8±14.4	36.5±19.2	$p < 0.001$
	T1	29.4±15.4	39.8±18	$p = 0.0014$
	T0 vs T1	$p < 0.001$	<i>ns</i>	
Shirado (sec)	T0	173.1±77.7	181.8±50.9	<i>ns</i>
	T1	184.1±82.2	174.3±52	<i>ns</i>
	T0 vs T1	<i>ns</i>	<i>ns</i>	
Sorensen (sec)	T0	101.2±56.9	159±41.6	$p < 0.001$
	T1	112.3±54.2	161.2±47.7	$p < 0.001$
	T0 vs T1	<i>ns</i>	<i>ns</i>	

CMJ: Counter Movement Jump; ST: step test; HR: heart rate; T0: baseline; T1: end of the 5-month program; I: Inactive; A: Active.

Table 3 details the results of the amplitude of the variations obtained between T0 and T1. Health perception ( $p \leq 0.001$ ), performances at the Sorensen test ( $p \leq 0.05$ ), Shirado test (tendency) and BMI (tendency) all show a significantly higher progression in the inactive compared with the active groups. The variations observed between T0 and T1 were not found significantly different between groups for worksite well-being, CMJ, handgrip, push-ups, fat mass, fat free mass and waist circumference.

**Table 3.** Intergroup evolution of variations between the beginning and the end of the study.

	Inactifs		Actifs		p
	mean sd	var	mean sd	var	
Health perception	20,2±35,4	13,6 [-2,7;35,1]	3,7±21,2	1,5 [-11;8,4]	0,001***
Worksite well-being	2±21,3	1,4 [-11,4;14,3]	1,8±17,2	-0,06 [-6,4;8,3]	0,9
CMJ (cm)	5,2±14	3,2 [-3,8;9,9]	3,9±21,8	3,3 [-1,6;12,2]	0,6
Handgrip (kg)	3,4±8,7	2,9 [-1,5;9,1]	4,1±10,9	3,2 [-3,1;10,3]	0,9
Puch-ups (rep)	29,5±65,3	16,4 [0;40]	50±230,2	6 [-5,9;26]	0,2
Shirado (sec)	20,5±73	0 [-14,3;28,7]	-2,9±22,4	0 [0;0]	0,05 <sup>t</sup>
Sorensen (sec)	35,4±119,8	0 [0;28,2]	0,08±21,7	0 [0;0]	0,02*
Fat mass (%)	-4,2±9,3	-4,1 [-9,6;-0,4]	-3,4±8,9	-2,7 [-7,8;3,3]	0,2
Fat free mass (kg)	0,8±2,6	1 [-0,4;2,4]	0,7±3,4	0,7 [-0,5;2,4]	0,8
BMI (kg/m <sup>2</sup> )	-0,6±3	-0,4 [-2;0,8]	0,1±2,4	0,4 [-1,3;1,7]	0,06 <sup>t</sup>
WC (cm)	-0,2±3,6	-0,4 [-2,3;1,5]	0,05±3,6	-0,1 [-2,5;2,8]	0,6

BMI: Body Mass Index; WC: Waist Circumference; CMJ: Counter Movement Jump; T0: baseline; T1: end of the 5-month program; I: Inactive; A: Active.

## g. Discussion

The main aim of the present study was to compare overall health indicators between active (above recommended levels of physical activity) and inactive (below recommended levels) employees with high and similar levels of worksite-induced sedentariness. According to our

results, BMI, fat-free mass, lower and upper limbs muscle capacities (CMJ and handgrip) and aerobic capacities are not different between active and inactive tertiary employees who both spend about 7.5 hours per days seated in front of computers (approximately 37.5h/week). This is to our knowledge the first study that questions the effect of a high level of sedentariness on health and fitness indicators among physically active and inactive workers.

While public health strategies have been developed to increase individuals' physical activity levels over the last decades, more concerns are expressed today regarding the progression of sedentariness. Indeed, it is now clear that physical activity and sedentary behaviors are two different constructs that have independent effects on health (Albawardi, Jradi et al. 2017). This is particularly important since sedentariness has become one of the largest public health concerns, being nowadays recognized as one of the main causes of preventable premature mortality. Although worksites have been identified as ideal settings to favor physical activity among workers (Dugdill 2008), the "tertiarisation" of our societies and industries has been favoring sedentariness, with employees spending now most of their daily time seated in front of computers. While most of the available studies have been evaluating the levels of physical activity of tertiary employees (Mundwiler, Schupbach et al. 2017), their time spent seated and/or in front of a computer screen (Yang, Hipp et al. 2017), or have been independently looking at the effect of physical activity programs (Grande, Silva et al. 2014) or interventions aiming at reducing sedentary time (Aittasalo, Livson et al. 2017), we did not find any work comparing fitness parameters between physically active and inactive tertiary employees who are characterized by a high level of sedentariness.

In their study, Ko and collaborators compared the incidence of metabolic risk factors and the prevalence of metabolic syndrome between white collars divided in physical activity tertiles (Ko, Yoon et al. 2016). According to their results, workers with the lowest physical activity levels present higher waist circumference, increased triglycerides concentrations, higher HDL-C concentrations and a higher risk for metabolic syndrome (Ko, Yoon et al. 2016). Unfortunately, their data do not allow the classification of their participants as active or inactive in regards to physical activity guidelines, and information regarding sedentary behaviors is missing, as well as details regarding the exact occupational activity of their participants (Ko, Yoon et al. 2016). More recently, Browne and colleagues conducted a cross-sectional study among about 500 sedentary tertiary employees, hypothesizing that sedentary occupational workers who meet physical activity recommendations (without precising the guidelines used) present lower risks for metabolic syndrome than inactive ones (Browne, Farias-Junior et al. 2017). Their results point out that active workers show lower odds for abdominal obesity, elevated blood pressure, reduced high-density lipoprotein cholesterol and overall metabolic syndrome, after adjustments for age, working hours, body mass index, and tobacco use (Browne, Farias-Junior et al. 2017). The significantly higher fat mass percentage and waist circumference observed in our inactive group are in line with these results. Although these studies tend to suggest that in employees who spend most of their daily time sedentary, physical activity has beneficial effect on their metabolic health, we missed finding any data related to physical and overall health fitness.

Not only objective health and fitness indicators were assessed in the present work, employees' self-perception of their overall health and work-related well-being were investigated. Although active workers show a significantly greater score for overall health

perception, worksite wellbeing was not significantly different compared with inactive employees. Although this might suggest that physical activity levels might not be associated with employees' work-related satisfaction and comfort, some recent studies suggest that tertiary employees' wellbeing might be related to sedentary behaviors, which may explain our results since both active and inactive workers present here at least 7.5 hours of sedentary time per day (Olsen, Brown et al. 2018). Such results are definitely of importance for both workers and employers, since work-related wellbeing has been clearly identified as a major predictive factor for prolonged or future sickness absence (Vendrig and Schaafsma 2017).

The second aim of the present work was to assess the effects of a 5-month worksite structured and monitored physical activity program among initially inactive and active employees (already regularly using the companies' physical facilities for the last 2 years). While the majority of the published papers in the field assesses the effects of physical educations, encouragement and motivational strategies (Aittasalo, Livson et al. 2017; Puig-Ribera, Bort-Roig et al. 2017) walking meetings (Mackenzie, Goyder et al. 2015) or sedentary breaks (Bergouignan, Legget et al. 2016), less studies have been conducted implementing structured aerobic and resistance exercise sessions (Pedersen, Blangsted et al. 2009; Genin, Degoutte et al. 2017). In 2009, Pedersen et al. conducted a one year randomized controlled trial questioning the effects of resistance training and all-round physical exercise sessions performed within workplaces (1 hour/ week during working hours) on tertiary employees health indicators (Pedersen, Blangsted et al. 2009). Their results showed significant reductions of cardiovascular and metabolic syndrome-related risk factors as well as musculoskeletal pain symptoms, concomitantly with minor increases in physical capacities.



The physical activity levels of the participants was however not considered. In the present study, the participants were asked to perform 2 to 3 exercise sessions per week, composed of resistance and aerobic exercises, in one of the physical activity facilities proposed by their companies. According to our results, while numbers of health and fitness indicators were improved by the program in our initially inactive subsample, active individuals also show improvements. While health perception and counter movement jumps were significantly improved in the inactive group only, the heart rate response to our aerobic test, the handgrip performance, the maximal number of push-ups, as well as the percentage of fat mass was significantly improved in both groups. Interestingly, the heart rate recovery 30 seconds and 1 minute after the aerobic test were improved in the experienced group only. These results suggest that while such a physical activity intervention has beneficial effects in initially inactive employees, it continues to favor positive adaptations in active ones. These results are in line with a previously published pilot study, suffering from reduced sample size but already suggesting the interest of worksite exercise programs among tertiary employees, whatever their initial physical activity level (Genin, Degoutte et al. 2017).

Although the present study provides main insights regarding the importance of considering both sedentary and physical activity levels when it comes to evaluating tertiary employees' health indicators, and underlines the beneficial effects of structured on-site physical interventions among both active and inactive workers, our results also point out the necessity to consider the employees' adherence rate to such programs. Indeed, 1 out of 5 participants did not complete the whole intervention, which must definitely be considered by stakeholders and investigators who must try to understand and identify the potential underlying reasons. This 20% dropout rate observed here, is in line with what is rarely

discussed but usually observed in other similar studies. In their study, Jakobsen et al. asked tertiary employees to exercise 5 times a week (10-minute sessions) for 10 weeks and observed a similar dropout rate of 22% (Jakobsen, Sundstrup et al. 2015). During their 1-year trial, Pedersen et al. obtained a 48% dropout rate among office workers who exercised 3 times a week (Pedersen, Blangsted et al. 2009) and in our previous pilot work, 30% of the enrolled participants were found to quit before the end of the intervention (Genin, Degoutte et al. 2017). While such high dropout rates are usually observed, the profile of these participants remains under-explored. Although further studies are needed, specifically designed to address this question, our results, as illustrated by the Figure 1, tend to suggest that the initial physical activity level of the enrolled employees should be considered with a total of 20% of non-compliant being observed in the initially active sub-sample against 27% among the initially inactive one. This also highlights the fact the least active employees –and therefore those who need it the most – are those who are at highest risk to drop out from such worksite PA programs.

Our results should clearly be interpreted in light of some limitations. The sample size might be considered as one of the limitations, underlying the difficulty to recruit volunteers for such interventions, reinforcing the need for deeper explorations of the potential specific profile of employees interested in workplace physical activity programs. The use of field testing to assess employees' physical fitness might also be a limitation, and more objective methods could be used, such as ergometers and direct methods to assess their aerobic capacities (laboratory-based maximal aerobic testing). Moreover, the use of BIA to assess body composition is not as accurate as dual-x-ray absorptiometry for instance; it composes however one of the best alternatives for studies enrolling large samples and remains a

reliable and validated tool in healthy adults as previously described (Verney, Schwartz et al. 2015).

To conclude, the present study suggests that improvements in some health and fitness indicators might not be found among active tertiary employees, compared with inactive ones, which might be due to the high level of sedentariness characterizing their occupational task. This result clearly calls for worksite-based interventions not only focusing on physical activity but also, and perhaps most importantly, trying to break down sedentary time. Our results also confirm that structured exercise interventions implemented with workplaces, improve health and fitness among both initially physically inactive and active tertiary workers, questioning however the profile of workers who are willing to be compliant to on-site physical interventions.

## 4. Etude 4

Employees' adherence to worksite physical activity programs: profiles of compliers versus non-compliers

Genin PM, Pereira B, Thivel D, Duclos M.

Work. 2018 Jul 17. doi: 10.3233/WOR-182745.

Work

## a. Résumé

Tandis que les politiques de santé publique ont souligné la nécessité de créer une culture qui est propice à l'activité physique régulière, ces dernières continuent de chercher de nouvelles stratégies et de nouveaux cadres opportuns. Les lieux de travail ont été identifiés comme intéressants puisqu'en effet les employés passent une très grande partie de leur temps au travail ; plusieurs interventions en entreprise ont donc été développées récemment. Alors que la littérature scientifique actuelle souligne clairement les effets bénéfiques des programmes d'activité physique en entreprise sur la santé globale des employés, les preuves disponibles semblent toutefois remettre en questions l'adhésion à de telles interventions. Basé sur des résultats déjà publiés et de nouvelles observations, ce travail discute du taux d'adhésion durant les programmes d'activité physique chez les employés compte tenu de leurs profils de « décrocheurs ».

**Mots-clés :** employés tertiaires, santé au travail, sédentarité.

## **b. Abstract**

While worldwide public health policies have emphasized the necessity to create a culture that favors regular physical activity, stakeholders and health institutions keep looking for new strategies and opportune settings. Workplaces have been identified since employees spent a considerable part of their time at work and several worksite interventions have been developed lately. While the actual scientific literature clearly points out the beneficial effects of physical activity programs implemented within companies on employees overall health, available evidences however seem to question their adherence to such interventions. Based on previously published results and new observations, this paper discusses the adherence rate during workplace physical activity programs and suggests new strategies to favor increased physical activity among employees, considering their dropouters or finishers' profiles.

**Key words.** Tertiary employees, occupational health, sedentariness.

### c. Introduction

Workplaces have been lately described as opportune settings to implement public health interventions that mainly advocate for active and healthy lifestyles. The World Health Organization and World Economic Forum have indeed defined workplaces as ideal sites to implement programs promoting health, particularly through physical activity and eating habits (Jirathananuwat and Pongpirul 2017). Employees spend a considerable part of their daily time at work and on-site physical activity facilities appear as a great way to encourage their engagement and practice while some of the main expressed barriers to physical activity are the lack of time and facilities proximity (Green 1988; Dugdill 2008). Moreover, with the “tertiarisation” of our societies, most employees today spend most of their working hours seated in front of computers. In addition, according to the 2006 national nutrition and health survey (ENNS), 53% of adults aged 18 to 74 (59% of men and 48% of women) spend three hours or more per day (working days and holidays) in front of a screen (television or computer) outside of work hours (Ekelund, Steene-Johannessen et al. 2016). Importantly, this proportion progresses with age in both men and women. This is particularly concerning since it has been clearly shown that both the total volume of sedentary time and its accrual in prolonged and uninterrupted bouts are associated with all-cause mortality (Diaz, Howard et al. 2017) but also with increased risk for major non communicable diseases (type 2 diabetes, cardiovascular diseases, cancers) (Lee, Mama et al. 2012). Employers are today encouraged to play a key role in the health and well-being of working-age adults (NHS 2008), particularly since the promotion of physical activity among employees will not only generate health benefits, but also reduce health-related care costs (Golaszewski 2000) and improve productivity (Proper, van den Heuvel et al. 2006).

Many studies have been conducted, proposing in-site physical activity interventions and providing positive results on employees overall health indicators. Vilela and collaborators for instance showed that a 4-month worksite physical activity program improved body composition among employees (Vilela, Benedito Silva et al. 2015). Similarly, Genin et al. showed that a 5-month worksite physical activity intervention improved overall health parameters (sleep, pain, muscle strength, body composition, health perception...) among initially inactive tertiary workers, also underlying improvement for most of these indicators in initially already active employees (Genin, Degoutte et al. 2017).

#### **d. Employees' adhesion to physical activity programs**

Although all the available evidences are in line with these two examples, collectively showing positive effects of such programs conducted within companies on employees' health and wellbeing, the profiles and adherence rates of the employees engaged in such programs remain unconsidered. This is of particular importance since these programs have been mainly developed to favor physical practice among inactive individuals.



**Table 1.** Main worksite interventional studies and their dropout rates.

References	PA Intervention	Frequency	Duration	Initial sample size	Final sample size	Dropout rate (%)
<i>Alittasalo et al., 2017</i>	Motivation group: meetings, workshop and tools	3*4hours meeting	1 year	296	205	31
<i>Boudet et al., 2017</i>	Different training groups (with different intensity of exercise)	4 day/week	3 weeks	89	80	10
<i>Bredahl et al., 2014</i>	Strength training	3*20min/week	5 months	573	ni	.
<i>Carr et al., 2016</i>	Sit-stand workstation+e-mails	Free	4 months	60	54	10
<i>Grande et al., 2014</i>	Stretching exercises	3*5min/week	3 months	20	20	0
<i>Lima et al., 2015</i>	Control vs exercise group (physical exercises)	5*10min/week	4 months	60	ni	.
<i>Markov et al., 2016</i>	Heart rate variability evaluation according to the seasons	.	6 months	26	26	0
<i>Pedersen et al., 2009</i>	Resistance training vs all-round physical exercise	3*20min/week	1 year	616	319	48
<i>Puig Ribera et al., 2017</i>	Control vs application group (persuasive messages)	Free	5 months	264	198	25
<i>Shafieinia et al., 2016</i>	Control vs exercise group (educational program + persuasive messages)	4*90min training sessions	3 months	108	95	12
<i>Taleb et al., 2012</i>	Control vs intervention (sit-stand workstation)	Free	3 months	32	30	6
<i>Torbeyns et al., 2017</i>	Bike desk	8*25min/week	5 months	23	19	18
<i>Jakobsen et al., 2015</i>	Work exercise vs home exercise + coaching for motivation	5*10min/week	10 weeks	254	200	22
<i>Mackenzie et al., 2015</i>	Advice, recommendation to "sit less" (walking and standing meetings)	Free	1 months	24	17	29
<i>Genin et al., 2017</i>	Control group vs intervention with novice and experimented group (aerobic + muscle-strengthening)	2*45min/week	5 months	95	67	29,5
<i>Corbett et al., 2018</i>	Aerobic + muscle-strengthening	3*60min/week	12 weeks	50	43	14
<i>Genin et al., 2018</i>	Intervention with inactive and active group (aerobic + muscle-strengthening)	2*45min/week	10 months	228	139	39

When considering some of the main studies in the field (Table 1), dropout rates up to 50% can be observed. In a study conducted by Jakobsen et al. (Jakobsen, Sundstrup et al. 2015), tertiary employees exercised 5 times 10 minutes per week (high-intensity strength training using elastic bands and kettlebells during working hour) in addition to physical activity education (motivational coaching sessions) for 10 weeks, and the authors noticed 22% of dropout (Jakobsen, Sundstrup et al. 2015). In 2009, Pedersen and collaborators obtained a 48% dropout rate during their 1-year study in which tertiary employees exercised 3 times a week (sessions lasting 20 minutes), alternating resistance and all-around physical exercises (Pedersen, Blangsted et al. 2009). In a recent study from our research group in which tertiary employees were proposed to complete a 5-month on-site physical activity program (exercise facilities implemented within their companies) composed of 2 to 3 aerobic and resistance training sessions per week, 30% of the initially involved participants gave up before the end of the intervention (Genin, Degoutte et al. 2017). Interestingly, our group has recently conducted two similar studies among public and private tertiary workers and our preliminary results indicate a dropout rate reaching 65% when the intervention lasts 10 months, with an intermediary dropout of 38% after the first 5 months (Genin PM 2018). Not only workplace exercise-based interventions suffer from a high degree of abandonment, motivation group strategies also report dropout rates up to 31% (Aittasalo, Livson et al. 2017), 29% of dropout were observed in responses to walking and standing meetings (Mackenzie, Goyder et al. 2015) and about 25% of workers were found to give up interventions based on encouraging text messages only (Puig-Ribera, Bort-Roig et al. 2017). Unfortunately, none of these studies tried to identify the reasons beneath these high levels of abandonment. Such dropout rates are not be specific to workplace PA programs with many PA interventions also indicating high levels of abandons, this must however not be under-interpreted and underestimated as

it might provide important insights to better understand potential adherence profiles (compliers vs non-compliers) and to better target workplace interventions.

#### **e. “Compliers” vs. “non-compliers”**

Yet this adherence issue has been already underlined by some, studies have been so far trying to find incentives, mainly financial ones to increase their adherence rates (Losina, Smith et al. 2017) instead of identifying the core reasons responsible for the employees dropout. Indeed, while the profile of the participants who give up interventions is rarely discussed and considered, our last results seem to suggest that employees who abandon workplace physical activity programs are those who would need it the most, suggesting that such interventions might miss their primary targeted population.

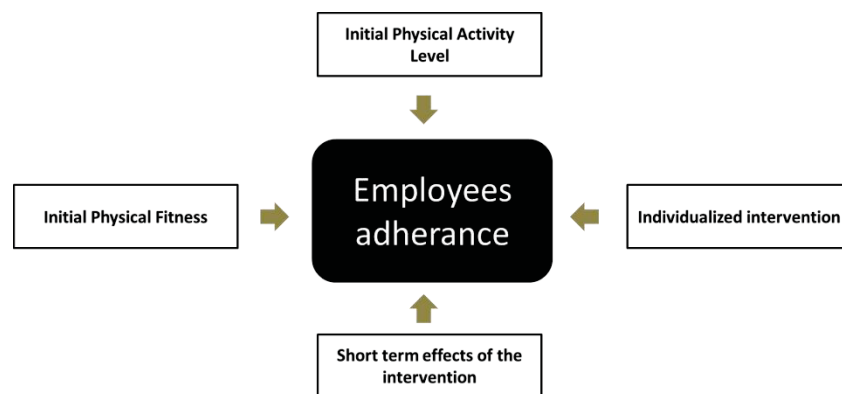
From September 2016 to June 2017, our research group assessed the effect of a 10-month physical activity intervention proposed to initially physically active and inactive tertiary employees. Briefly (the protocol has been detailed elsewhere, (Genin, Degoutte et al. 2017)), 98 participants had to engage in 2 to 3 exercise sessions per week within their workplace, while overall health indicators (body composition, anthropometric values, physical fitness, quality of life, health perception, pain, sleep quality) were assessed before (T0), at mid-point (T1) and after (T2) the 10-month program. Our sample was composed of voluntary inactive individuals that did not reach the physical activity recommendations and active ones that were already regular members of their companies' physical activity facilities (for at least 2 years). Taking into account the entire sample, 22% of the subjects dropped out before T1 and 47% before the end of the 10-month intervention. While these statistics seem in line with the previously cited literature, it appears interesting to give a deeper look at the profile

of the non-compliant participants, to better understand their high rates of withdrawal. Our retrospective analysis showed a higher dropout rate at T1 among initially inactive individuals (27%) *versus* the active ones (20%). This is even more pronounced at T2 where initially inactive employees showed a dropout rate of 64 % from T1 and 77% from T0 against 19% and 35% among active ones respectively.

Non-compliers were also found to have higher initial body weight, body mass index, and lower fat free mass than compliers. The percentage of fat mass was significantly higher among participants giving up prematurely ( $26.4 \pm 7.7$  %) compared with those who completed the whole program ( $24.2 \pm 7.5$  %) ( $p < 0.05$ ). Other physical fitness indicators were also found higher at T0 among compliant participants compared with those who gave up. These data seem to suggest that the initial fitness profile of employees should be considered when implementing such physical activity interventions. Moreover, they also suggest that such interventions (personalized, supervised, combining endurance and strength training) might not be adapted to individuals who might need it the most, those with the lowest physical fitness.

Importantly, we also observed that the short-term (first months) degree of success of such in-site physical activity programs might determine the rate of adherence. Indeed, our preliminary data indicate that the improvement of body composition, perceived effort induced by exercise or aerobic fitness during the first phase of the intervention might influence the adherence of tertiary employees to the remaining months of the program. For instance, we found better improvement of the heart rate response to exercise ( $p < 0.05$ ), the post-exercise heart rate recovery ( $p < 0.01$ ) and fat mass percentage ( $p < 0.05$ ) after the first 5 months in those who did not drop out between T1 and T2 compared to those who did. This

result is original and suggests that not only the initial health and fitness profile of the participants will determine their adhesion rate, but also the efficiency of the first months of an intervention to induce positive changes (Figure1).



**Figure 1.** Proposed Framework of the main identified reasons for employees' drop out to on-site physical activity interventions.

Beyond these scientific statistics and considerations, the main advance reason expressed by participants for engaging in worksite-based physical activity programs is the gain of time. Indeed, most of the employees who assiduously engage in such programs admit to be already active and that these on-site facilities represent a great opportunity to gain some time outside work (by training for instance during lunch time). They most of the time confess that they would be active anyway and only few of them start being active thanks to these facilities and programs proposed within companies (on going internal survey).

Obviously these preliminary data have to be considered with caution and some larger analysis should be conducted such as systematic reviews and meta-analysis to better understand and identify the potential predictive indicators for tertiary employees' adhesion

to on-site physical activity programs. This seems particularly important since these first insights suggest that while public health policies and strategies have been advocating workplaces as opportune settings to promote higher physical activity level among employees, such interventions might not favor the adhesion of the employees needed it the most, in other words those presenting lower health-related fitness and low physical activity levels. Companies' health and wellbeing strategies should consider adding individualized approaches based on their employees' profiles to their classical physical activity facilities.

## V. Discussion générale

Les sociétés actuelles montrent un déclin toujours plus important du niveau d'activité physique des populations, associé à une progression alarmante de leurs comportements sédentaires (Ng and Popkin 2012). L'évolution du milieu professionnel au cours du dernier siècle, avec le développement des activités tertiaires et la réduction des tâches nécessitant des efforts physiques, a grandement contribué à cette sédentarisation de notre société et à l'accroissement du niveau d'inactivité physique. Il est en effet aujourd'hui bien démontré que le temps passé à des activités sédentaires chez l'adulte est principalement d'origine professionnelle, caractérisé par des périodes prolongées et ininterrompues du temps passé assis (Ryan 2011).

Compte-tenu de la mutation inéluctable des activités professionnelles, le milieu du travail a aussi récemment été suggéré comme un environnement pertinent et intéressant pour favoriser l'activité physique, notamment au regard du temps quotidien considérable passé par les employés sur ce lieu (Dugdill, Brettle et al. 2008).

Alors que la littérature scientifique s'est fortement enrichie ces dernières années de travaux ayant pour objectifs d'inciter les employés à la pratique physique (à travers des messages d'incitations ou d'encouragements ; des ateliers éducatifs, etc.) ou à rompre leur temps sédentaire (à l'aide de stations de travail actives ou encore de réunions actives parmi d'autres), plus rares sont les travaux et initiatives proposant la mise en place de programmes d'activité physique structurée au sein même des entreprises. En plus d'une littérature encore limitée, les résultats publiés jusqu'alors sont contradictoires. En effet, si certains auteurs montrent des effets positifs de programmes d'activité physique mis en place sur le lieu de travail (Oldridge 2008; Anderson, Quinn et al. 2009; Pedersen, Blangsted et al. 2009;

Fang, Huang et al. 2018; Hunter, Gordon et al. 2018; Rowland, Berg et al. 2018), d'autres obtiennent des résultats plus nuancés (Rongen, Robroek et al. 2013; Grande, Silva et al. 2014; Bredahl, Saervoll et al. 2015; Corbett, Fennell et al. 2018; Kinnafick, Thogersen-Ntoumani et al. 2018; Lowensteyn, Berberian et al. 2018). A partir des résultats de leur méta-analyse sur le sujet, Dishman et collaborateurs expliquent de telles divergences par une importante hétérogénéité et une faible qualité méthodologique (Dishman, Oldenburg et al. 1998). Les travaux publiés jusqu'ici ont, qui plus est, restreint leurs analyses sur un nombre limité d'indicateurs de santé, ne permettant ainsi aucune conclusion solide sur la santé générale et le bien-être des employés.

Dans ce contexte, l'objectif principal de ce travail de doctorat a été d'évaluer la faisabilité de mise en place et l'efficacité de programmes d'activité physique conduits en entreprise sur les principaux indicateurs de santé d'employés du secteur tertiaire.

Si nos premiers résultats soulignent bien la faisabilité de ce type d'approche (Etude 1) et viennent confirmer les bienfaits de la mise en place de programmes structurés d'activité physique sur le lieu de travail sur la santé d'employés de bureau, soumis à près de 7 heures par jour de sédentarité « de fait » (temps passé assis + temps devant un écran), ce travail de doctorat vient enrichir la littérature dans le domaine de nouveaux résultats particulièrement importants à considérer:

- Quel que soit le niveau d'activité physique, le haut niveau de sédentarité induit par une activité tertiaire semble influencer le niveau de santé des employés, ainsi que les effets d'un programme d'activité physique sur ce dernier.



- La mise en place de programmes d'activité physique en entreprise se confronte à un faible taux d'adhésion qui semble déterminé à la fois par le profil initial du participant et par les effets à court terme du programme.

### **Mise en place, évaluation et efficacité ?**

La première étude avait pour objectif d'évaluer la faisabilité et la mise en place de l'évaluation d'un programme d'activité physique en entreprise dans une manufacture comprenant différents sites au sein de la même ville. En effet, la littérature actuelle propose essentiellement des études de courtes durées, avec peu de paramètres évalués, donc peu de résultats, avec parfois un nombre de sujets relativement faible. Ces limitations méthodologiques peuvent s'expliquer par le réel challenge que représente la mise en place de telles interventions et l'évaluation au sein même d'une entreprise, nécessitant la considération des disponibilités des employés, des facilités proposées par la structure ou encore du volume horaire de travail ou niveau de responsabilité de chaque employé, tout en épargnant la productivité et la rentabilité initiale des employés. Cette première étude a donc été élaborée de manière à évaluer la faisabilité d'organisation et d'implémentation à la fois d'un programme structuré et régulier d'activité physique sur le lieu de travail mais aussi de son évaluation par l'intermédiaire d'une batterie de tests évaluant la santé globale des employés et alliant tests de terrain, objectivité et validité des outils et mesures. Ainsi, ce premier travail conduit auprès de 95 employés de bureau d'une manufacture Clermontoise a permis de mettre en évidence à la fois : i) la faisabilité de la mise en place et de l'évaluation d'un programme de 5 mois d'activité physique sur différents sites d'une même entreprise comprenant un minimum de deux séances par semaine et ne nécessitant qu'une heure d'évaluation par employé et ; ii) de confirmer les effets positifs de ce dernier sur les

principaux indicateurs de santé dans cette population (*Journal of Occupational and Environmental Medicine*, 2017).

Si Corbett et al. avaient déjà mis en avant la faisabilité d'un programme de 12 semaines en entreprise auprès de 50 employés, leur évaluation comprenait uniquement la mesure de la composition corporelle (Corbett, Fennell et al. 2018). Dans le même sens, les auteurs d'une récente étude de 10 semaines n'ont considéré les effets de leur intervention qu'à travers le niveau d'activité physique des participants (observant une augmentation de ce dernier) (Kinnaïfick, Thogersen-Ntoumani et al. 2018). Hunter et collaborateurs quant à eux, ont pu évaluer plus d'indicateurs (capacités cardiorespiratoires, force maximale) mais leur échantillon reste faible (50 sujets) avec une durée d'étude elle aussi relativement faible (8 semaines) (Hunter, Gordon et al. 2018). Contrairement aux études déjà présentes dans la littérature, notre étude confirme l'amélioration de la qualité de vie générale et de la perception que l'individu a de lui-même, cependant, ces résultats ne sont pas significatifs pour l'item de qualité de vie spécifique au travail, ce qui suggère que les programmes d'activité physique ne permettent peut-être pas d'améliorer la qualité de vie au travail mais la santé mentale générale.

Cette première phase exploratoire principalement centrée sur un questionnement méthodologique a encouragé la mise en place d'une étude interventionnelle de plus grande ampleur aussi bien en termes de taille d'échantillon que de durée du programme, nous conduisant à l'élaboration d'une seconde phase expérimentale au sein de la même entreprise, d'une durée de 10 mois, avec un temps de mesure intermédiaire à 5 mois et un échantillon initialement souhaité de plus de 300 participants.

Les résultats de cette seconde phase expérimentale (Etude 2) (*Journal of Occupational and Environmental Medicine*, 2018) viennent renforcer ceux de notre première étude soulignant

également une amélioration significative du pourcentage de masse grasse, ce qui est conforme aux résultats de Pedersen et *al.* qui ont montré une amélioration de la composition corporelle (avec une diminution du pourcentage de masse grasse) suite à un programme d'activité physique en entreprise d'un an (Pedersen, Blangsted et al. 2009). Nous avons aussi observé une amélioration de la force musculaire et de la souplesse, tout comme récemment souligné en réponse à un programme en entreprise de 4 mois (Vilela, Benedito Silva et al. 2015). Dans le même sens, notre étude a révélé des améliorations pour les scores d'anxiété et de dépression, ce qui va également dans le sens de la littérature actuelle (Mackenzie, Goyder et al. 2015). Notre travail a donc confirmé qu'un programme d'activité physique structuré en entreprise favorisait l'amélioration des indicateurs de santé (Etudes 1, 2 et 3), ce qui va dans le sens de la littérature actuellement disponible (Vilela, Benedito Silva et al. 2015; Fournier, d'Arripe-Longueville et al. 2017; Genin, Degoutte et al. 2017).

Il est néanmoins important de souligner que contrairement à ce que notre étude de faisabilité laissait penser, le recrutement lors de cette seconde phase a été plus difficile, nous conduisant à l'inclusion d'une seconde entreprise dont le personnel de bureau présente des caractéristiques similaires à celui de la première manufacture. Les enquêtes antérieurement réalisées et l'expérience du terrain ont pu mettre en évidence le rôle prépondérant que doit jouer la structure dans la promotion de ces programmes d'activité physique sur site de manière à encourager et impliquer ses employés. En effet, une campagne d'information et d'incitation plus importante avait été réalisée lors de l'Etude 1 (ainsi qu'au sein de la seconde entreprise approchée), ceci ayant été associé à un taux de participation plus important aux programmes d'activité physique proposés, chez des

employés sédentaires. Il ne semble donc pas suffisant pour les entreprises de mettre en place des programmes d'activités au sein de leurs locaux, il apparaît nécessaire de créer une dynamique et une culture de la pratique pour que cela fonctionne.

### **Les niveaux d'activité physique et de sédentarité ont-ils un rôle indépendant ?**

Si l'objectif principal de nos deux premières études (Etudes 1 et 2) reposait sur l'évaluation de ce type de programme en entreprise auprès d'employés présentant un temps important de sédentarité imposé par leur travail, et non sur la considération du niveau d'activité physique, le recrutement et le traitement de nos résultats nous ont permis une analyse secondaire questionnant les potentiels effets différenciés de nos interventions sur des employés aux niveaux d'activité physique différents mais présentant un temps de sédentarité quotidien très important (sédentaires actifs *versus* sédentaires inactifs) (Etude 3).

De récentes études ont montré des associations indépendantes entre sédentarité et inactivité physique sur la santé (Ekelund, Steene-Johannessen et al. 2016). En effet, le temps consacré aux comportements sédentaires a des effets négatifs sur la santé, indépendamment du niveau d'activité physique (LeBlanc, Gunnell et al. 2017). Les résultats de nos travaux (Etude 3) suggèrent en effet que les indicateurs de santé ne seraient pas meilleurs chez les employés actifs par rapport aux inactifs, ce qui pourrait être dû au niveau élevé de sédentarité imposé par leur tâche professionnelle (*Frontiers in public Health*, 2018). Nos résultats viennent donc apporter des évidences supplémentaires au regard de la littérature qui a déjà montré qu'il existe une association dose-réponse entre le temps passé assis et la mortalité toutes causes confondues, indépendamment du niveau d'activité

physique (Katzmarzyk, Church et al. 2009). C'est une observation particulièrement intéressante puisqu'elle suggère que le temps passé assis ne peut être compensé par une activité physique occasionnelle, même en étant au-dessus des recommandations actuelles. En effet, les comportements sédentaires peuvent être associés à des risques importants pour la santé, même avec un niveau d'activité physique supérieur aux recommandations internationales (Katzmarzyk, Church et al. 2009).

Il semble donc que promouvoir l'activité physique en entreprise afin d'améliorer la santé des salariés ne soit pas suffisant face aux risques engendrés par les comportements sédentaires.

### **Existe-il un profil d'adhésion à ce type de programme en entreprise ?**

Si les résultats présentés et discutés jusque-là mettent bien en avant les effets bénéfiques de programmes d'activité physique mis en place au sein même de l'entreprise sur la santé physique et mentale d'employés du secteur tertiaire, ces derniers doivent être nuancés par une proportion relativement faible de participants ayant réalisés les études jusqu'à leur terme. Le constat d'un nombre important d'abandons au cours de nos deux interventions (Etudes 1 et 2) nous a évidemment conduits à questionner de potentiels facteurs explicatifs (Etude 3). Ainsi, de manière non initialement anticipée, un des résultats principaux de ce travail de thèse repose sur la formulation d'un profil potentiel de participants pour qui ce type d'intervention est adapté alors que pour d'autres il reste inefficace.

Cette nouvelle analyse de nos résultats met en effet en évidence un taux d'abandon de 29% avant la fin des 5 mois d'intervention au cours de l'Etude 1 (*Journal of Occupational and Environmental Medicine*, 2017) et de 38% au temps de mesure intermédiaire (T1) et 55% après 10 mois d'intervention (T2) lors de notre seconde étude (*Journal of Occupational and*

*Environmental Medicine*, 2018). De manière intéressante, alors que ces forts taux d'abandon ne sont pas discutés dans la littérature actuelle, les travaux conduits jusqu'alors semblent également observer un dropout conséquent, quels que soient la durée ou le contenu des interventions proposées (programme d'activité physique, éducation à la santé, etc.). En effet, les auteurs d'une étude de 10 semaines qui proposaient un programme d'activité physique ainsi que du coaching motivationnel, ont observé un taux d'abandon de 22% (Jakobsen, Sundstrup et al. 2015). Dans le même sens, Pedersen et al. ont obtenu un taux de décrochage de 48% au cours d'une étude d'un an où les employés réalisaient 20 minutes d'activité physique en entreprise, 3 fois par semaine durant une année (exercices de résistance + exercices complets) (Pedersen, Blangsted et al. 2009). Ces résultats sont similaires dans les études qui ont proposé des groupes de soutien/motivation avec par exemple 25% d'abandon dans une étude proposant des messages motivationnels (Puig-Ribera, Bort-Roig et al. 2017). En parallèle, une récente étude d'un an a observé 31% de taux de décrochage suite à des réunions de soutien, des groupes de travail (Aittasalo, Livson et al. 2017).

Aucune de ces études n'a cependant essayé d'identifier les raisons de ce fort taux d'abandon. D'après nos résultats (Etude 4), une proportion significativement plus importante d'abandon est observée auprès d'employés présentant un faible niveau de condition physique avant l'intervention, avec de manière importante, un pourcentage de masse grasse plus élevé.

A l'inverse si la principale raison avancée par les participants pour s'engager dans des programmes d'activité physique en entreprise est le gain de temps, il s'avère que la plupart des salariés qui s'engagent assidûment dans ces programmes avouent être déjà actifs et pour eux, ces installations sur site représentent une excellente opportunité de gagner du

temps en dehors du travail (par exemple pendant l'heure du déjeuner). Ils confirment la plupart du temps qu'ils seraient actifs de toute façon et que peu d'entre eux commencent à être actifs grâce à ces dispositifs et programmes proposés au sein des entreprises.

Le design de notre seconde étude interventionnelle présentant trois temps de mesure, dont un temps intermédiaire nous a aussi permis de questionner la potentielle perte de sujets lors de la seconde phase du programme. Ainsi, comme détaillé ci-dessus, si notre intervention de 10 mois a montré une perte totale de sujets de 55% entre le début et la fin du programme (T0 et T2), 38% de dropout entre T0 et T1 (5 premiers mois, mesure intermédiaire) et 29% entre T1 et T2 ont été observés (*Journal of Occupational and Environmental Medicine*, 2018 ; *Work*, 2018). Nous avons pu observer que le degré de réussite du programme à court terme (entre T0 et T1) pourrait déterminer le taux d'adhésion final. En effet, nos données préliminaires indiquent que l'amélioration de la composition corporelle, de l'effort perçu induit par l'exercice ou de la capacité aérobie durant la première phase de l'intervention pourraient influencer l'adhésion à long terme de nos employés. Il semblerait donc que les employés pour qui la mise en place d'interventions pour la santé, et notamment de programmes d'activité physique, soit la plus nécessaire, soient ceux qui présentent le plus faible taux d'adhésion (*Work*, 2018).

En d'autres termes, cette analyse secondaire consacrée à une meilleure compréhension du profil d'adhésion à ce type de programme en entreprise met en avant un taux d'abandon plus important chez les employés présentant un faible niveau d'activité physique, de condition physique et de santé générale au départ de l'intervention et chez ceux pour qui les premières semaines du programme ont un effet encore limité (Figure 7) (*Work*, 2018).

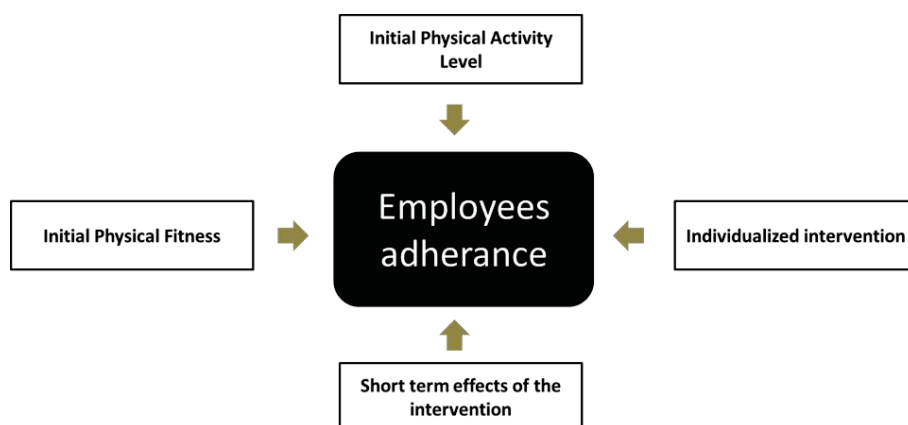


Figure 7. Facteurs pouvant favoriser le taux d'adhésion des programmes d'activité physique.

Ces résultats ne doivent pas être sous-interprétés ni sous-estimés car s'ils ne remettent pas en question l'efficacité des programmes d'activité physique en entreprise proposés aux employés du secteur tertiaire, ils en soulignent en revanche les limites en fonction du profil de ces employés et mettent en avant la nécessité de nouvelles interventions plus adaptées et certainement individualisées.

Ainsi, des bilans de santé initiaux (incluant la condition physique) permettraient de mieux orienter les participants, conciliant leurs attentes, leurs besoins et leur profil de pratiquant, de manière à optimiser les effets des interventions proposées avec une évaluation à court terme (5 mois) afin d'adapter encore le programme pour les « non gainers » c'est-à-dire ceux qui ne montrent pas d'amélioration des paramètres de condition physique et/ou de bien-être.

### Activité physique en entreprise : où en sommes-nous ?

Alors que l'entreprise a été suggérée comme un lieu de choix pour le développement et l'implémentation de nouvelles stratégies et interventions visant à améliorer la santé de la



population adulte, notamment à travers la promotion d'un mode de vie sain et actif, la littérature reste méthodologiquement hétérogène et relativement vaste. En 2009, Anderson et collaborateurs ont proposé un modèle analytique présentant les potentielles stratégies interventionnelles et leurs leviers d'action, permettant une amélioration des modes de vie et *in fine* de la santé des employés (Figure 8) (Anderson, Quinn et al. 2009). D'après leur modèle, les interventions en milieu du travail passent principalement par l'information et l'éducation à la santé (« informational messages, behavioral and social skills or approaches ») et par une adaptation du milieu et contexte de travail (« environmental changes and policy »), de manière à modifier les connaissances et comportements des employés ainsi que l'environnement du site de travail, tout ceci permettant l'adoption d'un mode de vie plus sain et ainsi une amélioration de la santé du travailleur (Figure 8).

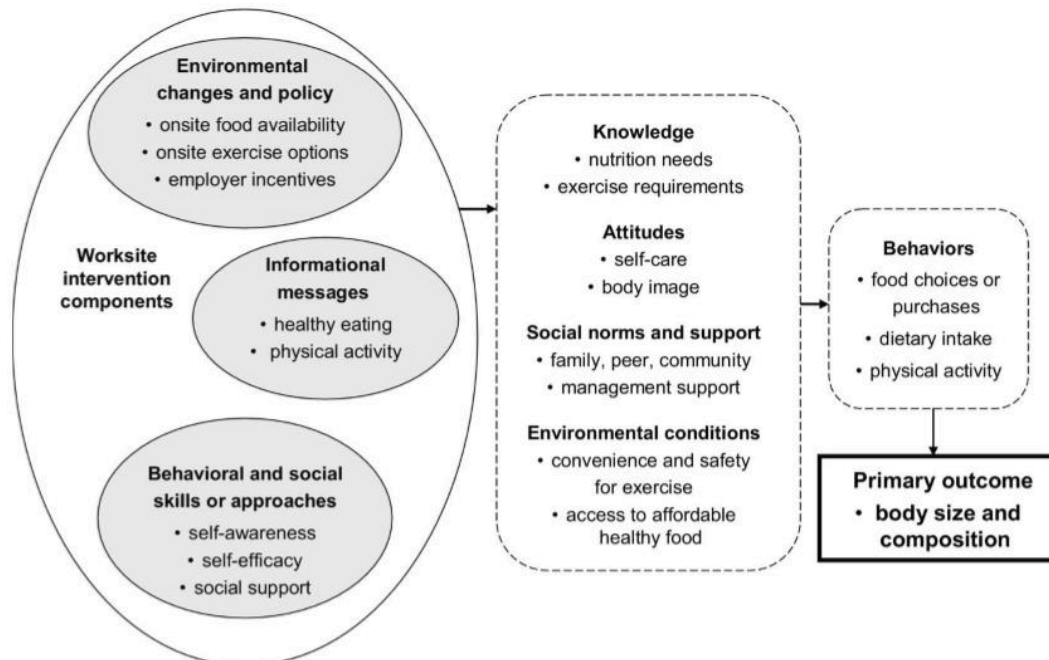
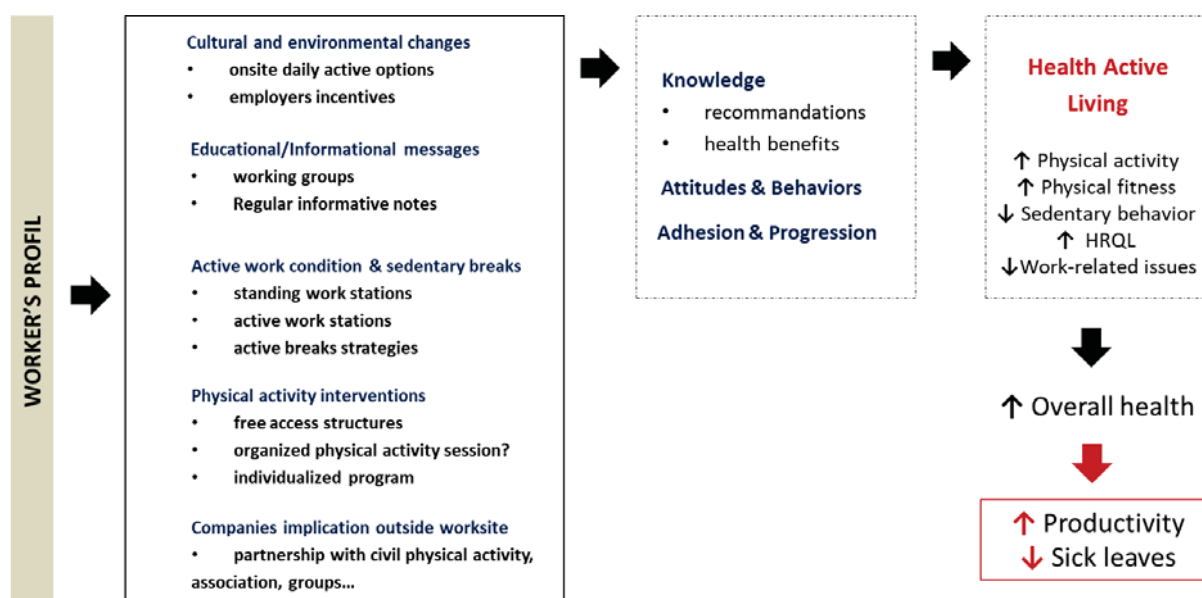


Figure 8. Cadre analytique pour les interventions de nutrition et d'activité physique dans le but d'améliorer le poids des salariés (Anderson et al., 2009).

Si ce modèle proposé en 2009 combine des approches de nutrition et d'activité physique, la Figure 9 propose une actualisation de ce dernier au regard de la littérature plus récente, considérant uniquement les enjeux liés à l'activité physique. Ainsi, d'après cette nouvelle conceptualisation, le profil initial de l'employé est à la base de l'orientation de l'intervention et de sa réussite. S'il semble évident que les approches informatives et éducationnelles, ainsi que le développement d'un environnement (attractivité des escaliers, aménagement de trajets plus agréables d'un point à un autre de la structure, etc.) et d'une culture favorable à l'activité quotidienne doivent être présents au sein de toutes les entreprises, nous avons enrichi le modèle d'approches visant à lutter contre la sédentarité, non pas en substitut à l'activité physique, mais en complément. Il semble en effet au regard de la littérature et de nos résultats, qu'une étape préliminaire incontournable à la mise en mouvement des employés passe par la rupture d'un temps de sédentarité toujours trop important, grâce à l'instauration de stations de travail actives ou encore de breaks actifs. Nos résultats montrent bien en effet que la seule augmentation du niveau d'activité physique peut conduire à des bénéfices réduits si elle ne s'accompagne pas d'une réduction du temps de sédentarité. Enfin, s'il nous semble important de présenter dans ce modèle les programmes d'activité physique effectués au sein même des entreprises, ces derniers doivent être individualisés dans leurs structurations et contenus au regard du profil des employés.

Le développement d'une culture de l'activité et de la santé semble également primordial. En effet, en soulignant les différents freins à la pratique physique en entreprise, certains auteurs ont montré que l'obstacle principal à cette participation est la culture interne à l'entreprise (Bredahl, Saervoll et al. 2015). Les salariés demandent plus d'interactions entre eux et leur direction, plus de soutien et plus d'aménagements propices à la pratique. Afin de réduire ces obstacles, ils demandent aussi la mise en place de plages horaires plus

facilitantes pour la pratique sur le lieu de travail. Certains salariés identifient quant à eux la charge de travail comme étant la première barrière les limitant à s'engager dans différentes stratégies d'interventions en milieu de travail (Hadgraft, Brakenridge et al. 2016). Ces observations justifient la nécessité de favoriser un environnement et une culture d'entreprise propices à la pratique. Il nous semble aussi, comme cela sera développé dans les perspectives de ce travail, important d'encourager les chefs d'entreprises à développer des partenariats avec les clubs et associations locales de manière à favoriser l'adhésion de certains employés ne souhaitant pas s'impliquer dans une pratique physique régulière sur leur lieu de travail et/ou avec leurs collègues. En effet, certains employés expliquent leur non engagement au sein de programmes conduits en entreprise en raison des barrières qu'il existe entre les salariés et leurs supérieurs, ce qui les empêchent de pratiquer sereinement (Hadgraft, Brakenridge et al. 2016).



**Figure 9. Proposition d'un nouveau modèle de promotion d'un mode de vie actif et de l'activité physique par et au sein de l'entreprise.**  
HRQL: Health Related Quality of Life.

Tous ces leviers d’actions devraient contribuer à améliorer et à développer les connaissances et la prise de conscience des employés pour un mode de vie actif et sain de manière à favoriser leur implication et garantir leur adhésion, pour à la fois améliorer leur santé générale et leur bien-être (physique, psychique, social) mais aussi pour optimiser leur activité professionnelle par une réduction du nombre et de la fréquence des arrêts de travail et une amélioration de la productivité (Figure 9).

## **VI. Perspectives**

### **Des programmes d’activité physiques plus adaptés.**

Nous avons vu que les programmes d’activité physique en entreprise ne favorisaient pas systématiquement l’adhésion de l’ensemble des salariés. Il serait donc intéressant de pouvoir identifier, selon le profil des employés, ceux qui ont besoin de programmes plus adaptés, d’interventions individualisées, afin de pouvoir agir sur cette population. Si l’activité physique en entreprise est une barrière pour ce public, il semblerait pertinent de pouvoir réaliser des collaborations entre les entreprises et des associations à proximité par exemple, afin de proposer de la reprise d’activité personnalisée (cf modèle Figure 9). Il semblerait aussi nécessaire de mettre l’accent sur la réalisation d’activité physique en groupes plus restreints et plus homogènes puisque cet aspect fait aussi partie des barrières rencontrées au sein des programmes sur le lieu de travail. En effet, proposer la reprise d’activité par groupe de niveaux pourraient permettre de faire adhérer plus facilement les salariés et sur plus long terme. Une étude menée sur les freins à l’activité physique en entreprise a effectivement montré que les salariés demandent plus de soutien et plus

d'accompagnement dans la pratique physique (Bredahl, Saervoll et al. 2015), ceci pouvant justifier de proposer cette reprise d'activité accompagnée en faible nombre. Nos études montrent qu'en fait ce sont les employés qui en ont le plus besoin (inactifs, sédentaires, faible condition physique, masse grasse élevée...) qui sont ceux qui n'adhèrent pas aux programmes ou qui abandonnent rapidement. Ce sont ces employés « à risques » qu'il faudrait pouvoir cibler par des programmes encore plus adaptés et personnalisés, avec un suivi et soutien rapprochés.

### **Une approche combinée Activité Physique / Sédentarité.**

En parallèle, la complexité des activités tertiaires (qui par définition, favorisent la sédentarité, combinée à l'effet indépendant du temps sédentaire et de l'activité physique sur la santé) devrait conduire les intervenants et les praticiens, à mener des interventions individualisées non seulement en favorisant l'activité physique, comme nous avons pu le voir, mais aussi en essayant de rompre ce temps sédentaire. En effet, les comportements sédentaires sont une préoccupation contemporaine, le temps passé assis de manière prolongé étant associé à des problèmes de santé importants, indépendamment du niveau d'activité physique (Patterson, McNamara et al. 2018). Nous savons dorénavant que le niveau de santé est influencé par le haut niveau de sédentarité, mais qu'il existe de nouvelles stratégies pour essayer de lutter contre la sédentarité imposée par la tâche professionnelle des salariés. Si de nombreux travaux ont été conduits pour évaluer les effets de stratégies de réduction de ce temps sédentaire dans les entreprises, aucun n'a à notre connaissance proposé une approche combinant à la fois activité physique et rupture de la sédentarité, alors que nos résultats semblent en justifier l'intérêt. Il y a depuis peu un intérêt pour les postes de travail actifs, avec un accent croissant sur la réduction du temps

sédentaire (Chau, der Ploeg et al. 2010), et cette option pourrait être une possibilité à envisager. Les bureaux actifs sont conçus pour combiner travail sédentaire et activité physique de faible intensité. Certains résultats suggèrent qu'il y a de meilleurs bénéfices pour la santé, comparativement à l'augmentation de l'activité physique en dehors des périodes sédentaires, en utilisant des activités de faibles intensités maintenues pendant de plus longues périodes (Levine, Schleusner et al. 2000). De plus, le concept des postes de travail actifs a été introduit afin d'augmenter le temps quotidien total d'activité physique, tout en diminuant simultanément le temps de repos inactif. Ainsi, les postes de travail actifs présenteraient un intérêt pour la santé cardio-métabolique en réduisant le temps sédentaire et en améliorant les paramètres de santé physique. Il est important de noter qu'il existe aujourd'hui désormais plusieurs types de postes actifs (pédalier, tapis de marche, assis-debout etc.), ce qui permettrait de rompre la monotonie avec un choix plus large, et éviter les abandons possibles. En effet, nous n'avons pas encore assez de recul sur ce sujet face à la littérature actuelle même si certains auteurs ont essayé de déterminer quelle station active était favorisée quand elles sont proposées en libre accès (Bastien Tardif, Cantin et al. 2018). En parallèle, l'introduction d'« active breaks » est aussi en plein développement. En effet, de très courtes périodes d'activité physique peuvent être plus faciles et plus attrayantes pour une population relativement sédentaire, face à des périodes d'activités plus longues. Ce type d'intervention a déjà montré des avantages modestes mais constants (Barr-Anderson, AuYoung et al. 2011). Intégrer des interventions comme celles-ci dans la routine de travail des salariés du secteur tertiaire au quotidien a déjà été mis en place dans différentes études, mais il serait intéressant d'essayer de combiner ceci avec un programme d'activité physique. Comparer un groupe activité physique seul, avec un groupe rupture de la sédentarité et un groupe qui associe ces deux stratégies (programme d'activité physique + rupture temps

sédentaire) pourrait être une piste d'investigation prometteuse. Néanmoins, il serait intéressant de proposer en supplément une combinaison d'approches avec des ergonomes puisqu'en effet, il n'y a pas assez de recul sur l'utilisation de ces stations actives, ce qui veut dire qu'aucune certitude n'existe du point de vue des conséquences (effets secondaires) musculo-squelettiques.

## **VII. Conclusion générale**

En conclusion, les travaux conduits dans le cadre de ce travail de Doctorat CIFRE ont permis d'attester de la faisabilité de l'implémentation et de l'évaluation individualisée de programmes d'activité physique structurés en entreprise au sein d'employés du secteur tertiaire, caractérisés par un haut niveau de sédentarité (Figure 10). Nos résultats soulignent que le niveau de santé est obligatoirement influencé par le haut niveau de sédentarité, et que le profil initial des salariés doit être déterminé afin de favoriser l'adhésion aux programmes. Néanmoins, l'implication des employés dans ce type de programmes repose sur la création d'une culture dynamique d'un mode de vie actif au sein de l'entreprise et leur réussite dépend du profil individuel des employés et de l'efficacité du programme à court terme. De manière importante, nos résultats mettent clairement en avant que la santé générale des employés de ce secteur tertiaire ne peut pas être uniquement améliorée par l'accroissement de leur niveau d'activité physique mais également très certainement par la réduction concomitante de leur temps de sédentarité. Si les travaux conduits jusqu'alors se sont intéressés de manière isolée à la promotion du niveau d'activité physique d'un côté ou

à cette rupture de sédentarité des approches combinées doivent être maintenant conduites de manière individualisée.

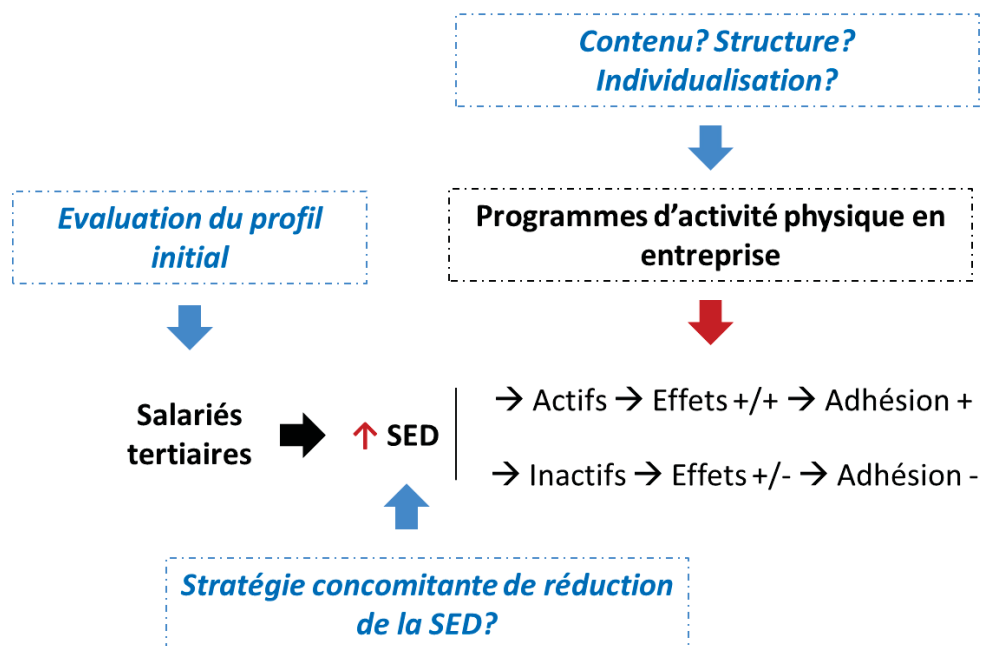


Figure 10. Schématisation des principales conclusions et perspectives.

SED : sédentarité



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## IX. Annexes

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### 1. Annexe 1 – Présentation de la structure ASM Omnisports.

Ce travail doctoral a fait l’objet d’un Contrat Industriel de Formation par la Recherche (CIFRE) financé par l’Association Nationale de la Recherche et de la Technologie (ANRT). Cette thèse a ainsi été portée par la collaboration de deux entités, l’une universitaire et l’autre industrielle : le Laboratoire des Adaptations Métaboliques à l’Exercice en conditions Physiologiques et Pathologiques (AME2P) de l’Université Clermont Auvergne et le pôle Santé Bien-Être de l’Association Sportive Montferrandaise (ASM). Ce travail s’est intéressé à l’évaluation d’un programme d’activité physique en entreprise auprès de salariés du secteur tertiaire sur les paramètres de santé et de condition physique. La réalisation de cette thèse a été faite suite à la demande du président de l’Association Sportive Montferrandaise (ASM), Pascal Thibault, avec un pilotage scientifique réalisé par le CHU de Clermont-Ferrand.

### **a. Les fondements de l'ASM.**

L'Association Sportive Montferrandaise (ASM) a été fondée, en 1911 par Marcel Michelin. Réservée, à l'origine, aux employés de l'entreprise Michelin, elle s'est ouverte depuis longtemps à son environnement. L'ASM Omnisports propose à près de 6.500 adhérents de nombreuses activités sportives au travers de 15 sections sportives et dans des infrastructures dont elle assure la gestion.

### **b. L'organisation fonctionnelle.**

L'ASM Omnisports, fidèle à ses origines et à ses valeurs, a défini une stratégie qui repose sur trois pôles d'excellence :

- Le pôle « ASM Vitalité » qui propose des offres d'activités physiques et sportives adaptées à tous à finalité santé et bien-être ;
- Le pôle « Sport Avenir Jeunesse » qui œuvre pour l'intégration des jeunes par le sport ;
- Le pôle « Pépinière de Haut Niveau » qui a pour objectif de former la future élite du rugby de l'équipe professionnelle.

Cette stratégie s'appuie sur une approche multisports et sur un travail de fond, au sein de ses 3 pôles d'excellence dont l'activité est transverse aux 15 sections sportives.

L'ASM Omnisports est une structure professionnalisée, avec 75 ETP salariés chargés de coordonner, gérer, mettre en œuvre et coordonner l'ensemble des activités physiques et sportives.

### **c. Le pôle ASM Vitalité.**

La finalité du pôle ASM Vitalité est d'accompagner la reprise et le maintien d'une activité physique régulière, de manière durable et individualisée.

Les objectifs fonctionnels sont donc de proposer aux adhérents :

- Des pratiques d'activités physiques diversifiées (éviter la lassitude, maintenir le plaisir de pratique, bénéficier des effets positifs et complémentaires d'activités physiques différentes) ;
- Des pratiques d'activités physiques encadrées par des professionnels (assurer la sécurité des pratiquants, adapter le contenu des séances).

Des pratiques d'activités physiques adaptées à des environnements et des enjeux différents (en milieu associatif, dans le cadre de projets de collectivités, de la cadre de projets institutionnels, en entreprises).

#### **d. Historique et évolution.**

Développé depuis 2007, le dispositif d'activités physiques Santé et Bien-être ASM VITALITE 'Entreprises' s'inscrit comme un axe développement majeur de l'ASM Omnisports en réponse aux besoins des entreprises et de la société en général.

Il s'appuie sur l'expérience développée pour la Manufacture Michelin et à destination de ses employés. Ce projet a été déployé sur tous les sites clermontois de la Manufacture ainsi que sur le site de Roanne (6 salles d'activités physiques au total pour près de 1600 salariés adhérents au dispositif ASM Vitalité / Michelin).

L'ASM Omnisports met désormais ce concept à disposition d'autres entreprises ou institutions auvergnates (CPAM Puy de Dôme, BE Ys, Leroy Merlin...), à l'échelle régionale (Auvergne Rhône Alpes) ou Nationale.



## Effect of a 5-Month Worksite Physical Activity Program on Tertiary Employees Overall Health and Fitness

Pauline Manon Genin, MSc, Fabrice Degoutte, PhD, Julien Finaud, PhD, Bruno Pereira, PhD, David Thivel, PhD, and Martine Duclos, PhD

**Objective:** This pilot study questions the effects of a worksite physical activity program on health and fitness in tertiary employees. **Methods:** Ninety-five employees were randomly assigned to Control (CON); Novice (NOV); Experienced group (EXP). The NOV and EXP groups followed a 5-month worksite physical activity program (at least two sessions/week). Body composition, physical activity level and physical fitness, eating habits, health perception, sleep quality, pain, and quality of life were assessed. **Results:** Fat mass decreased in NOV and EXP; the distance covered during the 6-minute walking test, push-ups, squat jump increased for NOV and EXP group. Physical activity level, health perception, quality of sleep, and eating habits were improved in NOV. **Conclusion:** This study underlines for the first time the beneficial effects of such worksite programs among tertiary employees on overall health and the feasibility of its design.

It is estimated that physical inactivity contributes to almost one in ten premature deaths (based on life expectancy estimates for world regions) from coronary heart disease and one in six deaths from any cause.<sup>1</sup> Sedentary behavior is associated with poor health on any age range, independently of the level of physical activity.<sup>2</sup> Sedentary behavior may not be only defined by lack of physical activity since effectively people can achieve recommended levels of physical activity, and yet spend large amounts of remaining time inactive.<sup>3,4</sup> These long periods of sedentary behavior increase risk of cardiovascular diseases, type 2 diabetes, cancers, obesity,<sup>2</sup> even in individuals with activity in the recommended levels.

Regular physical activity is key in the primary prevention of at least 35 chronic conditions.<sup>5</sup> Nowadays, exercise is the first-line treatment of 26 chronic diseases.<sup>6</sup>

Besides its effects on health-related physical fitness, physical activity is now recognized for its benefits on mental health, with many studies showing that regular physical activity reduces depression and anxiety symptoms, improves mood, and helps with stress management.<sup>7-9</sup>

French public health recommendations include a minimum of 150 minutes of moderate to vigorous exercise per week; however, less than half of 15 to 78 years old population is considered as active.<sup>10</sup> In addition, French working adults spent an average of 9.96 hours/day sitting on workdays (whose 4.17 hours/day in work

sitting) and 7.58 hours/day sitting on non-workdays.<sup>11</sup> The same study reported that being sedentary at work was associated with more sedentary behavior outside of work.

Worldwide, public health policies underline the urgent necessity to create a suitable culture of regular physical activity<sup>12,13</sup> where employers are encouraged to play a key role in the promotion of health and well-being among adults of working age.<sup>14</sup>

Workplaces represent today an ideal opportunity for new initiatives to promote physical activity. Workplaces could indeed reduce some barriers identified to limit the engagement into physical activity, such as lack of time and proximity.<sup>15</sup> Due to the difficulty of changing the population habits and to engage them in activity on usual contexts (such as associations, gymnasiums, etc), worksite programs might provide a great way to incite employees to increase their activity, especially due to the time people spend at the workplace.<sup>16</sup>

Increasing the level of employees' physical activity might maintain them healthy, reducing health care costs.<sup>17</sup> Moreover, more than 37% of USA workers are currently overweight (body mass index (BMI)  $\geq 25$  kg/m<sup>2</sup>), at least 29% are obese (BMI  $\geq 30$  kg/m<sup>2</sup>),<sup>18</sup> and this is associated with an increased rate for absenteeism and lost productivity.<sup>19,20</sup>

This illustrates the important economic benefit associated with regular physical activity, reducing the combined cost of different treatments for avoidable diseases and reducing the number of sick leave due to diseases or wounds.<sup>21,22</sup>

Some previous studies have indeed shown that interventions conducted to improve employees' health induce a reduction in absenteeism and sick leave, and favor increased productivity.<sup>23,24</sup>

It seems then that workplace-based physical activity interventions can improve global health, physical activity level,<sup>24-26</sup> weight status,<sup>27</sup> and may have positive effects on eating behavior.<sup>28</sup> However, a recent systematic review identified a low effect of such physical activity programs implemented on worksites.<sup>29</sup> This low effect might be due to a large heterogeneity in the individual effects. Moreover, these studies mainly focused their analysis on lifestyle improvements (physical activity increased in everyday life, outside of workplace),<sup>24,26</sup> and long-term outcomes such as productivity on workplace and sick leave.

Although there is a growing interest in the scientific literature concerning workplace physical activity interventions, most of the studies conducted so far focused specifically on health indicators (weight status, body composition, physical activity level, pain). The aim of this pilot study is to question the multidimensional effects of a workplace-implemented physical activity program on overall health using a large number of physical and psychological indicators.

### METHODS

#### Population and Design

Ninety-five office employees (tertiary sector workers) aged  $44 \pm 9.9$  years took part in this experimental study (62 males and 33 females). Participants were approached through the manufacture internal network. All the participants received information sheets and signed consent forms as requested by ethical authorities (Local Human Protection Committee).

After a medical visit to ensure the ability of the participants' to complete the entire protocol, they were stratified into three

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The authors have no conflict of interest to disclose.

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subgroups: (i) Control group (CON  $n = 22$ ; engaged in less than 150 minutes moderate physical activity per week for at least one year, according to the IPAQ short-form questionnaire) and not motivated to start the worksite physical activity program, (ii) Novice group (NOV = 37; participants unsupported by physical activity and who started the worksite physical activity program at the beginning of the study), (iii) participants engaged in the worksite physical activity program for the last 2 years at least (minimum of two 45 minutes sessions per week) [Experienced (EXP)  $n = 36$ ]. A first visit (V1) was realized in January 2016 in which the participants were asked to fill in several questionnaires (Quality of Life, Physical Activity Level, Sleep Quality, Somnolence, Insomnia, Eating Behaviors, Health Perception, and Pain), anthropometric measurements were performed, their body composition was assessed, and their physical fitness was evaluated using different physical tests. This visit was done by the same experimenter (PG) at worksite and during work time. All these measurements were also performed at the end of study (V2), 5 months later.

### The Worksite Physical Activity Program

EXP and NOV group were requested to take part in two training sessions per week, within their worksite training program. Each session should last 45 minutes minimum, alternating between muscle strengthening and cardiorespiratory exercise (one of each per week), supervised by a professional for a duration of 5 months (from February to June 2016). Their worksite facilities propose 18 free different physical activities distributed in groups, such as muscle strengthening, stretching, cardiorespiratory, or team sport. Each activity lasts around 45 minutes. Thus, the participants can choose the activities they want in these categories: muscle strengthening (weights machines) or cardiorespiratory (Latino dance, step, bike, fight exercise). The compliance was controlled by the computerized access to the sport facilities. Participants were also allowed to add a third weekly session, choosing among collective activities (ie, Pilates or stretching).

### Anthropometric Measurements and Body Composition

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Both mass and height were obtained at the same time of the day for the same subject, and not in the fasting state. BMI was calculated as body mass (kg) divided by height squared ( $m^2$ ).

Body composition was assessed by bioelectrical impedance analysis, performed with the Tanita MC780 (Hong Kong, China) multifrequency segmental body composition analyzer. This analyzer consists in a stand-alone unit where the subject has to step on bare foot (standard mode). Information concerning the subject (age, gender, and height) is entered by the experimenter. Once body mass has been assessed by the scale, the subject has to take grips with both hands (alongside his body) during the impedance measure (Hand-to-foot bioelectrical impedance analysis [BIA]). A full segmental analysis is performed in less than 20 seconds. Segmental fat mass and fat-free mass values are indicated by the end of the analysis on the digital screen (trunk, left and right arms and legs), as well as total body fat, fat-free mass, and water. Total fat and fat-free mass were reported by the researcher into an excel sheet for statistical treatment. The newly developed BIA analyzer has been recently validated in healthy adults.<sup>30</sup>

### Physical Activity Level (Short Version of the International Physical Activity Questionnaire IPAQ-SF)

This questionnaire consists of six questions asking participants to recall aspects of their physical activity over the last 7 days

(in this work, total physical activity does not include sitting time). The IPAQ-SF encompasses the amount of time spent sitting (in this work, total sitting time and the time spent seated during screen activities have been considered separately), walking and participating in moderate-to-vigorous physical activities for at least 10 minutes at a time in the last 7 days. The participants' physical activity level was expressed in MET/h/week.<sup>31</sup>

### Well-being, Quality of Life, and Health Perception

Well-being and quality of life at work were assessed using a newly developed questionnaire ("worksite well-being and quality of life questionnaire") especially designed for occupational health studies. The participants were asked to rate statements describing well-being state at work using visual analogue scales ranging from "not at all" to "absolutely" (ie, "I'm actually feeling distressed while at work"). This questionnaire has been recently validated in a similar population.<sup>32</sup>

All participants were also demanded to complete a short self-administered questionnaire specifically designed to explore their perception of health ("health perception scale"). Six criteria were investigated: (1) perceived physical fitness, (2) perceived ideal weight, (3) perceived healthy balanced diet, (4) perceived sleep quality, (5) perceived stress level, and (6) perceived general health. A 10-point scale from 1 (not at all) to 10 (very much) was used to assess each item. The six individual scores were computed to obtain a global score for health perception. This questionnaire has been previously validated in adults.<sup>33</sup>

## SLEEP

### Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI) is a self-rated questionnaire assessing sleep quality and disturbances over a 1-month time interval. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of scores for these seven components yields one global score. Clinical and clinimetric properties of the PSQI were assessed over an 18-month period with "good" sleepers and "poor" sleepers.<sup>34</sup>

### The Insomnia Severity Index (ISI; Morin, 1993)

The Insomnia Severity Index (ISI) assesses subjective symptoms and consequences of insomnia, and the degree of anxiety or distress caused by sleep difficulties.<sup>35</sup> The ISI is composed of seven items measuring the severity of sleep discordance (difficulty initiating sleep, difficulty maintaining it, waking too early in the morning), satisfaction with current sleep, disruption of daily functioning, perception of entourage about the apparent deterioration of the quality of life, and degree of worry or concern about sleep difficulties. Each item is rated on a scale from 0 to 4 and the total score ranges from 0 to 28. Typically, the total score at the ISI is used to classify individuals according to the severity of their insomnia: absence of insomnia (0 to 7), mild insomnia (8 to 14), moderate insomnia (15 to 21), severe insomnia (22 to 28).

### Somnolence Scale: Epworth<sup>36</sup>

The Epworth Sleepiness Scale (ESS) is a self-administered eight-item questionnaire that has been proposed as a simple method for measuring daytime sleepiness in adults (patients with various sleep disorders). This brief questionnaire asks subjects to rate on a 0 to 3 scale the chance that, over "recent times" they would have dozed in eight specific situations that are commonly met in daily life (0 = would never doze; 3 = high chance of dozing). Thus, subjects are asked to retrospectively characterize part of their usual behavior in a variety of situations that are more or less soporific. Subjects are



asked to distinguish dozing behavior from feeling of tiredness. The ESS score is the sum of eight item-scores and can range from 0 to 24.

### Pain

Pain was evaluated using the Nordic questionnaire that is a standardized and validated questionnaire usually used by occupational health practitioners to detect musculoskeletal pain.<sup>37</sup> The questions concentrate on symptoms most often encountered in an occupational setting focusing on work-activities specific musculoskeletal symptoms. The questions are forced choice variants that might be either self-administered or used in interviews, and in the present work, the questionnaire was self-administered.<sup>38</sup>

Pain was also assessed using the QuickDASH questionnaire. This is an 11-item disability scale. Participants are asked to indicate the amount of difficulty performing activities, the amount of limitation, or the extent of interference with activities (ranging the difficulty from 1 to 5, with 1 indicating the least impairment and 5 indicating the most). Items inquiring about the extent of arm, shoulder, and hand pain and tingling are rated from 1 (none) to 5 (extreme). Scores are summed and averaged, and the value is transformed to a score from 0 to 100 by subtracting 1 from the average and multiplying by 25. Higher scores indicate greater disability.<sup>39</sup>

### Eating Behaviors

Eating habits were collected using a self-administered questionnaire ("eating habits questionnaire") commonly used in clinical routine and research. Emphasis was placed on frequency of breakfast, snacking, tendency for extra helping during meals, and the type of beverages consumed. One question was asked in relation to each of these specific eating habits. Each item was clearly explained, and all the questions were followed by predetermined responses to facilitate comprehension (ie, "Do you eat breakfast? Every Day—Often—Sometimes—Never"; "Do you snack between meals? Every Day—Often—Sometimes—Never"; "Do you have tendency to have extra-helping during meals? Every Day—Often—Sometimes—Never"; "Which kind of drink do you consume when you are thirsty? Water - Sugar-sweetened beverage"). This questionnaire was adapted from validated eating habits questionnaire.<sup>40,41</sup>

### Physical Fitness

#### Aerobic Fitness

The patients were asked to perform a 6-minute Walking Test that was performed on an indoor 20-m corridor, following the recommendations from the American Thoracic Society (ATA). The subjects were instructed to walk the longest distance in 6 minutes. After 6 minutes, the distance covered was measured to the nearest meter by an investigator. Participants were asked to wear a heart rate monitor (Polar Electro Inc, Lake Success, NY) during the test and heart rate was recorded at the end of the 6 minutes. This test has been found reliable in healthy subjects<sup>42</sup> and it is highly reproducible.<sup>43</sup>

#### Muscle Capacities

Upper limbs muscle strength was assessed using the handgrip method, using the dominant and nondominant hand, as a non-invasive marker of muscle strength of upper extremities, well suitable for clinical use.<sup>44</sup> The participants were also asked to perform a maximal number of push-ups (knees on the floor) respecting an imposed frequency. The test stopped once they were not able to maintain this rhythmicity anymore or had difficulty to maintain the imposed position.<sup>45,46</sup> Lower limb muscle strength was assessed during both a squat and a counter movement jump using the

Optojump technology (Microgate SRL, Rome, Italy).<sup>47</sup> The Shirado test was used to assess the static endurance of the abdominal muscles<sup>48</sup> and the Sorensen test to assess back strength and the endurance of all the muscles involved in extension of the trunk.<sup>49</sup>

### Balance and Flexibility

The Sit-and-Reach test was used to evaluate the participants' flexibility,<sup>50</sup> while their balance was assessed using the Flamingo test.<sup>51</sup>

### STATISTICAL CONSIDERATIONS

All analyses were performed using Stata software (version 13; StataCorp, College Station, TX) and R software (<https://cran.r-project.org/>, package ADE4). Statistical analyses were done for a two-sided type I error of  $\alpha$  equal to 5%. Baseline subject's characteristics were presented as the mean  $\pm$  standard deviation (SD) or the median (interquartile range) for continuous data (assumption of normality assessed by using the Shapiro-Wilk test) and as the number of patients and associated percentages for categorical parameters. Quantitative variables were compared between independent groups (CON, NOV, and O2) by analysis of variance (ANOVA) or Kruskal-Wallis (KW) tests if conditions of ANOVA were not respected (normality and homoscedasticity analyzed using Bartlett test). When appropriate ( $P < 0.05$ ), post hoc test for multiple comparisons was applied to a type I-error correction: Tukey-Kramer post ANOVA and Dunn post KW. Comparisons between independent groups were done by Chi-squared or when appropriate by Fischer exact test for categorical variables. To analyze repeated correlated data, random-effects models were performed to study fixed effects as group, time-points evaluation and their interaction taking into account between and within-subject variability. The normality of residuals was checked for all models. Finally, multidimensional analyses as factorial mixed data analysis (FMDA) were performed for T0 data to complete these analyses. These statistical methods were useful for analyzing assets as elements of qualitative and quantitative variables in order to (1) uncover the underlying relationships and structures of the measured variables (latent constructs) and (2) to aggregate subjects into clusters such that each cluster represents a topic. When quantitative and categorical data are studied together, the usual methodology is to transform quantitative variables, categorizing them so as to submit these new variables in an exploratory multiple correspondence analysis (MCA). This methodology is relatively easy to implement and can be used when sample sizes are sufficient ( $n > 100$ ). Otherwise, the MCA could give unstable and nonrobust results. It is interesting to use the FMDA approach in two particular situations: (1) when the number of categorical variables is very small compared with the quantitative variables and (2) when the sample size is low. According to the limited literature on this subject, it appeared difficult to estimate an optimal sample size in order to question the multidimensional effects of a workplace-implemented physical activity program on overall health and fitness. Also, sample size has been estimated according to Cohen recommendations [Statistical power analysis for the behavioral sciences (2nd Ed.). New Jersey: Lawrence Erlbaum, 1988] who has defined effect-size bounds as small (ES: 0.2), medium (ES: 0.5), and large (ES: 0.8, "grossly perceptible and therefore large"). We calculated that a minimum of 22 workers per group would allow to highlight an effect size equal to 1 for a type I error  $\alpha$  equal to 0.018 (two-tailed with correction due to multiple comparisons) and statistical power of 80%. Considering possible to follow-up, we finally chose to include a minimum of 25 workers per group.

As no difference was found depending on the number of exercise session per week, all the participants have been grouped. A sensibility analysis was performed to measure the possible impact of



missing data (notably imputation of missing data). Results and practical conclusions were analogous (data not shown).

## RESULTS

Table 1 details the results for anthropometric characteristics and body composition of the employee.

No significant change in weight was observed during the study. By contrast, the two groups NOV and EXP significantly lost fat mass between T0 and T1. Some of this fat mass loss was central fat mass as waist circumference decreased. The mixed model shows a significant difference for waist circumference between CON and NOV ( $P \leq 0.05$ ) and between CON and EXP ( $P \leq 0.01$ ). The waist circumference delta was significantly higher ( $P \leq 0.05$ ) in the NOV group ( $-1.74 \pm 1.88$  cm) than in the CON group ( $0.04 \pm 1.04$  cm). Similar results were observed for hip circumference: the delta was higher in the NOV group than in the CON group ( $P \leq 0.01$ ) and higher in the EXP group than in the CON group ( $P \leq 0.05$ ).

There is a time effect on the distance walked in the 6-minute walk test between T0 and T1 with a significant increased distance in the three groups (Table 2), but no difference in the distance gained between each group.

The mixed model shows a significant difference for Shirado test between CON and NOV ( $P \leq 0.05$ ), and a significant difference between CON and NOV for counter movement jump. A time effect was depicted between T0 and T1 with a significant progression for the push-ups and the squat jump for NOV and EXP.

NOV increased their flexibility between T0 and T1 with a time effect.

Concerning balance, there is a time effect between T0 and T1 for balance open right for EXP and for balance open left for NOV and EXP.

Table 3 details the results for the different questionnaires.

The mixed model shows a significant difference for health perception between NOV and EXP ( $P \leq 0.001$ ). The health perception delta was significantly higher in NOV than in EXP ( $P \leq 0.01$ ). Moreover, there was a time effect between T0 and T1 for CON and NOV.

Concerning physical activity level, a time effect was depicted between T0 and T1 for CON and NOV, with both groups increasing their physical activity level. However, either at T0 or at T1, the EXP is the group with higher physical activity level. The mixed model for this questionnaire showed a significant difference between CON and NOV (NOV > CON,  $P \leq 0.05$ ) and between NOV and EXP ( $P \leq 0.01$ ). And the delta was significantly higher ( $P \leq 0.05$ ) in the NOV group than in the EXP. This was not associated with decreased time spent sitting.

The multidimensional analysis (Fig. 1) illustrates the associations between the different parameters studied. As mentioned in the statistical description, T0 only was considered in this analysis (where the NOV and CON groups are computed).

According to this approach, it appears that being part of the EXP group is strongly associated with better performance during functional tests (Shirado and Sorensen, 6-minute walking test, push-ups, or vertical jumps). The EXP also shows good sleep quality, good health perception, and higher level of physical activity. Conversely, participants in the CON group not only show higher values of fat mass, BMI, waist to hip ratio/hip circumference, but also more severe pain and poor sleep quality.

## DISCUSSION

Although public health policies encourage higher physical activity level and try to reduce sedentary behaviors at any age, workplaces have been pointed out as pertinent and interesting settings to favor physical activity.<sup>15</sup> Studies remain however contradictory with some authors showing positive effects of physical activity programs implemented inside companies,<sup>21,52,53</sup> while

TABLE 1. Baseline and Evolution of Anthropometry and Body Composition Parameters by Group

	CON			NOVICE			EXP			Mixed model	ANOVA $\Delta$	Post hoc $\Delta$
	T0	T1	$\Delta$	T0	T1	$\Delta$	T0	T1	$\Delta$			
Weight, kg	74.1 $\pm$ 19.7	79.5 $\pm$ 16.3	5.4 $\pm$ 3.4	77.3 $\pm$ 16.3	72.8 $\pm$ 13.1	-4.5 $\pm$ 3.2	72.6 $\pm$ 14.5	71.5 $\pm$ 13.9	-0.64 $\pm$ 1.38	ns	ns	
BMI, kg/m <sup>2</sup>	25 $\pm$ 5.4	26.3 $\pm$ 4.5	0.01 $\pm$ 0.26	25.8 $\pm$ 4.5	24.2 $\pm$ 2.9	-0.35 $\pm$ 0.66	23.7 $\pm$ 3.3	23.8 $\pm$ 3.4	-0.22 $\pm$ 0.47	ns	ns	
WC, cm	93.6 $\pm$ 16.7	97.1 $\pm$ 13.1	0.04 $\pm$ 1.04	96.1 $\pm$ 14.6	90.7 $\pm$ 10.7	-1.74 $\pm$ 1.88	89.5 $\pm$ 12.9	88 $\pm$ 12.6	-2.65 $\pm$ 2.22	CON-NOV <sup>a</sup> CON-EXP <sup>b</sup>	ns b	CON-NOVICE <sup>a</sup> CON-EXP <sup>a</sup>
HC, cm	103 $\pm$ 10.3	104.4 $\pm$ 9	-0.29 $\pm$ 1.18	105.6 $\pm$ 8.4	101.7 $\pm$ 5.6	-2 $\pm$ 1.63	102.2 $\pm$ 6.1	100.4 $\pm$ 6.3	-1.75 $\pm$ 1.46	CON-NOV <sup>b</sup> CON-EXP <sup>a</sup>	b	CON-NOVICE <sup>b</sup> CON-EXP <sup>a</sup>
WHR, cm	0.9 $\pm$ 0.1	0.9 $\pm$ 0.1	0 $\pm$ 0.01	0.9 $\pm$ 0.09	0.9 $\pm$ 0.1	0 $\pm$ 0.02	0.9 $\pm$ 0.1	0.9 $\pm$ 0.1	-0.01 $\pm$ 0.02	NS	t	CON-EXP <sup>a</sup> NOVICE-EXP <sup>a</sup>
NC, cm	37.5 $\pm$ 5.1	39.4 $\pm$ 4.2	0.18 $\pm$ 0.26	37.5 $\pm$ 4	37.1 $\pm$ 4.1	-0.19 $\pm$ 0.3	36.8 $\pm$ 3.7	37.1 $\pm$ 3.5	0.08 $\pm$ 0.13	CON-NOV <sup>c</sup> NOV-EXP <sup>b</sup>	b	CON-NOVICE <sup>b</sup> NOVICE-EXP <sup>b</sup>
FM (%)	24.1 $\pm$ 7.1	23.6 $\pm$ 7.8	-1.28 $\pm$ 0.77	25 $\pm$ 7.6	21.4 $\pm$ 5.5	-1.47 $\pm$ 1.37 <sup>c</sup>	21.2 $\pm$ 5.7	19.7 $\pm$ 6.3	-1.58 $\pm$ 1.31 <sup>c</sup>	ns	NS	
FFM, kg	53 $\pm$ 13.3	57.5 $\pm$ 12.5	0.95 $\pm$ 0.76 <sup>b</sup>	54.6 $\pm$ 10.3	54.4 $\pm$ 10.2	0.39 $\pm$ 0.86	54.4 $\pm$ 10.7	54.3 $\pm$ 9.9	0.38 $\pm$ 0.89	ns	NS	
Central Adiposity Index	7.5 $\pm$ 4.9	8.4 $\pm$ 3.5	-0.36 $\pm$ 0.46	6.7 $\pm$ 4.1	6.8 $\pm$ 3.2	0.67 $\pm$ 1.75	5.9 $\pm$ 3.5	6.4 $\pm$ 3.6	0.08 $\pm$ 0.82	ns	NS	

$\Delta$ : Delta (value T1 - value T0, considering participants with full data collection at both T0 and T1 only). Results adjusted on age and gender.

ANOVA, analysis of variance; BMI, body mass index; FFM, fat-free mass; FM, fat mass; HC, hip circumference; NC, neck circumference; t, tendency; WC, waist circumference; WHR, waist to hip ratio.

<sup>a</sup> $P < 0.05$ .

<sup>b</sup> $P < 0.01$ .

<sup>c</sup> $P < 0.001$ .

TABLE 2. Baseline and Evolution of Functional Tests Results by Group

	CON				NOVICE				EXP				ANOVA $\Delta$	Mixed Model	Post hoc $\Delta$
	T0	T1	$\Delta$		T0	T1	$\Delta$		T0	T1	$\Delta$				
6WT distance, m	570.7 $\pm$ 51.2	617.9 $\pm$ 67.4	49.6 $\pm$ 46.5 <sup>a</sup>		598.3 $\pm$ 62.7	648.5 $\pm$ 74	44.9 $\pm$ 53.2 <sup>b</sup>		644.9 $\pm$ 63.3	698.3 $\pm$ 78.8	58.5 $\pm$ 58.9 <sup>c</sup>		ns	ns	NOVICE-CON <sup>t</sup>
6WT HR, bpm	122.8 $\pm$ 18.7	123.3 $\pm$ 22.9	5.1 $\pm$ 18.8		136.1 $\pm$ 26.2	124.8 $\pm$ 21.7	-8.5 $\pm$ 19.4		128.2 $\pm$ 26.5	133.5 $\pm$ 18.6	6.2 $\pm$ 21.9		ns	ns	
Shirado, sec	185 $\pm$ 87.4	147.2 $\pm$ 80.7	-27.1 $\pm$ 58.9		160.3 $\pm$ 87.6	197.8 $\pm$ 102	15.5 $\pm$ 72.3		236.1 $\pm$ 65.7	221.8 $\pm$ 93.3	-10.8 $\pm$ 47.4		ns	NOV-EXP <sup>a</sup>	
Sorensen, sec	58.4 $\pm$ 39.1	62 $\pm$ 35.3	11.8 $\pm$ 10		78.8 $\pm$ 48.6	87.3 $\pm$ 38.4	1.3 $\pm$ 32.9		96.1 $\pm$ 52.2	97.4 $\pm$ 50.3	-7.9 $\pm$ 24		ns	CON-NOV <sup>a,b</sup>	
Puch ups (rep)	17.5 $\pm$ 10.7	24.1 $\pm$ 18.8	5.4 $\pm$ 7.5		21.2 $\pm$ 9.7	28.6 $\pm$ 10.3	5.7 $\pm$ 5.1 <sup>c</sup>		36.5 $\pm$ 17.1	42.7 $\pm$ 16.8	5.3 $\pm$ 7 <sup>b</sup>		ns	ns	
HG HD, kg	38.2 $\pm$ 10.7	40.4 $\pm$ 12.2	0.8 $\pm$ 4		42.2 $\pm$ 11.1	44.2 $\pm$ 10.7	1.2 $\pm$ 2.4 <sup>c</sup>		41.7 $\pm$ 11.5	40.8 $\pm$ 8.7	-0.9 $\pm$ 2.9 <sup>a</sup>		ns	ns	
HG HND, kg	34.5 $\pm$ 10.8	38.9 $\pm$ 11.6	2.5 $\pm$ 3.2 <sup>t</sup>		38.9 $\pm$ 10.6	40.4 $\pm$ 10.2	1 $\pm$ 3.1		38.9 $\pm$ 11	40.8 $\pm$ 8.7	1.9 $\pm$ 2.9 <sup>a</sup>		ns	ns	
Squat Jump, cm	20.2 $\pm$ 6.1	22.1 $\pm$ 7.2	0.8 $\pm$ 1.7		21.1 $\pm$ 5.5	24 $\pm$ 5.6	2.6 $\pm$ 2.2 <sup>c</sup>		22.7 $\pm$ 5.9	25 $\pm$ 6.8	2.3 $\pm$ 3.6 <sup>a</sup>		ns	CON-NOV <sup>t</sup>	
CMI, cm	25.6 $\pm$ 7.6	26.4 $\pm$ 8.8	-0.2 $\pm$ 1.5		26.4 $\pm$ 5.9	28.8 $\pm$ 5.9	1.8 $\pm$ 2.2		29.6 $\pm$ 7.4	30.3 $\pm$ 8.3	0.3 $\pm$ 2.2		t	CON-NOV <sup>a</sup>	
Flexibility, cm	25.2 $\pm$ 15.1	31.4 $\pm$ 13.4	2.8 $\pm$ 9.7		23 $\pm$ 13.7	26.9 $\pm$ 12.1	3.5 $\pm$ 5.8 <sup>a</sup>		28.7 $\pm$ 11.7	29.2 $\pm$ 12.9	1.2 $\pm$ 4.8		ns	NOV-EXP <sup>b</sup>	
Balance open right, sec	77.5 $\pm$ 59.5	100.1 $\pm$ 79.8	32.2 $\pm$ 54.7		124.1 $\pm$ 81.7	165.9 $\pm$ 75.7	29.2 $\pm$ 63		160.3 $\pm$ 85.2	207.2 $\pm$ 103.1	50 $\pm$ 53.9 <sup>b</sup>		ns	ns	
Balance open left, sec	83 $\pm$ 66.2	109.9 $\pm$ 87.5	52 $\pm$ 78.3 <sup>t</sup>		114.8 $\pm$ 74.9	187.7 $\pm$ 68.8	60.9 $\pm$ 66 <sup>b</sup>		160.7 $\pm$ 93.6	199 $\pm$ 102.7	41.4 $\pm$ 56.9 <sup>a</sup>		ns	ns	
Balance close right, sec	7.6 $\pm$ 8.8	8.7 $\pm$ 8	1.9 $\pm$ 6.3		16.9 $\pm$ 21.6	34.2 $\pm$ 49.3	14.9 $\pm$ 31.9		17.6 $\pm$ 25.2	22.2 $\pm$ 20.7	3.5 $\pm$ 17.5		ns	ns	
Balance close left, sec	10.4 $\pm$ 19.2	9.1 $\pm$ 10.2	4.6 $\pm$ 5.4		17 $\pm$ 19.3	14.1 $\pm$ 14	-3.6 $\pm$ 14.4		12.8 $\pm$ 14.6	17.8 $\pm$ 17.1	4.8 $\pm$ 13.2		ns	ns	

$\Delta$ , Delta; 6WT, 6-minute walk test; ANOVA, Analysis of Variance; CMI, counter movement jump; HD, hand dominant; HG, hand grip; HND, hand no dominant; HR, heart rate; t, tendency.

<sup>a</sup> $p < 0.05$ .

<sup>b</sup> $p < 0.01$ .

<sup>c</sup> $p < 0.001$ .

TABLE 3. Baseline and Evolution of Self-Reported Physical Activity, Health Perception, Sleep, Wellbeing, Eating Habits, and Pain by Group

	CON				NOVICE				EXP				ANOVA $\Delta$	Mixed Model	Post hoc $\Delta$
	T0	T1	$\Delta$		T0	T1	$\Delta$		T0	T1	$\Delta$				
Physical activity level	1,008.8 $\pm$ 559.6	1,177.5 $\pm$ 809.2	237.8 $\pm$ 330.5 <sup>a</sup>		714.9 $\pm$ 516.4	1,548.4 $\pm$ 858.8	887.5 $\pm$ 795.3 <sup>b</sup>		1,678.1 $\pm$ 860.1	1,706 $\pm$ 653.1	-62.6 $\pm$ 665.8		a	CON-NOV <sup>a</sup>	NOVICE-EXP <sup>b</sup>
Sedentary (screen)	49.9 $\pm$ 8.2	55.2 $\pm$ 6.9	4.9 $\pm$ 9.4		56.2 $\pm$ 9.7	50.9 $\pm$ 9.1	-6.4 $\pm$ 9.4		53.7 $\pm$ 9.1	53.1 $\pm$ 9.5	-1.5 $\pm$ 1.1		ns	ns	
Sedentary (total)	62.8 $\pm$ 7.7	62.7 $\pm$ 5	-0.08 $\pm$ 8.9		70.3 $\pm$ 9.7	65.6 $\pm$ 9.3	-7.9 $\pm$ 12.9		66 $\pm$ 8.6	63.8 $\pm$ 10.3	-2.9 $\pm$ 12.2		ns	ns	
Health perception	47.4 $\pm$ 13.5	56.6 $\pm$ 13.5	7.9 $\pm$ 10 <sup>a</sup>		45.9 $\pm$ 12.7	61.8 $\pm$ 12.3	13.4 $\pm$ 12.5 <sup>c</sup>		63.4 $\pm$ 13.8	64.9 $\pm$ 11	2.5 $\pm$ 7.9		a	NOV-EXP <sup>c</sup>	NOVICE-EXP <sup>b</sup>
Sleep (insomnia)	8.9 $\pm$ 4.9	7.7 $\pm$ 4.6	-0.5 $\pm$ 3		9.1 $\pm$ 4.7	6.1 $\pm$ 3.8	-3 $\pm$ 3.5 <sup>c</sup>		6.3 $\pm$ 3.4	52 $\pm$ 3.4	-1.3 $\pm$ 2.6 <sup>t</sup>		ns	ns	
Sleep (somnolence)	7.5 $\pm$ 3.3	8.6 $\pm$ 3.6	0.5 $\pm$ 2.5		8 $\pm$ 3.2	7 $\pm$ 2.7	-0.7 $\pm$ 2.5		6.5 $\pm$ 3.4	6.3 $\pm$ 3.4	-0.4 $\pm$ 2.7		ns	ns	
Bad eating habits	1.2 $\pm$ 0.8	0.5 $\pm$ 0.5	-0.2 $\pm$ 0.4		1 $\pm$ 0.9	0.5 $\pm$ 0.6	-0.5 $\pm$ 0.7 <sup>b</sup>		0.9 $\pm$ 0.6	0.6 $\pm$ 0.6	-0.4 $\pm$ 0.6 <sup>b</sup>		ns	ns	
Worksite well-being	7.4 $\pm$ 1	7 $\pm$ 1.2	0 $\pm$ 1.3		7.3 $\pm$ 1.1	7.4 $\pm$ 1.1	0 $\pm$ 1.4		7.4 $\pm$ 1.1	7.3 $\pm$ 0.9	-0.3 $\pm$ 1		ns	ns	
Pain	0.8 $\pm$ 0.9	0.5 $\pm$ 0.5	-0.2 $\pm$ 0.5		1 $\pm$ 1	0.6 $\pm$ 0.7	-0.2 $\pm$ 0.5		0.5 $\pm$ 0.6	0.4 $\pm$ 0.4	-0.2 $\pm$ 0.6		ns	ns	

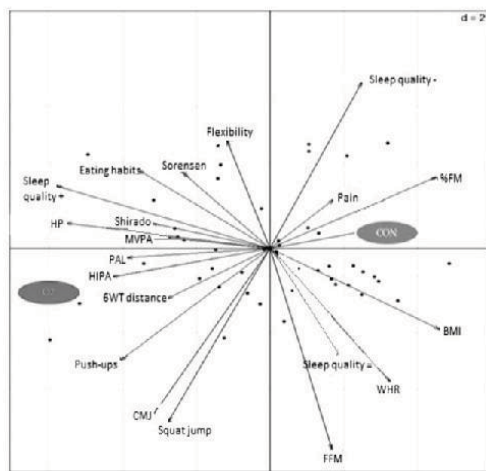
$\Delta$ , Delta; ANOVA, analysis of variance; t, tendency.

<sup>a</sup> $p < 0.05$ .

<sup>b</sup> $p < 0.01$ .

<sup>c</sup> $p < 0.001$ .





**FIGURE 1.** Multidimensional analysis of mixed data. Sleep quality +: good quality of sleep; Sleep quality -: moderate quality of sleep; Sleep quality -: poor sleep quality; Eating behaviors: good eating habits. 6WT distance, 6-minute walk test; BMI, body mass index; CMJ, counter movement jump; CON, Control group; FFM, fat-free mass; FM, fat mass; HIPA, high-intensity physical activity; HP, health perception; MVPA, moderate to vigorous physical activity; O2, Oxygen group; PAL, physical activity level; WHR, waist hip report.

others obtained less convincing results.<sup>29</sup> According to a recent meta-analysis, such discrepancies between studies can be explained by a deep lack of methodological quality, making any definitive conclusion difficult.<sup>54</sup> Moreover, most of the studies conducted so far in this area focused their analysis on specific health indicators and we were not able of finding any work questioning the impacts of workplace interventions on overall health.

The main aim of the present pilot work was to question the efficacy of an in-site physical activity program, and its evaluation among tertiary employees, comparing experienced and novice participants (including a control group with no intervention). Interestingly, this is the first study to assess the effects of such an intervention on overall health using a large number of physical and psychological indicators.

Although the present results indicate that a 5-month in-site physical activity program improves overall health among tertiary employees, it also showed that most of the health indicators under study were still improved in experienced participants. Interestingly, the CON group also shows a significant increase of its physical activity level, fat-free mass, 6-minute walking test performance, and health perception, which might suggest the ability of such studies to make all the participants (even the CON group) concerned about their health and cause a change in their daily habits.

The results for anthropometric measurements and body composition through mixed models showed significant differences in waist circumference between the CON and NOV group and between CON and EXP. Regarding fat mass, a time effect between T0 and T1 with a significant difference for NOV and EXP has been found. These results agree with the current literature. It has been repeatedly shown that a regular physical activity practice could be associated with a reduction in waist circumference.<sup>15,52,54,55</sup> Furthermore, Verweij et al<sup>55</sup> have shown that worksite intervention whose main aim was to increase employees' physical activity level was able to reduce waist circumference. However, body composition was not measured in the majority of these studies. Body

composition measurement is a strength of the present protocol, especially as we used a BIA device that has been recently shown to provide satisfactory results compared with DXA in adults.<sup>30</sup> On the contrary, Verney et al<sup>30</sup> showed that the adiposity index proposed by this device was not a reliable proxy to assess central adiposity, which is a measure of particular interest due to its implication in the development of metabolic complications. Waist circumference was however assessed to estimate central body fat. Although no significant results were achieved for most of these parameters, our multidimensional analysis emphasizes the positive association between these anthropometric and body composition indicators and the control group, suggesting the beneficial effect of the intervention on these parameters. Moreover, it has already been shown that a multi-week physical activity program (24 weeks with a regular program) and seminar about general health education can reduce principally waist circumference and BMI.<sup>56</sup>

Our analysis also revealed better performances in the NOV and EXP group for most of the functional tests. The distance covered during the 6-minute walk test, performance during the Sorensen test, Shirado test, jump tests, and the number of push-ups realized were higher on NOV and EXP groups. There was however no significant difference for the handgrip test, flexibility or balance test between groups. Once more, these results confirmed that engaging in a regular physical activity program has beneficial effects on physical fitness and motor skills, as previously shown in the literature. Tammelin et al<sup>57</sup> compared two groups of workers (sedentary employees and less sedentary employees), and showed that the least sedentary employees presented better physical abilities.<sup>57</sup> However, it remains important to consider the exact nature for each employee job. In fact, in 2003, Ruzic et al<sup>58</sup> showed that the physical hardship of job and fatigue could be a limiting factor in the improvement of physical capacity business. Again, our multidimensional analysis confirms these results, as it shows that most of the performed functional tests are positively associated with the engagement in the EXP group (association in the same half of the graph, and sometimes even the same quarter).

Regarding the questionnaire, physical activity level was increased for CON and NOV with a greater significance for NOV. These results are mainly explained by the activities proposed within the intervention. Certainly, the delta parameter was significantly higher in the NOV group than in the EXP group, which is explained by the introduction of physical activity in the NOV group. Significant differences between the two groups for the level of physical activity corresponded essentially to the different activities proposed as part of the Oxygen program. This may explain why the level of total physical activity was significantly higher before intervention in EXP than CON and NOV, the difference being associated with achieving or not the Oxygen sessions according to the groups. These results agree with the literature that has repeatedly shown that physical activity programs at workplace help to raise the level of total physical activity,<sup>25,26,54</sup> which has been clearly underlined by Dishman et al<sup>54</sup> in their meta-analysis. Interestingly, our results do not show groups difference of intervention effect in terms of sedentary time. Although the use of a self-reported questionnaire might in part explain such a result, the fact that our study only enrolled tertiary workers that by definition spend a large part of their time seated might also explain this lack of difference. Further studies are then needed using better methods to assess sedentary behaviors in such a population.

The present work is to our knowledge the first to question the effect of physical activity on health perception until now. According to our results, individuals who practice a regular physical activity present a better perception of their health. This is consistent with the study by Chen et al,<sup>59</sup> who showed a reduced stress and anxiety level in response to a physical activity intervention in employees of state agencies.



Mixed models have not shown significant difference in terms of eating habits. However, the literature has already shown that engagement in regular physical activity allowed a significant improvement in eating behaviors.<sup>28</sup> But this last study compared the same group of subjects before and after a 6-month physical activity program, while we compared different interventional groups (CON vs NOV vs EXP), which can contribute to explain our different results.

One of the main interests for companies in implementing on-site physical activity programs is to reduce risk-related pain. Using specific questionnaires, we also assessed pain felt by employees, with a special focus on back and neck; both areas are particularly relevant when it comes to tertiary employees. Although it does not reach level of significance, our results indicate lower scores for neck and back pain in people who have been engaged in the Oxygen program (both NOV and EXP) than people in the control group. This is confirmed by our multidimensional analysis showing a positive association between the CON group and the high values of pain: variables lying in the same quarter of the graph that shows the importance of the association. Again, this agrees with the current available evidences that already showed the positive effect of such programs on pain management, and especially the intensity of the pain felt, on the workforce.<sup>60</sup> The use of questionnaires to assess pain is certainly a methodological issue in the present work, making difficult to obtain specific and more detailed results.

Furthermore, it has been shown that physical activity can improve overall sleep quality (decrease sleep latency, early waking, insomnia, and increase quality of sleep).<sup>61</sup> The use of self-reported questionnaires (although validated) to assess sleep quality might also explain the lack of significant results. However, we can still observe rather pronounced differences between groups with better values for NOV and EXP. Once again, the fact that these results are not significant may be explained by the disparity that exists in our sample. Although the sample size and heterogeneity do not allow to show statistically significant differences, multidimensional analysis graphically illustrates very clearly the association between the practice of the Oxygen program and “good” sleep, unlike what it was observed in the CON group.

Interestingly, even though our results showed better performances or improvements in the two intervention groups (NOV and EXP), a particular focus has to be done on the control group. Indeed, individuals in the control group who show interesting improvements on some of the parameters, despite absence of intervention. For instance, we can see an increase of fat-free mass, distance covered during the 6-minute walk test, level of physical activity, and health perception. These positive effects remain modest compared with what has been found in the NOV or EXP groups but display interesting indications showing the impact of participation in a study. Many studies conducted over the last 50 years highlight the impact of the “placebo” process or the “CON” group. Similarly, there are psychological or psychophysiological effects accompanying a participation in a study. Usually, this reaction is favorable, which might explain the improvement of participants in the CON group of our study. This clearly joins up with the previously described mere-measurement effect suggesting behavioral changes in individuals without intervention or specific advice, but just as they are part of measurements campaigns, which can explain the results observed in this work in the control group.<sup>62</sup>

Although this is a pilot project, some limitations have to be considered when interpreting the results, such as low number of subjects, tools used, and heterogeneity between and within groups (ie, gender distribution in groups, study time). Moreover, even though we used validated field tests, more objective measurement of the physical activity level could have been used, that is, using accelerometers. In addition, we could have taken measures on

different times and not just at 5 months. Importantly, although some participants gave up before the end of the program (as previously pointed), our complementary statistical approaches underline the accuracy of our results and reinforce our conclusions regarding such an intervention among tertiary employees.

## CONCLUSION

To conclude, this pilot study underlines the beneficial effects of work-site physical activity programs proposed to tertiary employees on overall health and the feasibility of its design. Although this is the first study to enroll both experimented and novice participants, further studies are now needed using larger sample sizes and more objective methods.

Moreover, it would be interesting and necessary to develop a theoretical model entailing and connecting some of the study behavioral and physiological outcomes in the context of workplace physical activity programs. This would require involving practitioners and researchers together in the design and elaboration of new studies and programs.

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## Health and Fitness Benefits But Low Adherence Rate

### Effect of a 10-Month Onsite Physical Activity Program Among Tertiary Employees

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**Objective:** The aim of this study was to assess the effects of a 10-month structured physical activity intervention implemented within the workplace on overall health indicators among tertiary (office workers) employees. **Methods:** In this quasi-experimental study, 224 employees followed a 10-month worksite physical activity program. Overall health was assessed at baseline, after 5 months, and by the end of the intervention. **Results:** Fat mass percentage decreased significantly. There was a time effect favoring push-ups, abdominal strength, flexibility, heart rate postexercise, heart rate +30 seconds, and heart rate +60 seconds postexercise. Anxiety, depression, and eating habits also improved. In total, 45% of participants completed the whole intervention. **Conclusion:** Although a structured on-site physical activity program supports improved health indicators, adherence remains a concern and requires specialists to develop new strategies.

**Keywords:** occupational health, physical activity, physical fitness, tertiary employees, worksite

Over the past century, our societies have faced increasing and worrying declines in population's physical activity levels, mainly due to an automation of our daily living and occupational activities.<sup>1</sup> Despite the clearly recognized beneficial effects of physical activity on cardiovascular,<sup>2</sup> functional,<sup>3</sup> social, and mental health,<sup>4</sup> only a small proportion of adults engage in adequate physical activity.<sup>5</sup> Some European studies estimate that two-thirds of adult populations do not achieve the recommended physical activity levels.<sup>6</sup> Other data from the UK reveal that only 39% of men and 29% of women comply with government recommendations on physical activity.<sup>7</sup> While the lack of physical activity remains a public health concern, national and international strategies are required to create a conducive culture, encouraging regular physical activity.

The "tertiarisation" of our societies (relating to the increasing dominance of our tertiary sectors and declines in manual and physical occupations) has favored both physical inactivity (with the automation of occupational tasks reducing human efforts) and sedentariness (with an increasing time spent seated in front of a

computer screen). Indeed, the prevalence of sedentary professions increased by 20% in the United States between 1960 and 2008, with a concomitant decline in physically active ones.<sup>8</sup> In France, working adults spend about 10 hours a day sitting on working days (with at least 4 hours at work) and approximately 7.5 sitting hours a day on nonworking days, generating a positive association between the time spent sedentary at work and sedentary behaviors outside work.<sup>9</sup> However, due to the important amount of time employees spend at work, workplaces have been recently suggested as a new strategic opportunity to promote daily physical activity and reduce sedentary behaviors. Moreover, Dugill et al<sup>5</sup> suggested workplaces as ideal opportunities to tackle recurrent barriers to physical activity such as the lack of time and proximity, facilitating physical activity access to individuals who might not be active in other settings (associations or gyms), and using peer networks and employers' incentives.<sup>10</sup> Although employers are increasingly encouraged to play a key role in the promotion of working adults' health and well-being,<sup>7,11</sup> it is possible that favoring employees' good health will also reduce a company's absenteeism, and ideally, increase workplace productivity.<sup>12</sup>

Collectively, these data promote the implementation of worksite interventions designed to increase individuals' physical activity levels and reduce the time spent in sedentary behaviors. However, the majority of the available evidence involves interventions that tend to reduce sedentary behaviors through the use of standing desks or active breaks.<sup>13,14</sup> There is also some social behavior theory evidence investigating sensitization methods to encourage physical activity (text messages, group discussions, among others).<sup>15</sup> Fewer studies have implemented on-site structured physical activity programs. Among these was a 1-year study, using motivation group strategies during meetings and workshops to promote physical activity among employees.<sup>16</sup> Other researchers have used communication strategies such as regular newsletters, to promote the beneficial effects of walking.<sup>17</sup> More recently, studies aiming at replacing sedentary with more active time have been conducted. Alkhajah et al<sup>18</sup> requested office workers aged 20 to 65 years to use sit-to-stand workstations during 3 months, with a goal of reducing sitting time. Although some studies have questioned the effects of structured physical exercise sessions implemented within workplaces,<sup>19,20</sup> there are often limitations to the evaluation of the interventions that include reduced sample size, limited number of measured outcomes, and short limited durations.

In 2009, Pedersen et al<sup>21</sup> conducted one of the first interventions targeting structured onsite physical activity to employees. The 1-year intervention comprised 1 hour per week of various physical activity modalities (eg, steppers, punch bags, Nordic walking). Results demonstrated decreased fat mass percentage and reduced back and shoulder pain among 549 office workers.<sup>21</sup> More recently, Vilela et al<sup>22</sup> implemented a 4-month onsite physical activity program comprising 15 minutes of muscular endurance that was performed five times a week. Similarly, results showed improved body composition and overall fitness among the employees who followed the program compared with a control group.<sup>22</sup> Also, fat mass percentage and physical activity levels showed improvements in workers who engaged in three 15-minute sessions

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per week of stretching exercises conducted within their workplace over a 3-month period.<sup>23</sup> Lastly, two worksite sessions per week combining resistance and aerobic exercises (for 5 months) showed beneficial effects on body composition, overall fitness, health perception, sleep quality, pain, eating habits, and physical activity level among office workers spending about 7 hours per day seated in front of a computer screen.<sup>3</sup>

While studies targeting specific subgroups of employees at risk or concerned by chronic disease have been suggested as necessary,<sup>24</sup> Fang et al<sup>19</sup> have recently pointed out that a 1-year physical activity program comprising three sessions (of 60 minutes each) per week in overweight employees reduced their risk factors for metabolic syndrome, concomitantly improving their overall fitness, workplace relationships, job satisfaction, and quality of life.

Although these studies collectively suggest the beneficial effects of onsite physical activity programs, their designs and methodological approaches could be improved due to limitations such as reduced sample size, short-term interventions, lack of engagement monitoring, inadequate physical activity quantification, and limited rather than comprehensive health related outcomes.<sup>24</sup> Several systematic reviews and meta-analyses indeed report a weak effect of workplace health promotion programs, an important heterogeneity of the observed results, and a lack of statistical power due to relatively small sample sizes.<sup>25,26</sup>

The aim of the present study was to assess the effects of a 10-month structured physical activity intervention implemented within the workplace on overall health indicators (fitness, quality of life, health perception, sleep, pain, anxiety, and depression) in a large group of tertiary employees.

## METHODS

### Participants

A total of 224 office employees (tertiary workers) from two local companies participated in the study (162 females, 60 males; mean  $\pm$  standard deviation age:  $43.8 \pm 10$  years; body mass:  $67.3 \pm 13.3$  kg; BMI:  $24 \pm 3.7$  kg/m<sup>2</sup>). Participants were approached through their employers' internal network providing information via regular emails to all the employees. To be included, the participants were required to (i) be office workers; (ii) show no contraindications to physical activity; and (iii) be free of any medication that could interfere with the study outcomes. All participants received information sheets and signed consent forms as requested by ethical authorities (Local Human Protection Committee, CPP Sud Est IV).

### Design

Before inclusion in the study, the volunteers' pending participation was approved by a physician in order to ensure their ability to complete the entire protocol. Then, a screening session occurred in September 2016 in which the participants were asked to complete several questionnaires (health perception, eating habits, worksite well-being, sleep quality, anxiety, depression, and pain), anthropometric measurements were performed, their body composition was assessed, and their physical fitness was evaluated. Screenings were conducted by the same experimenter at worksite and during work time. All these measurements were repeated at the mid-point of study 5 months later (February 2017) and at the end, at 10 months (June 2017).

### Anthropometric Measurements and Body Composition

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Both mass and height were obtained at the same time of the day for the same participant, and not in the fasting state. Body mass index (BMI) was calculated

as body mass (kg) divided by height squared (m<sup>2</sup>). All the anthropometric measures were performed in accordance with the Anthropometric Standardization Reference Manual.<sup>27</sup> Body composition was estimated using bioelectrical impedance analysis, performed with the Tanita MC780 multifrequency segmental body composition analyzer. This analyzer consists in a stand-alone unit onto which the participant stepped in bare feet using the standard mode. Information concerning the participant (age, gender, and height) was manually entered by the researcher. Once body mass has been assessed by the scale, the participant had to hold fixed straps with both hands (alongside the body) during the impedance measure (hand-to-foot bio-impedance analysis [BIA]). A full segmental analysis was performed in less than 20 seconds. Total body fat, total fat-free mass, and body water were reported by the researcher into an excel sheet for statistical treatment. The newly developed BIA analyzer was recently validated in healthy adults.<sup>28</sup>

### Well-Being, Quality of Life, and Health Perception

Well-being and quality of life at work were assessed using the Worksite Well-being and Quality of Life questionnaire, specifically designed and validated for occupational health studies.<sup>29</sup> The participants were asked to rate statements describing well-being state at work (eg, "I'm actually feeling distressed while at work") using visual analogue scales ranging from "not at all" to "absolutely."

All participants were also asked to complete the Health Perception Scale that is a short self-administered questionnaire designed to explore their perception of health.<sup>30</sup> Six criteria were identified thanks to this questionnaire: healthy balanced diet, perceived sleep quality, perceived stress level, and perceived general health. A 10-point scale from 1 (not at all) to 10 (very much) was used to assess each item. The six individual scores were computed to obtain a global score for health perception.

### Sleep Quality

The Pittsburgh Sleep Quality Index (PSQI) is a self-rated questionnaire assessing sleep quality and disturbances over a 1-month period. Nineteen individual items generate seven "component" scores: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. The sum of scores for these seven components yields one global score. Previously, clinical and clinical properties of the PSQI were assessed over an 18-month period with "good" sleepers and "poor" sleepers.<sup>31</sup>

### Pain

Pain was evaluated using the Nordic questionnaire that is a standardized and validated questionnaire typically used by occupational health practitioners to detect musculoskeletal pain.<sup>32</sup> The questions concentrate on symptoms most often encountered in an occupational setting focusing on work-activities specific musculoskeletal symptoms. The questions are forced choice variants that might be either self-administered or used in interviews, and in the present study, the questionnaire was self-administrated.<sup>33</sup>

### Eating Behaviors

Eating habits were collected using the self-administrated Eating Habits Questionnaire,<sup>34,35</sup> commonly used in clinical routine and research. Emphasis was placed on the frequency of breakfast, snacking, tendency for extra helping during meals, and the type of beverages consumed. One question was asked in relation to each of these specific eating habits. Each item was clearly explained, and all the questions were followed by predetermined responses to facilitate comprehension (ie, "Do you eat breakfast? Every Day – Often – Sometimes – Never"; "Do you snack between meals? Every Day – Often – Sometimes – Never"; "Do you have tendency to have extra-



helping during meals? Every Day – Often- Sometimes –Never”; “Which kind of drink do you consume when you are thirsty? Water – Sugar-sweetened beverage”).

### Anxiety and Depression

Anxiety and depression were evaluated using a self-assessment scale that was found to be a reliable instrument for detecting states of depression and anxiety.<sup>36</sup> The anxiety and depressive subscales were also shown to be valid for the measurement of the severity of emotional disorders. Both the Depression and Anxiety scales provide scores from 0 to 21, with 0 representing the absence of depression or anxiety and 21 representing a very high level for both.

### Aerobic Fitness

The step test was performed on a stool that had a height of 16.25 inches (41.3 cm) for men and 11.8 inches (30 cm) for women. Stepping up and down was required for a total duration of 6 minutes at the rate of 24 cycles per minute, which was set by a metronome. Participants were asked to wear a heart rate monitor (Polar Electro Inc, Lake Success, New York) during the test and heart rate was recorded at the end of the 6 minutes, 30 seconds, and 1 minute after the end of the test. This test has been found reliable in healthy individuals and it is highly reproducible.<sup>37</sup>

### Muscle Function

Upper limb muscle strength was assessed using a handgrip dynamometer on the dominant hand, as a noninvasive estimate of muscle strength of upper limbs, well suitable for clinical use.<sup>38</sup> The participants were also asked to perform a maximal number of push-ups (knees on the floor) while simultaneously complying to an imposed frequency. The test stopped once they were unable to maintain this cadence or had difficulty to maintain the correct position.<sup>39,40</sup> Lower limb muscle strength was assessed using a Counter Movement Jump (CMJ) using the Optojump technology (Microgate SRL, Rome, Italy).<sup>41</sup> The Shirado test was used to assess the static endurance of the abdominal muscles<sup>42</sup> and the Sorensen test to assess back strength and the endurance of all the muscles involved in extension of the trunk.<sup>43</sup>

### Flexibility

The sit and reach test is a common estimate of flexibility, and specifically measures the flexibility of the lower back and hamstring muscles.<sup>44</sup> This test involves sitting on the floor with legs stretched out straight ahead. Shoes should be removed. The soles of the feet are placed flat against the box. Both knees should be locked and pressed flat to the floor. Where appropriate, the tester may assist by gently holding the knees down. With the palms facing downwards, and the hands on top of each other or side by side, the participant reaches forward along the measuring line as far as possible. After some practice reaches, the participant reaches out and holds that position for at least 1 to 2 seconds, while the distance is recorded. The tester also needs to ensure that there are no jerky movements.<sup>45</sup>

### Balance

A stabilometric platform was used to assess postural stability. Participants were asked to stand barefoot in a relaxed posture, on a bipedal standing position on the force platform with feet in a fixed and parallel position (the distance between their heels was fixed to the pelvis width). Four measurements were performed by participants in the following standing positions: two feet with open eyes, two feet with eyes closed, the dominant foot with open eyes, and the dominant foot with eyes closed.<sup>46</sup>

### On-Site Physical Activity Intervention

The intervention consisted of two training sessions per week for a total of 10 months. The intervention was conducted within the

participants' worksite using physical activity facilities provided by the companies to their employees. The participants were free to choose between the 18 different physical activities proposed, such as muscle strengthening, stretching, cardiorespiratory, or team sport. However, they were asked to perform at least one muscle strengthening (weight machines) and one cardiorespiratory session (such as Latino dance, step aerobics, cycling, boxercise) per week. Each session was supervised by a professional and lasted 45 minutes. The participants had access to these facilities at any time of the day to facilitate their engagement. The attendance of the participants during the intervention was recorded using a computerized access to the sport facilities (each participant had to clock in each time he/she was starting and ending an exercise session).

### Statistical Considerations

All analyses were performed using Statview (version 4 for window; SAS Institute, Cary, NC). Statistical analyses were based on a two-sided type I error of  $\alpha = 5\%$ . Baseline participants' characteristics were presented as the mean  $\pm$  standard deviation (SD). Assumption of normality was assessed by using the Smirnov–Kolmogorov test. To analyze repeated data collections, analysis of variances (ANOVAs) with repeated measures were used. When omnibus  $P$  value was less than 0.05, a Tukey–Kramer post-hoc test was performed to take into account the multiple comparisons and the possibility of an inflated type I error. When assumption of normality was not reached, random-effects models were performed taking into account between and within-participant variability (as random-effect).

## RESULTS

Table 1 details the results for anthropometric characteristics, body composition, and functional tests of the employees. No significant changes in body mass, BMI, waist circumference, fat-free mass, and central adiposity index were observed during the study. In contrast, the ANOVA showed a loss of fat mass percentage with decreases between T0 and T2 ( $P \leq 0.01$ ).

Among the results for functional tests, no change was observed for CMJ, handgrip, back strength, and for the Romberg index (balance) ( $P > 0.05$ ).

Other physical test results showed a time effect for push-ups, abdominal strength, and flexibility. The post-hoc analysis results identified respective improvements between T0-T1 ( $P \leq 0.01$ ) and T0-T2 ( $P \leq 0.001$ ) for push-ups, T0-T2 ( $P \leq 0.05$ ) and T1-T2 ( $P \leq 0.05$ ) for abdominal strength, and T0-T1 ( $P \leq 0.001$ ) and T0-T2 ( $P \leq 0.001$ ) for flexibility.

Results from the aerobic fitness showed a significant time effect for heart rate postexercise, specifically, decreases in heart rate +30 seconds and heart rate +60 seconds after exercise ( $P \leq 0.001$ ), but without a change in resting heart rate.

Table 2 details the results for health perception, sleep, wellbeing, eating habits, anxiety, depression, and pain by group. No significant effect of the PA worksite intervention was observed on well-being, pain, and sleep quality. Nonetheless, the results showed a significant decrease for total health perception ( $P \leq 0.001$ ), which was attributed to the decrease in the score of item 4 (rest) between T1 and T2 ( $P \leq 0.05$ ). Participants' physical fitness perception was improved between T0-T1 ( $P \leq 0.05$ ) and T0-T2 ( $P \leq 0.05$ ). None of the other items relating to health perceptions generated significance.

The ANOVA showed a time effect for anxiety and depression with a decrease between T1-T2 ( $P \leq 0.001$ ) and T0-T2 ( $P \leq 0.001$ ). Finally, there was a time effect for eating habits denoting improvements between T0-T1 ( $P \leq 0.01$ ) and T0-T2 ( $P \leq 0.001$ ).

Thirty-seven per cent of participants stopped participating in the program between the first and second measurement times, while an additional 28% ceased before the final study measurement. In

TABLE 1. Baseline and Evolution of Anthropometry, Body Composition Parameters, and Functional Tests

	T0	T1	T2	ANOVA	T0 vs T1	T0 vs T2	T1 vs T2	Posthoc
Weight, kg	66.1 ± 12.7	66.3 ± 13	66 ± 12.8	ns	0.09 [-0.2 to 0.4]	0.14 [-1.90, 0.5]	0.05 [-0.3 to 0.4]	
BMI, kg/m <sup>2</sup>	23.5 ± 3.5	23.5 ± 3.6	23.4 ± 3.6	ns	0.07 [-0.2 to 0.3]	0.15 [-0.2 to 0.5]	0.08 [-0.3 to 0.4]	
WC, cm	84.1 ± 11.3	84.6 ± 11.4	84.4 ± 11.5	ns	-0.008 [-0.3 to 0.3]	0.02 [-0.3 to 0.3]	0.03 [-0.3 to 0.4]	
FM (%)	24.3 ± 7.5	23.9 ± 7.7	23.5 ± 8	*	0.09 [-0.2 to 0.4]	0.4 [0.09-0.7]	0.3 [-0.01 to 0.7]	T0-T2**
Central adiposity Index	47.3 ± 9.5	47.5 ± 9.1	47.4 ± 9.4	ns	0.05 [-0.2 to 0.3]	-0.02 [-0.3 to 0.3]	-0.09 [-0.4 to 0.25]	
Rest heart rate, bpm	5.3 ± 3.3	5.3 ± 3.4	5.3 ± 3.3	ns	0.05 [-0.2 to 0.3]	0.04 [-0.3 to 0.4]	-0.01 [-0.4 to 0.3]	
Rest heart rate, bpm	69.9 ± 11.7	70.1 ± 11	69.9 ± 10.7	ns	-0.1 [-0.4 to 0.1]	-0.003 [-0.3 to 0.3]	0.16 [-0.2 to 0.5]	
Heart rate, bpm	146.5 ± 19.1	138.3 ± 15.5	129.9 ± 18.9	***	0.5 [0.2-0.8]	0.8 [0.5-1.2]	0.3 [-0.05 to 0.6]	T0-T1**/T0-T2**/T1-T2***
Heart rate +30, bpm	126.9 ± 20.5	119.4 ± 17.3	112.4 ± 20.6	***	0.3 [-0.02 to 0.6]	0.5 [0.1-0.8]	0.2 [-0.1 to 0.6]	T0-T1**/T0-T2**/T1-T2***
Heart rate +60, bpm	112.8 ± 20.2	105.6 ± 17.6	99.6 ± 18.8	***	0.5 [0.2-0.8]	0.6 [0.2-0.9]	0.2 [-0.01 to 0.6]	T0-T1**/T0-T2**/T1-T2***
RPE	4.4 ± 1.8	3.9 ± 1.8	3.8 ± 1.8	**	0.5 [0.2-0.8]	0.6 [0.2-0.9]	0.03 [-0.3 to 0.3]	
CMI, cm	19.6 ± 5.8	20 ± 6.7	19.8 ± 5.7	ns	-0.2 [-0.5 to 0.1]	-0.2 [-0.5 to 0.1]	-0.03 [-0.4 to 0.3]	
Handgrip, kg	36.1 ± 27.5	35.1 ± 9.9	35.1 ± 9.7	ns	-0.07 [-0.4 to 0.2]	-0.2 [-0.5 to 0.1]	-0.1 [-0.4 to 0.2]	
Push-ups (rep)	26.5 ± 18.2	30.1 ± 17.6	30.2 ± 17.8	***	-0.16 [-0.4 to 0.14]	-0.3 [-0.6 to 0.03]	-0.15 [-0.5 to 0.2]	
Shirado, s	170.9 ± 23.2	170.9 ± 26.3	176.2 ± 19.7	*	-0.07 [-0.3 to 0.2]	-0.4 [-0.7 to -0.09]	-0.4 [-0.7 to -0.03]	T0-T2*/T1-T2*
Sorensen, s	173.6 ± 19.1	176.5 ± 18.4	175.3 ± 17.5	ns	-0.1 [-0.4 to 0.1]	-0.3 [-0.6 to 0.07]	-0.09 [-0.4 to 0.25]	
Flexibility, cm	1.9 ± 8.7	4.3 ± 9.4	3.8 ± 8.6	***	-0.3 [-0.6 to 0.003]	-0.3 [-0.6 to 0.5]	0.02 [-0.3 to 0.3]	T0-T1**/T0-T2**
Romberg index, dp	165 ± 113.4	177.3 ± 125.8	162.6 ± 185.3	ns	0.02 [-0.2 to 0.2]	0.09 [-0.1 to 0.3]	0.1 [-0.1 to 0.3]	
Romberg index (up)	1.213.9 ± 1028.3	925.4 ± 889.1	990 ± 832.2	ns	0.3 [0.1-0.5]	0.3 [0.06-0.5]	-0.03 [-0.3 to 0.2]	

BMI, body mass index; bp, bipodal; bpm, beats per minute; CMI, Counter Movement Jump; rep, repetition; T0, baseline; T1, middle of the 10-month program; T2, end of the 10-month program; up, unipodal; WC, waist circumference.

\*P &lt; 0.05.

\*\*P &lt; 0.01.

\*\*\*P &lt; 0.001.

TABLE 2. Baseline and Evolution of Self-Reported Health Perception, Sleep, Wellbeing, Eating Habits, Anxiety, Depression, and Pain by Group

	T0	T1	T2	ANOVA	T0 vs T1	T0 vs T2	T1 vs T2	Posthoc
Health perception (total)	5.8 ± 1.3	5.9 ± 1.2	4.2 ± 3	***	-0.1 [-0.4 to 0.13]	-0.1 [-0.4 to 0.2]	0.009 [-0.3 to 0.3]	T0-T2**/T1-T2***
Item 1 (physical fitness)	6.1 ± 1.7	6.5 ± 1.4	6.6 ± 1.8	*	-0.2 [-0.5 to 0.07]	-0.3 [-0.7 to -0.03]	-0.2 [-0.5 to 0.1]	T0-T1*/T0-T2*
Item 2 (physical appearance)	4.2 ± 1.9	4.3 ± 1.9	4.3 ± 2.1	ns	0.02 [-0.3 to 0.3]	-0.2 [-0.3 to 0.3]	-0.04 [-0.4 to 0.3]	
Item 3 (balanced diet)	6.3 ± 1.9	6.1 ± 1.8	6.4 ± 1.9	ns	-0.03 [-0.3 to 0.2]	-0.2 [-0.5 to 0.1]	-0.1 [-0.5 to 0.2]	
Item 4 (rests)	6.1 ± 2.1	6.5 ± 2.1	5.9 ± 2.4	*	-0.2 [-0.5 to 0.08]	0.03 [-0.3 to 0.3]	0.2 [-0.09 to 0.6]	T1-T2*
Item 5 (stress)	5.9 ± 2.2	5.9 ± 2.2	5.7 ± 2.4	ns	-0.05 [-0.3 to 0.2]	0.007 [-0.3 to 0.3]	0.05 [-0.3 to 0.4]	
Item 6 (health level)	6.9 ± 1.7	6.9 ± 1.5	6.8 ± 1.8	ns	-0.12 [-0.4 to 0.2]	-0.08 [-0.4 to 0.2]	0.04 [-0.3 to 0.4]	
Sleep quality	6.7 ± 3.4	6.1 ± 3.4	6.4 ± 3.5	ns	0.2 [-0.05 to 0.5]	0.1 [-0.2 to 0.4]	-0.09 [-0.4 to 0.2]	
Eating habits	1.1 ± 0.3	0.9 ± 0.4	0.9 ± 0.3	***	0.3 [0.04-0.6]	0.4 [0.09-0.7]	0.07 [-0.3 to 0.4]	T0-T1**/T0-T2***
Worksite well-being	7.2 ± 1.3	7.5 ± 1.3	7.3 ± 1.4	ns	-0.08 [-0.4 to 0.2]	-0.04 [-0.4 to 0.3]	0.04 [-0.3 to 0.4]	
Anxiety	6.8 ± 3.3	6.3 ± 3.4	3.9 ± 3.8	***	0.1 [-0.1 to 0.4]	0.8 [0.5-1.1]	0.7 [0.4-1]	T0-T2**/T1-T2***
Depression	11.6 ± 1.4	11.6 ± 1.3	7.4 ± 5.8	***	-0.02 [-0.3 to 0.3]	1 [0.7-1.4]	0.99 [0.7-1.3]	T0-T2**/T1-T2***
Pain	1.8 ± 1.7	1.7 ± 1.8	1.9 ± 1.9	ns	0.03 [-0.3 to 0.3]	-0.08 [-0.4 to 0.2]	-0.1 [-0.4 to 0.2]	

ANOVA, analysis of variance.

\*P &lt; 0.05.

\*\*P &lt; 0.01.

\*\*\*P &lt; 0.001.



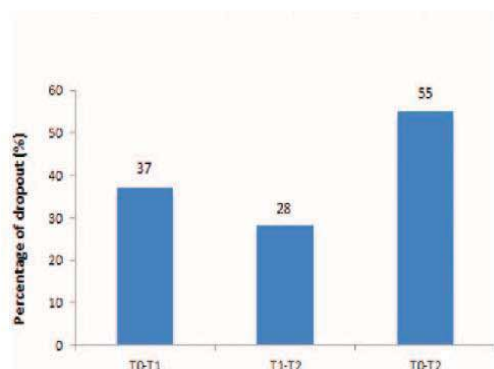


FIGURE 1. Percentage of dropout (%).

total, 55% of the participants did not complete the whole intervention (Fig. 1).

### DISCUSSION

While public health policies encourage increased physical activity engagement and reduced sedentary behaviors at any age, workplaces are pertinent and interesting settings to promote health related outcomes from physical activity.<sup>5</sup> Currently, the literature is limited by relatively few well-designed and appropriately powered studies that examine the impact of onsite interventions (within-companies) with conflicting results about the physical activity interventions in the workplace with some showing positive<sup>47–49</sup> and less convincing results.<sup>25</sup> A recent meta-analysis concluded that such discrepancies between studies can be explained by the lack of depth in methodological quality, making any definitive conclusion difficult.<sup>50</sup> Moreover, most of the studies conducted to date in this area have focused their analysis on specific health indicators without proposing a view of the employees' overall health. Available results in the field are somewhat limited to the effects of physical education sessions, encouragement and motivational strategies,<sup>16,51</sup> walking meetings,<sup>52</sup> or sedentary breaks.<sup>14</sup> Few studies have been custom built, implemented, and evaluated the broader impacts of structured aerobic and resistance exercise sessions.<sup>3,21</sup>

In this context, the aim of the present work was to assess the effects of a 10-month structured physical activity intervention implemented within the workplace on overall health indicators among tertiary employees. According to our results, two to three supervised sessions of physical exercise per week, performed within the worksite facilities, favor tertiary employees in multiple ways: a reduction in fat mass percentage, increased aerobic and anaerobic fitness parameters, improved habits in eating, rest and fitness, as well as desirable reductions in self-perceptions of depression and anxiety.

Our results showed no significant difference in total body mass and other anthropometric measurements. This result supports previous studies reporting unchanged anthropometric parameters after a 1-year program.<sup>53</sup> However, our results showed maintenance of fat-free mass over 10 months accompanied by a significant loss of fat mass percentage. Although favorable body composition results concur with previously published studies of a similar duration,<sup>23</sup> Atlantis et al.<sup>54</sup> however, found improved body weight and waist circumference after only 24 weeks of an exercise program (comprising aerobic exercise 20 minutes duration 3 days/week and weight-training 30 minutes 2 to 3 days/week) that was combined with health-related educational seminary among sedentary employees. This discrepancy can be explained by the fact that more than half of their participants were overweight or obese, while employees in the current study were lean. Also, our objective was more to promote overall health rather than to induce weight loss.

Indeed, our 10-month intervention favored improved overall fitness, particularly improved performances between baseline and T1 for push-ups and flexibility and a greater endurance of the abdominal muscles (using the Shirado test) by the end of the program. Similarly, our participants showed improved aerobic capacities with decreased maximal heart rate and reduced 30- and 60-second postexercise heart rates by the end of the intervention. These results are in accordance with previously published papers.<sup>22,55</sup> Vilela et al.<sup>22</sup> for instance also showed better flexibility, along with improved sit-up and push-up test performances after a 4-month intervention among chemical plant employees. Our results are further supported by Ruzic et al.<sup>56</sup> who showed that work-based physical activity programs could favor improved physical fitness among employees with a low work index (as a proxy for the physical demand imposed by occupational tasks) such as tertiary workers, while such improvements remain limited among employees with a high work index. Others, however, have been unable to report any modification of their participants' physical fitness in response to onsite physical activity interventions.<sup>23,53</sup> Importantly, although Grande et al.<sup>23</sup> also conducted their study among tertiary employees, their participants presented challenging characteristics with a higher initial body weight (mean 73 kg) and a higher BMI (above 25 kg/m<sup>2</sup>) defining them as overweight, which could explain such discrepancies. Moreover, cardiorespiratory fitness and muscular strength were both demonstrated to be strong predictors of total mortality, cardiovascular mortality, and incident cardiovascular disease in both general population and in subjects with chronic disease.<sup>57,58</sup>

Alongside with physical fitness and fat mass, our employees also improved anxiety and depression. The available literature repeatedly shows that regular physical activity programs at workplaces help reduce stress and anxiety among employees.<sup>52,53,59–61</sup> Indeed, Hallam et al.,<sup>60</sup> for instance, found that a 100-day challenge of 10,000 steps a day favored a reduction in depression, anxiety, and stress among 2000 employees (without describing the type of occupational activities contributing to the 10,000 steps). In another study, a significant decrease in work stress was observed in response to the integration of short bouts of physical activity into organizational routine.<sup>62</sup> These studies, however, relied on intervention that was composed of targeted psychological challenges or work time interruptions. Until the current study, to the best of the authors' knowledge, anxiety and depression had not been evaluated in response to a physical activity program implemented within the workplace.

In the current study, anxiety and depression were significantly reduced, despite the participants not changing their self-perceptions of work-related stress and work-related well-being. Although this might seem contradictory, this result might indicate that regular physical activity, even when implemented inside worksite, can improve overall well-being without decreasing the employee's work-related stress and welfare. Regular physical activity might help individuals improve their daily well-being without reducing their work-specific related stress and pressure. Further studies seem then necessary to distinctly assess overall and work-specific well-being and comfort among employees. Although it has been shown that regular physical activity and increased quality of life are usually associated with better overall sleep quality (decrease sleep latency, early waking, insomnia, and increase quality of sleep),<sup>63,64</sup> sleep was not improved in the present work. Despite some evidence of validation,<sup>31</sup> the use of a self-reported questionnaire imposes some limitations of this instrument that mask more objective measures of sleep quality. Our result could also be confounded by the fact that our participants reported a relatively great sleep quality at baseline, providing a plausible explanation for the lack of changes in response to our program.

The literature remains relatively limited in describing the effects of worksite-related physical activity programs on eating



patterns. On the basis of established relationships between physical activity levels, appetite control, and eating habits, targeting improved nutrition in sedentary individuals (such as tertiary employees) with uncontrolled appetite regulation and possibly higher daily intakes<sup>65</sup> may be a challenge. However, when interventions also increase an individual's physical activity levels, favorable nutritional compensatory responses can be expected (Schubert et al, 2016; Donnelly et al, 2017). Nonetheless, it seems necessary to control eating habits when implementing physical activity intervention. Several studies have reported improved eating patterns in response to regular physical activity programs without focusing on tertiary employees.<sup>66,67</sup> In their work, Johnson et al,<sup>68</sup> for instance, questioned eating habits among tertiary employees and found improved food-related behaviors in response to a web-based prevention program; details of the impact of physical activity on eating patterns among workers were unclear. Our results showed that eating habits improved after the first 4 months of intervention, without any additional improvement by the end of the 10 months. This result agrees with Johnson et al<sup>68</sup> who also found improved eating patterns during the first 6 months of their intervention without any further modifications. Yet, further studies are needed to investigate how regular physical activity can favor rapid adaptations of individuals' eating habits.

Although most of the studies conducted to date have assessed pain among employees whose daily tasks require body motion and muscle work,<sup>69</sup> few concern tertiary employees. Although these workers often lack manual tasks, they spend a considerable part of their time seated, which might have important musculoskeletal implications, particularly at lumbar, back, and neck sites. In their study, Pedersen et al<sup>21</sup> conducted a 1-year randomized controlled trial with tertiary employees, examining the effects of resistance training and all-round physical exercise sessions performed within workplaces. Their results showed significant reductions of pain symptoms. Using questionnaires, we also assessed pain felt by employees, with a particular focus on the back and neck, both areas being particularly relevant to tertiary employees who spend a large proportion of their time seated. Although we did not observe any pain improvement, the use of self-reported questionnaires may explain our results. However, similar to sleep responses, the employees in the current study presented with a relatively low level of pain at baseline. The initial lack of pain most likely explains why we did not observe any significant changes (the highest pain score being observed within our sample being 3.8 of 10, which remains indeed low). Once more, the results suggest that onsite physical activity interventions could more specifically consider the employees' profiles in order to maximize health benefits.

Our results also point out the necessity of strategies to target the employees' adherence rate to such programs. Indeed, one of two participants did not complete the whole intervention. Adherence may become the key consideration by stakeholders and researchers investing in workplace interventions who must try to understand and address the potential underlying reasons for noncompletion. The 55% dropout rate observed here agrees with what is rarely discussed, but usually observed in other similar studies. For example, in their study, Jakobsen et al<sup>70</sup> asked tertiary employees to exercise five times per week (10-minute sessions) for 10 weeks and observed a dropout rate of 22%. Moreover, during their 1-year trial, Pedersen et al<sup>21</sup> obtained a 48% dropout rate among office workers who exercised three times per week, and in another study, 30% of the enrolled participants were found to give up before the end of the intervention.<sup>3</sup> Although such high dropout rates are usually observed, the profile of these participants remains underexplored. In other words, even though most of the studies conducted so far emphasize the positive effects of physical activity among employees, the high dropout rates observed clearly question the reliability and feasibility of onsite structured physical activity programs. Many

larger analyses should be conducted to better understand and identify the potential predictive indicators for tertiary employees' adherence to on-site physical activity programs.

Our results obviously have to be interpreted in light of some limitations. The sample size might be considered as one of the limitations, demonstrating the difficulty of recruiting volunteers for such interventions, and reinforcing the need for deeper explorations of the potential specific profile of employees interested in workplace physical activity programs. The use of field testing to assess employees' physical fitness might also be a limitation and more objective methods could be used such as ergometers and direct methods to assess their aerobic capacities (laboratory-based maximal aerobic testing). Obviously, the use of BIA to assess body composition is not as accurate as other devices such as dual-x-ray absorptiometry; however, BIA offers one of the best alternatives for studies enrolling large samples and remains a reliable and validated tool in healthy adults, as previously described.<sup>28</sup> The lack of biological data collection might also be pointed out as a potential limitation. Indeed, while Pedersen et al<sup>21</sup> found similar results showing that a 60-minute onsite exercise session per week (training and all-round physical exercise) favored a significant improvement of tertiary employees' physical capacities, they also found improved cardiovascular and metabolic syndrome related risk factors as an important metabolic health indicator. Finally, the European EPIC cohort study showed significant interactions between PA and BMI in relation to all-cause mortality, with a greater risk reduction due to increased PA level observed in those categorized as normal weight and abdominally lean, and with a markedly reduced risks (–15% to 30%) observed between individuals categorized as inactive and moderately active.<sup>71</sup> Our participants were abdominally lean, of normal weight, but with a high level of sedentary time, which underlines the significance of our results from a preventive health perspective.

## CONCLUSION

While tertiary employees spend a considerable part of their time being sedentary, the current study highlights the beneficial effects of on-site physical activity programs on their overall health. Despite these benefits, it seems that such interventions suffer from a substantial drop-out rate that must lead occupational health specialists to develop new strategies promoting the employees' adhesion. Although the program was theoretically adapted to tertiary workers (on site, individualized, supervised, multiactivities), not all employees participated and about half of them dropped out during the 10-month intervention. Moreover, further studies should focus on addressing sedentary time and increasing light to moderate PA before and/or in addition to structured PA program.

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# Effect of Work-Related Sedentary Time on Overall Health Profile in Active vs. Inactive Office Workers

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**Objective:** While public health strategies are developed to fight sedentary behaviors and promote physical activity, some professional activities, and especially tertiary ones, have been pointed out for their highly sedentary nature. Although workplace physical activity programs are increasingly proposed by companies to their employees in order to increase their physical activity levels, sitting and screen time remain extremely high. The main aim of this work was to compare health indicators between active and inactive tertiary employees with similar high levels of sedentariness. Secondly, we questioned the effects of a 5-month workplace physical activity program on overall health indicators among initially active and inactive tertiary employees.

**Methods:** Anthropometric measurements, body composition (bio-impedance), physical fitness (cardiorespiratory and musculoskeletal fitness) and health-related quality of life and perception of health status (self-reported questionnaires) were assessed among 193 active and inactive tertiary employees before (T0) and after a 5-month workplace physical activity intervention (T1), composed of 2 physical sessions per week.

**Results:** Significant improvements were found in performance of push-ups ( $p < 0.001$ ), back muscle strength ( $p < 0.001$ ) fat mass ( $p < 0.01$ ) and waist circumference ( $p < 0.05$ ) in active compared with inactive employees both at baseline and at the end of the program. Health perception ( $p < 0.001$ ) was significantly different between groups at T0 but not at T1. However, no significant difference was observed for fat-free mass, BMI, workplace well-being and lower and upper limbs muscle strength. The variations between T0 and T1 demonstrate that, while all the studied parameters progressed positively during the 5-month program, health perception ( $p < 0.001$ ), back muscle strength ( $p < 0.05$ ) and BMI (tendency) showed a significantly higher progression in the inactive compared with the active group.

**Conclusion:** Health indicators might not be improved among active tertiary employees compared with inactive ones, which might be due to the high level of sedentariness characterizing their occupational task. Structured on-site physical activity programs can improve health in both initially active and inactive employees.

**Keywords:** tertiary employees, physical activity, sedentariness, health, fitness

## INTRODUCTION

Over the last decades, sedentariness has become one of the largest public health concerns, recognized as one of the main causes of preventable premature mortality. Diaz et al. recently highlighted that both the total volume of sedentary time as well as its accrual in prolonged, uninterrupted bouts are associated with increased all-cause of mortality (1), which has been associated with poor health at all ages, independently of the level of physical activity (2). It is crucial to clarify that sedentariness is not the same as lack of physical activity, as people can reach the recommended levels of physical activity for their age, yet spend a large amount of their time engaging in sedentary activities (3, 4). Evidence suggests that the time dedicated to sedentary activities (leisure and work) has increased from 26 to 38 h per week between 1965 and 2009 in the United States and from 30 to 42 h between 1960 and 2005 in Great Britain, expressing alarming prospects for 2030 (5). According to the 2006 national nutrition and health survey (ENNS), 53% of adults aged 18 to 74 (59% of men and 48% of women) spend 3 h or more per day (working days and holidays) in front of a screen (television or computer) outside of working hours. Importantly, this proportion progresses with age in both men and women.

When it comes to work-related sedentary time particularly, it appears that the prevalence of sedentary professions increased by 20% in the United States between 1960 and 2008, with a concomitant decline of more “physically active professions” (5). In France, working adults have been shown to spend on average 9.96 h per day sitting on workdays (with at least 4.17 h/day seated at work) and 7.58 h/day sitting on non-workdays (6). Importantly, Saidj et al. reported clear associations between the sedentary time at work and the adoption of sedentary behaviors outside work.

Worldwide, public health policies underline the urgent need to create a suitable culture of regular physical activity (7), where employers are encouraged to play a key role in the promotion of health and well-being among adults of working age (8).

Workplaces represent today an ideal opportunity for new initiatives to promote physical activity. Workplaces could indeed reduce some of the barriers that have been identified to limit the engagement in physical activity, such as lack of time and proximity (9). Due to the difficulties in changing the habits of populations and to promote physical activity in usual settings (such as associations, gymnasiums, etc.), workplace-based programs might provide a great way to incite employees to increase their activity levels, especially due to the amount of time people spend at their workplace (10). There is clear evidence that increasing the employees' level of physical activity has beneficial effects on their health, concomitantly reducing health care costs

(11) and the cost of different treatments for preventable diseases, and decreasing the number of sick leave due to diseases or injuries (12, 13). Some previous studies have indeed shown that interventions conducted to improve employees' health, may lead to reduced absenteeism and sick leave, while favoring increased productivity (14, 15).

Although some controlled and well-designed studies have found that workplace-based physical activity interventions can improve general health, physical activity levels (14, 16), weight status (17) and may have positive effects on eating behavior among employees (18); a recent systematic review identified some limitations of such interventions, due to large inter-individual heterogeneity (19). At the same time, a recent study conducted in 2017, underlined the beneficial effects of worksite physical activity programs proposed to tertiary employees on overall health (20). Although this pilot study was the first to our knowledge to enroll both experimented (active individuals, already regular users of their companies' physical facilities) and novice (inactive before the intervention) participants, further studies are now needed using larger sample sizes and more objective methods. Moreover, while the studies conducted so far mainly focused on increasing the level of physical activity of workers, tertiary employees remain highly sedentary due to the static nature of their work, which might have deleterious effects, independently of their physical activity levels. Some interesting studies effectively suggest that long periods of sedentary behaviors increase the risk of cardiovascular diseases, type 2 diabetes, some cancers and obesity, among other conditions, even in individuals reaching recommended levels of physical activity (2).

While it remains evident that workplace interventions have to be conducted to favor healthy active living among tertiary employees, the sedentary nature of such professional activities must be considered. The first aim of the present study was to compare overall health indicators among physically active and inactive tertiary employees, showing a high level of sedentariness. Secondly, we assessed the effects of a 5-month physical activity workplace intervention on overall health indicators between sedentary previously active and newly active tertiary employees.

## METHODS

### Participants and Design

A total of 193 office employees (tertiary workers; 83 females, 110 males; age:  $44.2 \pm 9.8$  years; weight:  $72.6 \pm 14.7$  kg; BMI:  $24.5 \pm 3.8$  kg/m<sup>2</sup>) took part in this quasi-experimental study. Participants were approached and recruited through the



manufacturer internal network, thanks to various informative announcements to the employees. After a medical inclusion to control for their ability to complete the whole study, anthropometric measurements and body composition were assessed, aerobic fitness, muscle capacities, well-being as well as quality of life and health perception were measured (T0). The participants followed then a 5-month on-site physical activity intervention and all these measures were replicated by the end of the intervention (T1). All the participants received information sheets and signed consent forms as requested by ethical regulations. To be included the participants had to: (i) be tertiary employees; (ii) show no contraindications to physical practices; (iii) be free of any medication that could interfere with the study outcomes. Employees who showed a regular participation in their worksite physical activity program for the last 2 years were classified as active while the others were classified as inactive. Their physical activity level was also confirmed through a self-reported physical activity questionnaire (21, 22) based on the World Health Organization's Physical activity guidelines (at least 150 min of moderate to vigorous activity per week) (23). All the participants received information sheets and signed consent forms as requested by ethical procedures. This study has been reviewed and approved by our local ethical authorities (Local Human Protection Committee - CPP SUD EST VI / CNIL).

### On-Site Physical Activity Intervention

Active and inactive groups were requested to take part in two to three training sessions per week, within their worksite training program. Each session lasted 45 min minimum, alternating between muscle-strengthening and cardiorespiratory exercises (one of each per week), supervised by a professional for a duration of 5 months. The program proposed 18 different physical activities such as muscle strengthening, stretching, cardiorespiratory or team sports. The participants were asked to perform at least one muscle-strengthening (weights machines) and one cardiorespiratory session (Latin dance, step, bike, fight exercise...) per week. Compliance was controlled by a computerized access to the sport facilities.

### Anthropometric Measurements and Body Composition

A digital scale was used to measure body mass to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Both body mass and height were obtained at the same time of the day for the same subject, and not in a fasting state. Body Mass Index (BMI) was calculated as body mass (kg) divided by height squared ( $m^2$ ). Body Composition was assessed by bioelectrical impedance analysis, performed with the Tanita MC780 multi frequency segmental body composition analyzer. This analyzer consists in a stand-alone unit where the subject has to step on bare foot (standard mode). Information concerning the subject (age, gender, and height) is entered by the researcher. Once body mass has been assessed by the scale, the subject has to take grips with both hands (alongside his body) during the impedance measure (Hand to foot BIA). A full segmental analysis is performed in

less than 20 s. Total body fat, total fat-free mass and body water were reported by the researcher into an excel sheet for statistical treatment. The newly developed BIA analyzer has been recently validated in healthy adults (24).

### Well-Being, Quality of Life and Health Perception

Well-being and quality of life at work were assessed using a newly developed questionnaire ("worksite well-being and quality of life questionnaire") especially designed for occupational health studies. The participants were asked to rate statements describing their well-being at work using visual analog scales ranging from "not at all" to "absolutely" (i.e., "I'm actually feeling distressed while at work"). This questionnaire has been recently validated in a similar population (25).

All participants were also asked to complete a short self-administered questionnaire specifically designed to explore their perception of health ("health perception scale"). Six criteria were investigated: (1) perceived physical fitness, (2) perceived ideal weight, (3) perceived healthy balanced diet, (4) perceived sleep quality, (5) perceived stress level, and (6) perceived general health. A 10-point scale from 1 (not at all) to 10 (very much) was used to assess each item. The six individual scores were computed to obtain a global score for health perception. This questionnaire has been previously validated in adults (26).

### Aerobic Fitness

The step test was performed on a stool of 16.25 inches (41.3 cm) for men and 11.8 inches (30 cm) for women for a total duration of 6 min at the rate of 24 cycles per minute, which was set by a metronome. Participants were asked to wear a heart rate monitor (Polar Electro Inc, Lake Success; USA) during the test and heart rate was recorded at the end of the 6 min, 30 s and 1 min after completion of the test. This test has been found reliable in healthy subjects and it is highly reproducible (27).

### Muscle Capacities

Upper limbs muscle strength was assessed using the handgrip on the dominant hand, as a non-invasive marker of muscle strength of upper limbs, well suitable for clinical use (28). The participants were also asked to perform a maximal number of push-ups (with the knees on the floor) respecting an imposed frequency. The test stopped once they were not able to maintain this rhythmicity or showed difficulties to maintain the correct position (29, 30). Counter Movement Jump (CMJ) was used to assess lower limb muscle strength using the Optojump technology (Microgate SRL, Rome, Italy) (31). The Shirado test was used to assess the static endurance of the abdominal muscles (32) and the Sorensen test to assess back strength and endurance for all the muscles involved in the extension of the trunk (33).

### STATISTICAL CONSIDERATIONS

Sample size has been estimated in order to compare overall health indicators as fat mass percentage among physically active and inactive tertiary employees showing a high level



of sedentariness. According to our previous work (20) and to Cohen's recommendations (34) who has defined effect-size bounds as: small (ES: 0.2), medium (ES: 0.5) and large (ES: 0.8, "grossly perceptible and therefore large"), we calculated that a minimum of 185 participants would allow to highlight an effect size equal to 0.5 for a two-tailed type I error at 5%, a statistical power of 90% and a ratio 60–40% for inactive/active employees. All analyses were performed using Stata software (version 13, StataCorp, College Station, TX). Statistical analyses were done for a two-sided type I error of  $\alpha = 5\%$ . Baseline subject's characteristics were presented as the mean  $\pm$  standard deviation (SD) or the [median interquartile range] for continuous data (assumption of normality assessed by using the Shapiro-Wilk test) and as the number of patients and associated percentages for categorical parameters. Quantitative variables were compared (at each time-point evaluation T0 and T1) between independent groups (active vs. inactive tertiary employees) by Student *t*-test or Mann-Whitney test if conditions of *t*-test were not respected (normality and homoscedasticity analyzed using Fisher-Snedecor test). Comparisons between independent groups were done by Chi-squared or when appropriate by Fischer-exact test for categorical variables. To analyze repeated correlated data, the evolution of variations between the beginning and the end of the study was calculated for each parameter. Then, random-effects models were performed to study fixed effects as group (noted intergroup evolution of variations in **Tables 1, 2**), time-points evaluation and their interaction taking into account between and within subject variability. The normality of residuals was checked for all models. A sensibility analysis was performed to measure the possible impact of missing data (notably imputation of missing data). Results and practical conclusions were analogous (data not shown).

## RESULTS

A total of 193 middle and upper classes office workers took part in the study; 84 females and 110 males with an average age of 44.2

$\pm 9.8$  years, an average weight and BMI of  $72.6 \pm 14.7$  kg and  $24.5 \pm 3.8$  kg/m<sup>2</sup> respectively. At baseline (T0), 98 and 95 participants composed the inactive and active groups respectively against 71 and 73 at the end of the intervention (T1).

**Figure 1** illustrates the dropout rate observed during the 5-month workplace program. 22% of all subjects dropped out before the end of the intervention, with a higher rate observed in the initially active employees: 20% did not complete the whole study against 27% in the inactive sample ( $p < 0.05$ ).

**Table 1** details the results for anthropometric characteristics and body composition, while **Table 2** presents the participants' functional characteristics, well-being and health perception. There was a statistically significant difference for push-ups ( $p \leq 0.001$ ;  $p \leq 0.01$  respectively), Sorensen test ( $p \leq 0.001$ ), fat

**TABLE 1 |** Intra- and inter-group results for anthropometry and body composition.

		Inactive	Active	I vs. A
Fat mass (%)	T0	24.8 $\pm$ 7.5	21.7 $\pm$ 7.1	$p = 0.0032$
	T1	22.8 $\pm$ 6.9	20.8 $\pm$ 7.3	$p = 0.0722$
	T0 vs. T1	$p < 0.001$	$p < 0.001$	
Fat-free mass (kg)	T0	52.5 $\pm$ 11.3	53.6 $\pm$ 10.7	ns
	T1	54.5 $\pm$ 10.9	52.7 $\pm$ 9.9	ns
	T0 vs. T1	ns	ns	
BMI (kg/m <sup>2</sup> )	T0	25 $\pm$ 4.6	24.1 $\pm$ 3.2	ns
	T1	24.9 $\pm$ 3.9	23.7 $\pm$ 3.1	$p = 0.0864$
	T0 vs. T1	ns	ns	
WC (cm)	T0	92 $\pm$ 15.3	87.5 $\pm$ 12.3	$p = 0.0264$
	T1	92 $\pm$ 13.4	87 $\pm$ 12.1	$p = 0.0287$
	T0 vs. T1	ns	ns	

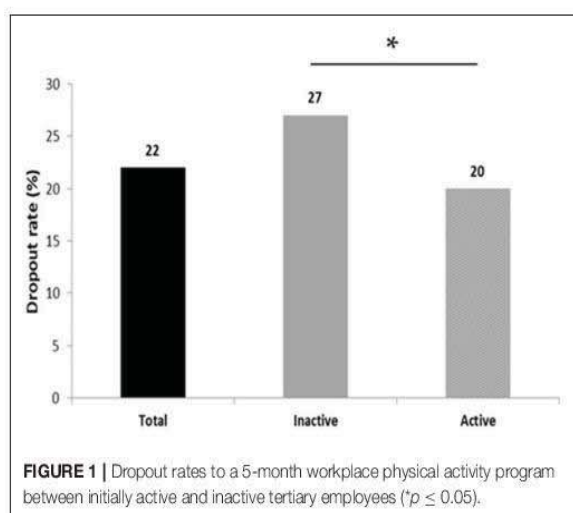
BMI, Body Mass Index; WC, Waist Circumference; T0, baseline; T1, end of the 5-month program; I, Inactive; A, Active.

**TABLE 2 |** Intra- and inter-group results for functional tests, health perception and well-being.

		Inactive	Active	I vs. A
Health perception	T0	51.2 $\pm$ 15.1	61.3 $\pm$ 14.3	$p < 0.001$
	T1	59.1 $\pm$ 14.7	62.5 $\pm$ 12.7	ns
	T0 vs. T1	$p < 0.001$	ns	
Worksite well-being	T0	7.34 $\pm$ 1.4	7.3 $\pm$ 1.3	ns
	T1	7.3 $\pm$ 1.2	7.4 $\pm$ 1.3	ns
	T0 vs. T1	ns	ns	
Rest heart rate (bpm)	T0	71.3 $\pm$ 11	67.2 $\pm$ 11.6	ns
	T1	73.5 $\pm$ 10.5	68.3 $\pm$ 10.3	ns
	T0 vs. T1	ns	ns	
Heart rate (bpm)	T0	150.4 $\pm$ 20.2	147.9 $\pm$ 19.9	ns
	T1	141.1 $\pm$ 18.3	135.6 $\pm$ 17.3	$p = 0.0698$
	T0 vs. T1	$p = 0.0029$	$p < 0.001$	
Heart rate +30 (bpm)	T0	126 $\pm$ 26.6	128.3 $\pm$ 22	ns
	T1	127.8 $\pm$ 19.3	116.9 $\pm$ 19.2	$p = 0.0329$
	T0 vs. T1	ns	$p < 0.001$	
Heart rate +60 (bpm)	T0	116 $\pm$ 20.8	112.4 $\pm$ 22.4	ns
	T1	111.3 $\pm$ 21.3	103 $\pm$ 18.4	$p = 0.0236$
	T0 vs. T1	ns	$p < 0.001$	
CMJ (cm)	T0	24.6 $\pm$ 7.7	23.6 $\pm$ 7.1	ns
	T1	26.7 $\pm$ 7.6	24.4 $\pm$ 8.9	ns
	T0 vs. T1	$p = 0.0256$	ns	
Handgrip (kg)	T0	24.6 $\pm$ 7.7	23.6 $\pm$ 7.1	ns
	T1	41.8 $\pm$ 10.7	40.3 $\pm$ 11.1	ns
	T0 vs. T1	$p = 0.0035$	$p = 0.0082$	
Push-ups (rep)	T0	22.8 $\pm$ 14.4	36.5 $\pm$ 19.2	$p < 0.001$
	T1	29.4 $\pm$ 15.4	39.8 $\pm$ 18	$p = 0.0014$
	T0 vs. T1	$p < 0.001$	ns	
Shirado (s)	T0	173.1 $\pm$ 77.7	181.8 $\pm$ 50.9	ns
	T1	184.1 $\pm$ 82.2	174.3 $\pm$ 52	ns
	T0 vs. T1	ns	ns	
Sorensen (s)	T0	101.2 $\pm$ 56.9	159 $\pm$ 41.6	$p < 0.001$
	T1	112.3 $\pm$ 54.2	161.2 $\pm$ 47.7	$p < 0.001$
	T0 vs. T1	ns	ns	

CMJ, Counter Movement Jump; ST, step test; HR, heart rate; T0, baseline; T1, end of the 5-month program; I, Inactive; A, Active.





mass ( $p \leq 0.01$ ; tendency respectively) and waist circumference ( $p \leq 0.05$ ) between active and inactive at T0 but also at T1. **Table 2** also highlights a significant difference for health perception at T0 between active and inactive participants ( $p \leq 0.001$ ), but this difference no longer exists at T1. No significant change in worksite well-being, rest heart rate, CMJ, Shirado test, fat-free mass or BMI was observed during the study. There was a time effect for the inactive group which demonstrates significant progressions between T0 and T1 for health perception ( $p \leq 0.001$ ), and CMJ ( $p \leq 0.01$ ). In contrast, the two groups significantly improved their results for handgrip ( $p \leq 0.01$ ), push-ups (inactive:  $p \leq 0.001$  and active:  $p \leq 0.05$ ), fat mass ( $p \leq 0.001$ ) and their heart rate post exercise (inactive:  $p \leq 0.01$  and active:  $p \leq 0.001$ ) between T0 and T1.

**Table 3** details the results of the amplitude of the variations obtained between T0 and T1. Health perception ( $p \leq 0.001$ ), performances at the Sorensen test ( $p \leq 0.05$ ), Shirado test (tendency) and BMI (tendency) all show a significantly higher progression in the inactive compared with the active groups. The variations observed between T0 and T1 were not found significantly different between groups for worksite well-being, CMJ, handgrip, push-ups, fat mass, fat-free mass and waist circumference.

## DISCUSSION

The main aim of the present study was to compare overall health indicators between active (above recommended levels of physical activity) and inactive (below recommended levels) employees with high and similar levels of worksite-induced sedentariness. According to our results, BMI, fat-free mass, lower and upper limbs muscle capacities (CMJ and handgrip) and aerobic capacities are not different between active and inactive tertiary employees who both spend about 7.5 h per days seated in front of computers (approximately 37.5 h/week). This is to our knowledge the first study that questions the effect of a high

level of sedentariness on health and fitness indicators among physically active and inactive workers.

While public health strategies have been developed to increase individuals' physical activity levels over the last decades, more concerns are expressed today regarding the progression of sedentariness. Indeed, it is now clear that physical activity and sedentary behaviors are two different constructs that have independent effects on health (35). This is particularly important since sedentariness has become one of the largest public health concerns, being nowadays recognized as one of the main causes of preventable premature mortality. Although worksites have been identified as ideal settings to favor physical activity among workers (9), the "tertiarisation" of our societies and industries has been favoring sedentariness, with employees spending now most of their daily time seated in front of computers. While most of the available studies have been evaluating the levels of physical activity of tertiary employees (36), their time spent seated and/or in front of a computer screen (37), or have been independently looking at the effect of physical activity programs (38) or interventions aiming at reducing sedentary time (39), we did not find any work comparing fitness parameters between physically active and inactive tertiary employees who are characterized by a high level of sedentariness.

In their study, Ko et al. compared the incidence of metabolic risk factors and the prevalence of metabolic syndrome between white collars divided in physical activity tertiles (40). According to their results, workers with the lowest physical activity levels present higher waist circumference, increased triglycerides concentrations, higher HDL-C concentrations and a higher risk for metabolic syndrome (40). Unfortunately, their data do not allow the classification of their participants as active or inactive in regards to physical activity guidelines, and information regarding sedentary behaviors is missing, as well as details regarding the exact occupational activity of their participants (40). More recently, Browne et al. conducted a cross-sectional study among about 500 sedentary tertiary employees, hypothesizing that sedentary occupational workers who meet physical activity recommendations (without precisising the guidelines used) present lower risks for metabolic syndrome than inactive ones (41). Their results point out that active workers show lower odds for abdominal obesity, elevated blood pressure, reduced high-density lipoprotein cholesterol and overall metabolic syndrome, after adjustments for age, working hours, body mass index, and tobacco use (41). The significantly higher fat mass percentage and waist circumference observed in our inactive group are in line with these results. Although these studies tend to suggest that in employees who spend most of their daily time sedentary, physical activity has beneficial effect on their metabolic health, we missed finding any data related to physical and overall health fitness.

Not only objective health and fitness indicators were assessed in the present work, employees' self-perception of their overall health and work-related well-being were investigated. Although active workers show a significantly greater score for overall health perception, worksite wellbeing was not significantly different compared with inactive employees. Although this might suggest that physical activity levels might not be associated



**TABLE 3 |** Intergroup evolution of variations between the beginning and the end of the study.

	Inactive		Active		<i>p</i>
	mean sd	var	mean sd	var	
Health perception	20.2 ± 35.4	13.6 [−2.7;35.1]	3.7 ± 21.2	1.5 [−11;8.4]	<i>p</i> < 0.001
Worksite well-being	2 ± 21.3	1.4 [−11.4;14.3]	1.8 ± 17.2	−0.06 [−6.4;8.3]	
CMJ (cm)	5.2 ± 14	3.2 [−3.8;9.9]	3.9 ± 21.8	3.3 [−1.6;12.2]	
Handgrip (kg)	3.4 ± 8.7	2.9 [−1.5;9.1]	4.1 ± 10.9	3.2 [−3.1;10.3]	
Puch-ups (rep)	29.5 ± 65.3	16.4 [0;40]	50 ± 230.2	6 [−5.9;26]	
Shirado (sec)	20.5 ± 73	0 [−14.3;28.7]	−2.9 ± 22.4	0 [0;0]	<i>p</i> = 0.0743
Sorensen (sec)	35.4 ± 119.8	0 [0;28.2]	0.08 ± 21.7	0 [0;0]	<i>p</i> = 0.0341
Fat mass (%)	−4.2 ± 9.3	−4.1 [−9.6;−0.4]	−3.4 ± 8.9	−2.7 [−7.8;3.3]	
Fat-free mass (kg)	0.8 ± 2.6	1 [−0.4;2.4]	0.7 ± 3.4	0.7 [−0.5;2.4]	
BMI (kg/m <sup>2</sup> )	−0.6 ± 3	−0.4 [−2;0.8]	0.1 ± 2.4	0.4 [−1.3;1.7]	<i>p</i> = 0.0612
WC (cm)	−0.2 ± 3.6	−0.4 [−2.3;1.5]	0.05 ± 3.6	−0.1 [−2.5;2.8]	

BMI, Body Mass Index; WC, Waist Circumference; CMJ, Counter Movement Jump; T0, baseline; T1, end of the 5-month program; I, Inactive; A, Active.

with employees' work-related satisfaction and comfort, some recent studies suggest that tertiary employees' wellbeing might be related to sedentary behaviors, which may explain our results since both active and inactive workers present here at least 7.5 h of sedentary time per day (42). Such results are definitely of importance for both workers and employers, since work-related wellbeing has been clearly identified as a major predictive factor for prolonged or future sickness absence (43).

The second aim of the present work was to assess the effects of a 5-month worksite structured and monitored physical activity program among initially inactive and active employees (already regularly using the companies' physical facilities for the last 2 years). While the majority of the published papers in the field assesses the effects of physical educations, encouragement and motivational strategies (39, 44) walking meetings (45) or sedentary breaks (46), less studies have been conducted implementing structured aerobic and resistance exercise sessions (20, 47). In 2009, Pedersen et al. conducted a 1 year randomized controlled trial questioning the effects of resistance training and all-round physical exercise sessions performed within workplaces (1 h/ week during working hours) on tertiary employees health indicators (47). Their results showed significant reductions of cardiovascular and metabolic syndrome-related risk factors as well as musculoskeletal pain symptoms, concomitantly with minor increases in physical capacities. The physical activity levels of the participants was however not considered. In the present study, the participants were asked to perform 2 to 3 exercise sessions per week, composed of resistance and aerobic exercises, in one of the physical activity facilities proposed by their companies. According to our results, while numbers of health and fitness indicators were improved by the program in our initially inactive subsample, active individuals also show improvements. While health perception and counter movement jumps were significantly improved in the inactive group only, the heart rate response to our aerobic test, the handgrip performance, the maximal number of push-ups, as well as the percentage of fat mass was significantly improved in both groups. Interestingly,

the heart rate recovery 30 s and 1 min after the aerobic test were improved in the experienced group only. These results suggest that while such a physical activity intervention has beneficial effects in initially inactive employees, it continues to favor positive adaptations in active ones. These results are in line with a previously published pilot study, suffering from reduced sample size but already suggesting the interest of worksite exercise programs among tertiary employees, whatever their initial physical activity level (20).

Although the present study provides main insights regarding the importance of considering both sedentary and physical activity levels when it comes to evaluating tertiary employees' health indicators, and underlines the beneficial effects of structured on-site physical interventions among both active and inactive workers, our results also point out the necessity to consider the employees' adherence rate to such programs. Indeed, 1 out of 5 participants did not complete the whole intervention, which must definitely be considered by stakeholders and investigators who must try to understand and identify the potential underlying reasons. This 20% dropout rate observed here, is in line with what is rarely discussed but usually observed in other similar studies. In their study, Jakobsen et al. asked tertiary employees to exercise 5 times a week (10-min sessions) for 10 weeks and observed a similar dropout rate of 22% (48). During their 1 year trial, Pedersen et al. obtained a 48% dropout rate among office workers who exercised 3 times a week (47) and in our previous pilot work, 30% of the enrolled participants were found to quit before the end of the intervention (20). While such high dropout rates are usually observed, the profile of these participants remains under-explored. Although further studies are needed, specifically designed to address this question, our results, as illustrated by the **Figure 1**, tend to suggest that the initial physical activity level of the enrolled employees should be considered with a total of 20% of non-compliant being observed in the initially active sub-sample against 27% among the initially inactive one. This also highlights the fact the least active employees—and therefore those who need it the most—are



those who are at highest risk to drop out from such worksite PA programs.

Our results should clearly be interpreted in light of some limitations. The sample size might be considered as one of the limitations, underlying the difficulty to recruit volunteers for such interventions, reinforcing the need for deeper explorations of the potential specific profile of employees interested in workplace physical activity programs. The use of field testing to assess employees' physical fitness might also be a limitation, and more objective methods could be used, such as ergometers and direct methods to assess their aerobic capacities (laboratory-based maximal aerobic testing). Moreover, the use of BIA to assess body composition is not as accurate as dual-x-ray absorptiometry for instance; it composes however one of the best alternatives for studies enrolling large samples and remains a reliable and validated tool in healthy adults as previously described (24).

To conclude, the present study suggests that improvements in some health and fitness indicators might not be found among active tertiary employees, compared with inactive ones, which might be due to the high level of sedentariness characterizing

their occupational task. This result clearly calls for worksite-based interventions not only focusing on physical activity but also, and perhaps most importantly, trying to break down sedentary time. Our results also confirm that structured exercise interventions implemented with workplaces, improve health and fitness among both initially physically inactive and active tertiary workers, questioning however the profile of workers who are willing to be compliant to on-site physical interventions.

## AUTHOR CONTRIBUTIONS

PG and BP analyzed the data used in the manuscript, PD and JF participated in the project design. PG, DT, FD, and MD wrote and reviewed the paper.

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**Conflict of Interest Statement:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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## Sounding Board

# Employees' adherence to worksite physical activity programs: Profiles of compliers versus non-compliers

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**Abstract.** While worldwide public health policies have emphasized the necessity to create a culture that favors regular physical activity, stakeholders and health institutions keep looking for new strategies and opportune settings. Workplaces have been identified since employees spent a considerable part of their time at work and several worksite interventions have been developed lately. While the actual scientific literature clearly points out the beneficial effects of physical activity programs implemented within companies on employees overall health, available evidences however seem to question their adherence to such interventions. Based on previously published results and new observations, this paper discusses the adherence rate during workplace physical activity programs and suggests new strategies to favor increased physical activity among employees, considering their dropouters or finishers' profiles.

**Keywords:** Tertiary employees, occupational health, sedentariness

## 1. Introduction

Workplaces have been lately described as opportune settings to implement public health interventions that mainly advocate for active and healthy lifestyles.

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The World Health Organization and World Economic Forum have indeed defined workplaces as ideal sites to implement programs promoting health, particularly through physical activity and eating habits [1]. Employees spend a considerable part of their daily time at work and on-site physical activity facilities appear as a great way to encourage their engagement and practice while some of the main expressed barriers to physical activity are the lack of time and facilities proximity [2, 3]. Moreover, with the "tertiarisation" of our societies, most employees today



spend most of their working hours seated in front of computers. In addition, according to the 2006 national nutrition and health survey (ENNS), 53% of adults aged 18 to 74 (59% of men and 48% of women) spend three hours or more per day (working days and holidays) in front of a screen (television or computer) outside of work hours [4]. Importantly, this proportion progresses with age in both men and women. This is particularly concerning since it has been clearly shown that both the total volume of sedentary time and its accrual in prolonged and uninterrupted bouts are associated with all-cause mortality [5] but also with increased risk for major non communicable diseases (type 2 diabetes, cardiovascular diseases, cancers) [6]. Employers are today encouraged to play a key role in the health and well-being of working-age adults [7], particularly since the promotion of physical activity among employees will not only generate health benefits, but also reduce health-related care costs [8] and improve productivity [9].

Many studies have been conducted, proposing *in-site* physical activity interventions and providing positive results on employees overall health indicators. Vivela and collaborators for instance showed that a 4-month worksite physical activity program improved body composition among employees [10]. Similarly, Genin et al. showed that a 5-month worksite physical activity intervention improved overall health parameters (sleep, pain, muscle strength, body composition, health perception...) among initially inactive tertiary workers, also underlying improvement for most of these indicators in initially already active employees [11].

## 2. Employees' adhesion to physical activity programs

Although all the available evidences are in line with these two examples, collectively showing positive effects of such programs conducted within companies on employees' health and wellbeing, the profiles and adherence rates of the employees engaged in such programs remain unconsidered. This is of particular importance since these programs have been mainly developed to favor physical practice among inactive individuals.

When considering some of the main studies in the field, dropout rates up to 50% can be observed. In a study conducted by Jakobsen et al. [12], tertiary employees exercised 5 times 10 minutes per week (high-intensity strength training using elastic bands

and kettlebells during working hour) in addition to physical activity education (motivational coaching sessions) for 10 weeks, and the authors noticed 22% of dropout [12]. In 2009, Pedersen and collaborators obtained a 48% dropout rate during their 1-year study in which tertiary employees exercised 3 times a week (sessions lasting 20 minutes), alternating resistance and all-around physical exercises [13]. In a recent study from our research group in which tertiary employees were proposed to complete a 5-month on-site physical activity program (exercise facilities implemented within their companies) composed of 2 to 3 aerobic and resistance training sessions per week, 30% of the initially involved participants gave up before the end of the intervention [11]. Interestingly, our group has recently conducted two similar studies among public and private tertiary workers and our preliminary results indicate a dropout rate reaching 65% when the intervention lasts 10 months, with an intermediary dropout of 38% after the first 5 months [14]. Not only workplace exercise-based interventions suffer from a high degree of abandonment, motivation group strategies also report dropout rates up to 31% [15], 29% of dropout were observed in responses to walking and standing meetings [16] and about 25% of workers were found to give up interventions based on encouraging text messages only [17]. Unfortunately, none of these studies tried to identify the reasons beneath these high levels of abandonment. Such dropout rates are not be specific to workplace PA programs with many PA interventions also indicating high levels of abandons, this must however not be under-interpreted and underestimated as it might provide important insights to better understand potential adherence profiles (compliers vs non-compliers) and to better target workplace interventions.

## 3. Compliers vs non-compliers

Yet this adherence issue has been already underlined by some, studies have been so far trying to find incentives, mainly financial ones to increase their adherence rates [18] instead of identifying the core reasons responsible for the employees dropout. Indeed, while the profile of the participants who give up interventions is rarely discussed and considered, our last results seem to suggest that employees who abandon workplace physical activity programs are those who would need it the most, suggesting that such interventions might miss their primary targeted population.



From September 2016 to June 2017, our research group assessed the effect of a 10-month physical activity intervention proposed to initially physically active and inactive tertiary employees. Briefly (the protocol has been detailed elsewhere, [11]), 98 participants had to engage in 2 to 3 exercise sessions per week within their workplace, while overall health indicators (body composition, anthropometric values, physical fitness, quality of life, health perception, pain, sleep quality) were assessed before (T0), at mid-point (T1) and after (T2) the 10-month program. Our sample was composed of voluntary inactive individuals that did not reach the physical activity recommendations and active ones that were already regular members of their companies' physical activity facilities (for at least 2 years). Taking into account the entire sample, 22% of the subjects dropped out before T1 and 47% before the end of the 10-month intervention. While these statistics seem in line with the previously cited literature, it appears interesting to give a deeper look at the profile of the non-compliant participants, to better understand their high rates of withdrawal. Our retrospective analysis showed a higher dropout rate at T1 among initially inactive individuals (27%) *versus* the active ones (20%). This is even more pronounced at T2 where initially inactive employees showed a dropout rate of 64% from T1 and 77% from T0 against 19% and 35% among active ones respectively.

Non-compliers were also found to have higher initial body weight, body mass index, and lower fat free mass than compliers. The percentage of fat mass was significantly higher among participants giving up prematurely ( $26.4 \pm 7.7\%$ ) compared with those who completed the whole program ( $24.2 \pm 7.5\%$ ) ( $p < 0.05$ ). Other physical fitness indicators were also found higher at T0 among compliant participants compared with those who gave up. These data seem to suggest that the initial fitness profile of employees should be considered when implementing such physical activity interventions. Moreover, they also suggest that such interventions (personalized, supervised, combining endurance and strength training) might not be adapted to individuals who might need it the most, those with the lowest physical fitness.

Importantly, we also observed that the short-term (first months) degree of success of such *in-site* physical activity programs might determine the rate of adherence. Indeed, our preliminary data indicate that the improvement of body composition, perceived effort induced by exercise or aerobic fitness during

the first phase of the intervention might influence the adherence of tertiary employees to the remaining months of the program. For instance, we found better improvement of the heart rate response to exercise ( $p < 0.05$ ), the post-exercise heart rate recovery ( $p < 0.01$ ) and fat mass percentage ( $p < 0.05$ ) after the first 5 months in those who did not drop out between T1 and T2 compared to those who did. This result is original and suggests that not only the initial health and fitness profile of the participants will determine their adhesion rate, but also the efficiency of the first months of an intervention to induce positive changes (Fig. 1).

Beyond these scientific statistics and considerations, the main advance reason expressed by participants for engaging in worksite-based physical activity programs is the gain of time. Indeed, most of the employees who assiduously engage in such programs admit to be already active and that these on-site facilities represent a great opportunity to gain some time outside work (by training for instance during lunch time). They most of the time confess that they would be active anyway and only few of them start being active thanks to these facilities and programs proposed within companies (on going internal survey).

Obviously these preliminary data have to be considered with caution and some larger analysis should be conducted such as systematic reviews and meta-analysis to better understand and identify the potential predictive indicators for tertiary employees' adhesion to on-site physical activity programs. This seems particularly important since these first insights suggest that while public health policies and strategies have been advocating workplaces as opportune settings to promote higher physical activity level among employees, such interventions might not favor the adhesion of the employees needed it the most, in other words those presenting lower health-related fitness and low physical activity levels. Companies' health and wellbeing strategies should consider adding individualized approaches based on their employees' profiles to their classical physical activity facilities.

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## Conflict of interest

None to report.

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## 6. Annexe 6 – Revue relative à la thèse

# PHYSICAL ACTIVITY, INACTIVITY, AND SEDENTARY BEHAVIORS: DEFINITIONS AND IMPLICATIONS IN OCCUPATIONAL HEALTH

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### Abstract

Based on the increasing evidence linking excessive sedentary behaviors and adverse health outcomes, public health strategies have been developed and constantly improved to reduce sedentary behaviors and increase physical activity levels at all ages. Although the body of literature in this field has grown, confusion still exists regarding the correct definition for sedentary behaviors. Thus, there is a need to provide a clear definition in order to distinguish sedentary behaviors from physical activity and inactivity. This paper will briefly review the most recent and accepted definitions of these concepts and illustrate their relationships. Nowadays, since most working adults spend a high proportion of their waking hours in increasingly sedentary tasks, there will be a particular focus on the field of occupational health. Finally, simple modifications in the workplace will be suggested in order to decrease sedentary behaviors.

**Key words.** Physical activity, Sedentary behaviors, Occupational Health, Inactivity

## 1. Introduction

The beneficial effects of physical activity have been clearly described in the literature with recent meta-analyses providing a high level of evidence regarding its impact on overall mortality (1,2), cardiovascular disease-related mortality (3) or cancer-related mortality (3, 4, 5). In addition to reducing the risk of mortality, regular physical activity favors healthy growth and aging and prevents the occurrence of many chronic diseases (6). The last century has been the cradle of our societies' modernization and automation favoring the occurrence and development of sedentary opportunities and behaviors. This sedentariness has lately been described as a major mortality risk factor (7), independent of physical activity (8), and approximately 5.3 million of deaths are attributed to physical inactivity (9).

A worker's activity has evolved throughout the last century, clearly shifting to more sedentary occupational tasks, and this "tertiarisation" results in workplaces that are of particular concern. In their research, Church and colleagues reported a decrease of about 100 calories in the daily occupation-related energy expenditure over the last 50 years in the United States, which plays a significant role in the body weight of both men and women (10). To date, while few data are available regarding employees' physical activity, their sedentary time and health-related consequences have been particularly studied. Recent research including meta-analyses have clearly underlined the negative impact of seated occupational activities on overall mortality (11, 12). According to some studies, the mortality rate is increased by 2% for every seated hour and can reach up to 8% per hour when the total consecutive time spent seated is above 8 hours per day (13). These statistics are part of a large body of evidence associating occupational activities with health issues, clearly urging for appropriate worksite interventions to improve tertiary employees' health.

Our societal changes, favoring the minimization of physical effort, are particularly problematic based on the assumption that individuals possess an innate tendency to conserve energy and avoid unnecessary physical exertion. This general trend to avoid energy expenditure may explain why people do not exercise regularly despite the known negative effects of physical inactivity on health (14-16). Moreover, we are currently living in a paradoxical time where our society has become more "technophilic", favoring strategies to avoid and/or minimize physical effort (and *per se* human motion) with more time devoted to sedentary behaviors; while on the other hand, there is a growing interest and concern for healthy lifestyles. Interestingly, new pharmacologic drugs for treating non-communicable chronic diseases are being sold with the message to move more and decrease the time spent sedentary, emphasizing the importance of an active lifestyle that cannot be replaced by any pharmacologic strategies.. Both recommendations and public health strategies that promote physical activity and discourage sedentariness must rest on clear and universal definitions of these concepts to avoid any equivocal and misinterpreted messages.

The aim of this brief review is to (a) provide an update on the definitions of physical activity, inactivity and sedentariness; (b) examine their roles in occupational health; and (c) suggest simple modifications in the workplace in order to decrease sedentary behaviors.

## **2. Definitions of Physical Activity and Sedentary Behaviors**

Trained, active, inactive, and sedentary are some of the terms that have been used to describe many individuals. Misuse of these adjectives by public health communications, commercial advertisements and scientific reports often leads to biased messages and conclusions.

For the last couple of years, researchers in the fields of physical activity and sedentary behaviors, particularly members of the Sedentary Behavior Research Network (SBRN), have worked together to clarify the definitions related to physical activity, inactivity and sedentary behaviors (Table 1 presents the main definitions) (17).

**Table 1.** Main definitions

Terms	Definitions
Physical Activity	Any body movement generated by the contraction of skeletal muscles that raises energy expenditure above resting metabolic rate. It is characterized by its modality, frequency, intensity, duration and context of practice (18)
Physical Inactivity	Represents the non-achievement of physical activity guidelines
Exercise	Subcategory of physical activity that is planned, structured, repetitive, and that favors physical fitness maintenance or development (18)
Sport	Sport is part of the physical activity spectrum and corresponds to any institutionalized and organized practice, reined over specific rules.
Sedentary Behaviors	Any waking behaviors characterized by an energy expenditure $\leq 1.5$ METs, while in a sitting, reclining or lying posture (17)

In 2017, a new terminology consensus was created to highlight the differences between these concepts (see Tremblay et al., 2017). Physical activity is defined as any body movement generated by the contraction of skeletal muscles that raises energy expenditure above resting metabolic rate, and is characterized by its modality, frequency, intensity, duration and context of practice. In 1985, Caspersen defined exercise as a subcategory of physical activity that is planned, structured, repetitive, and that favors physical fitness maintenance or development (18). Each word in this definition of physical activity is of crucial importance to properly understand its meaning. According to the last updated definition, while resting energy expenditure corresponds to an energy expenditure of one metabolic equivalent (MET), sedentary behaviors are any waking behaviors characterized by



an energy expenditure  $\leq 1.5$  METs, while in a sitting, reclining or lying posture (17). This last definition is of particular importance since in 2015 Gibbs and colleagues called for a better definition of sedentary behaviors that considers both intensity and posture (19). Screen time and sitting time are usually the two main indicators used to quantify the time devoted to sedentary behaviors. From an energetic and biological point of view, there is also a clear need to consider the exact nature of each sedentary behavior that may not have similar physiological consequences. Indeed, sedentary activities demanding cognitive effort favor an increase in cortisol concentrations, glycemic instability, energy intake as well as a decrease in the parasympathetic/sympathetic balance (22). Such physiological implications have to be considered since sedentary behaviors involving cognitive tasks (mental work) have the profile of an activity with very low movement and with a component of neurogenic stress (20-22).

Physical activity and sedentary behaviors are not the opposite of each other. Individuals are considered to be active when they reach physical activity recommendations for their age, which does not prevent them from also devoting a significant part of their time to sedentary behaviors. In other words, individuals can be classified as both active and sedentary. Tertiary employees are the most demonstrative example of sedentariness as they spend a considerable part of their time seated in front of a computer screen. This defines them as highly sedentary, while they may or may not reach their aged-related physical activity recommendations outside work (23). This confusion mainly rests on the challenge of differentiating between sedentariness and physical inactivity that must be defined as not following physical activity guidelines. This inappropriate understanding of these terms can be illustrated using the recent paper by Rantalainen and collaborators (24), who compared the amount and patterns of time devoted to moderate-to-vigorous physical activities

(MVPA) between two groups of habitual recreational runners: i) running between of 20 to 40 km per week and ii) running more than 50 km per week) and a “sedentary group” composed of office workers (24). However, to be included in their “sedentary group”, participants had to engage in less than 150 minutes per week of MVPA, defining them as inactive and not sedentary. The misuse of the concept in this study was justified by the fact that the three groups showed a statistically similar overall sedentary time. This study clearly highlights that individuals may be classified as both active and sedentary and that inactive and sedentary must not be confused in order to avoid any misinterpretations, incorrect conclusions and/or public health messages (25).

Similarly, the term physical activity is commonly confused with sport (not at the scientific level). Sport is part of the physical activity spectrum and corresponds to any institutionalized and organized practice, based on specific rules. Some very active individuals might not be sport athletes even though they regularly train and show a high level of physical activity. This distinction is of importance with respect to public health messages since individuals and patients may fear the term “sport” while what is really required is a higher or regular amount of physical activity participation.

Once clearly understood, the adoption of these different concepts rests on individuals’ behaviors. It is important to consider the behavioral dimensions of physical activity and sedentariness. To be physically active and avoid too much sedentary time is, today, a voluntary behavior. External and societal influences are strong, but these constraints must be changed into habits. Physical activity must be included as a core element of human nature and we must go back from what Epstein referred to in the nineties as “sedentary alternatives” (26) to daily “active alternatives” (27).

### **3. Sedentary behaviors and physical activity: Implications in occupational health**

While the worksite has been recently suggested as a new strategic opportunity to promote physical activity, due to the important amount of time employees spend at work, the “tertiarisation” of work also highlights the urgent need to fight sedentary behaviors and sedentary time during working hours. The prevalence of sedentary professions increased by 20% in the United States between 1960 and 2008, with a concomitant decline of more “physically active professions” (10). In France, working adults have been shown to spend about 10h per day sitting on workdays (with at least 4.17h/day seated at work) and 7.58h/day sitting on non-workdays, with a clear association between the time spent sedentary at work and sedentary behaviors outside of work (28). These data underline that physical activity programs and interventions must be proposed to tertiary employees to increase their activity levels. Strategies that aim at breaking this sedentary time must also be conducted. Recent data have shown that among office workers, who spend at least 7h per day seated at their desk mostly in front of a screen, health indicators such as waist circumference, body mass index or fat mass are not improved among active employees compared to inactive ones, suggesting the potential negative impact of sedentary time over physical activity levels (29). These results are of particular importance and are associated with recommendations formulated by Rosenberg and colleagues (2015) calling for interventions targeting high-risk populations, such as tertiary employees (30).

Standing work stations have been proposed to break this sedentary time. Although standing stations remain inactive, according to the framework proposed by the Sedentary Behavior Research Group, passive standing corresponds to 2 METs, which is above the 1.5 METs threshold used to define sedentary behaviors, considered as low physical activity (17).

Although this energetic cost of passive standing rests on a strong body of scientific evidence, a recent study showed that passive standing does not significantly increase heart rate and energy expenditure above rest (31). According to the authors, the observed rises in heart rate and energy expenditure are due to the transition from sitting to standing before returning to resting values, particularly in “energy saver individuals” (31). This may explain why some studies failed to find any effects of standing desk allocation *versus* classical sitting on metabolic profiles and body composition among tertiary employees (32). This could also explain why regular sitting breaks have been shown to improve health compared with permanent passive standing positions (33). In their research, Bailey and Locke showed that only active breaks consisting in brief bouts of light-intensity activities (2-minute walk every 20 minutes) but not passive standing breaks might enhance cardiometabolic health in tertiary employees (34). Although further research is needed regarding the exact effects of standing desks and regular breaks, active standing (17) such as walking and cycling desks or walking breaks should be prescribed, regardless of the employees’ physical activity level. Even though new investigations are warranted, some promising results already demonstrate the beneficial effect of walking or bike-desks on overall health, well-being and work-related cognitive performance among tertiary workers (35). Some recent findings have also underlined the cardiometabolic benefits obtained by interrupting sitting time by the use of active walking desks compared with prolonged sitting (36). Future research should consider a potential inter-individual variability in the responses to such strategies, with some people that might adopt compensatory mechanisms leading to increased sedentary time outside of work, for instance.

While worksites have been pointed out as new ideal settings to promote physical activity, the complexity of tertiary activities that by definition favor sedentariness, combined with the

independent effect of sedentary time and physical activity on health, must lead stakeholders and practitioners to conduct individualized interventions not only favoring physical activity but also, breaking this sedentary time. Even though it has been suggested that performing 60 to 70 minutes of moderate physical activity per day could eliminate the deleterious impact of sitting time, it does not eliminate the increased risk associated with screen time (37). Moreover, only a small proportion of the population reaches such an amount of daily physical activity, which must reinforce individualized strategies. It is important to note that breaking apart sedentary times and having little bouts of light physical activity is the beginning of human mobility for our tertiary physically inactive and sedentary bodies, whose genes were programmed 40 000 years ago to walk not only 30 min a day (2,5km) but 20km per day (38).

## 7. Annexe 7 – Publication 1 non relative à la thèse

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### ORIGINAL ARTICLE

## Reduced neural response to food cues following exercise is accompanied by decreased energy intake in obese adolescents

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**BACKGROUND:** Acute exercise has been found to favor a transient anorexigenic effect in obese adolescents. Although the role of some gastro-peptides has been suggested as an explanation for this observed reduced energy intake after exercise, it is unknown whether neural pathways involved in the regulation of food intake are modulated in youth.

**METHODS:** Body composition (dual-energy X-ray absorptiometry) and aerobic capacities were assessed in 19 obese adolescent boys. Participants were randomized to remain at rest in a sitting position (CON condition) or to exercise 45 min at 65% of their maximal capacities (EX condition) by the end of the morning. An attentional computer task with electroencephalography recording was completed immediately after the exercise or sitting period to measure an event-related component (P3b) reflecting the level of cognitive engagement in the processing of food cues. A lunch test-meal was offered *ad libitum* and appetite feelings assessed at regular intervals using visual analog scales.

**RESULTS:** The 45-min cycling exercise set at 65%  $\dot{V}O_{2\max}$  induced a mean energy expenditure of  $399 \pm 75$  kcal. Both absolute ( $P < 0.05$ ) and relative ( $P < 0.001$ ) subsequent energy intake were significantly reduced after EX ( $1037 \pm 260$  and  $639 \pm 256$  kcal, respectively) compared with CON ( $1116 \pm 243$  and  $1011 \pm 239$  kcal, respectively). The energy ingested derived from each macronutrient and self-reported appetite remained unchanged. Although the amplitudes of the P3b component evoked by food and non-food visual stimuli were not significantly different during CON, the response to food cues was significantly reduced compared with non-food stimuli after exercise ( $P < 0.01$ ).

**DISCUSSION:** An acute exercise favors decreased neural response to food cues compared with non-food ones in obese adolescents that may contribute to their subsequently reduced energy intake.

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### INTRODUCTION

Pediatric overweight, obesity, and their metabolic complications, are of public health concern and their constant progression highlights the urgent need for new and effective prevention strategies and weight loss programs. For years the lack of physical activity (and therefore decreased overall energy expenditure) and the development of unhealthy eating behaviors have been incriminated as two independent sides of the energy balance equation. Today the scientific literature provides evidence that those two parameters interact with each other and that physical activity has indirect effects on energy intake in both adults<sup>1,2</sup> and youth.<sup>3</sup>

It's been effectively considered for years that food intake rested on basic mechanisms where every calorie expended was directly compensated for by an ingested calorie. But the control and regulation of food intake are much more complex and exercising does not necessarily lead to energy intake. This is indeed what recent research shows, demonstrating that regardless of weight status, an individual does not increase energy intake after an acute bout of exercise<sup>4</sup> and may even

decrease post-exercise food intake after intensive exercise,<sup>4</sup> favoring reduced short-term energy balance. Although the majority of research has been conducted in adults, recent studies have been conducted in children and adolescents. Although young elite athletes have been shown to increase their food intake in response to an acute bout of cycling exercise (set at 70% of their maximal capacities),<sup>5</sup> *ad libitum* energy consumption has been found unchanged after such exercise in lean inactive adolescents compare with a control session.<sup>6</sup> However, in obese adolescents, an acute bout of intensive exercise (above 70% of the maximal aerobic capacities) has been shown to favor a transient anorexigenic effect, favoring negative energy balance.<sup>7–10</sup> Interestingly, an uncoupling effect of exercise on subsequent energy intake (in kilocalories) and appetite feelings has been underlined in youth, suggesting that the reduced post-exercise food consumption observed was not driven by decreased hunger or increased satiety feelings.<sup>11</sup> Recently, Prado and collaborators were the first to demonstrate a role for gastro-peptides, with an acute intensive cycling exercise resulting in a transient increase in the anorexigenic PYY<sub>3–36</sub> in

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obese adolescents,<sup>10</sup> consistent with previously published data in adults.<sup>4</sup>

The crosstalk between peripheral actors (such as gastro-peptides or adipokines) and the hypothalamus has been identified as a possible explanation for differences in post-exercise food consumption,<sup>12</sup> but recent data suggest that physical activity and acute exercise can also affect other neural networks involved in the cognitive processing of food-related cues.<sup>13,14</sup>

In 2012, using functional magnetic resonance imaging (fMRI) with healthy lean young men and women, Evero *et al.*,<sup>13</sup> showed that 60 min of cycling at 83% of maximal heart rate (compared to rest) reduced the neural response to food vs control images in several brain areas involved in motivation, attention, and visual processing, while simultaneously reducing self-perceptions of hunger and prospective food consumption; see also Cornier *et al.*,<sup>15</sup> for similar effects with chronic exercise. This decreased neural activation suggests that the attentional response to food-related cues could be attenuated with exercise, which could contribute to the indirect effects of physical activity on energy intake. Unfortunately, whether or not this reduced neural activation was associated with an actual suppression of energy intake was not measured.

Hanlon *et al.*,<sup>14</sup> also questioned the impact of acute exercise on the attentional response to food cues and energy intake with a sample of normal weight and obese women and through the measurement of event-related potentials (ERPs). ERPs refer to the scalp-recorded electrical response of the brain to a specific timed event. They are exquisitely sensitive to real time neural processes, and can be decomposed into a number of components, which are thought to reflect different stages of information processing with a temporal resolution on the scale of milliseconds. Capitalizing on those assets, Hanlon *et al.*,<sup>14</sup> reported that a moderate-to-vigorous 45-min treadmill exercise (relative to rest) leads to the reduction of a particular component, the late positive potential, in response to visual food cues in both obese and lean women. This was also interpreted as a lower neurologically determined food motivation, and more specifically, a lower attentional processing of the food stimuli. However, the authors did not find a difference in 24-h self-reported energy intake between testing days.

Another long-latency ERP component, the P3b, would more directly reflect the intensity by which cognitive resources in the brain are engaged to attend to certain stimuli.<sup>16</sup> Importantly, enhanced P3b amplitudes have been reported to task-relevant<sup>17</sup> or motivationally significant events such as emotionally arousing pictures<sup>18</sup> or addiction relevant cues among addicted individuals (for example, Warren and McDonough for smokers<sup>19</sup>). To date, only a few studies investigated P3b amplitudes for food (vs non-food) pictures in obese adults<sup>20–23</sup> and children.<sup>24</sup> These studies clearly indicate that the P3b is sensitive to processing differences related to adiposity, hunger level and feeding practices. However, they have led to very inconsistent results so far (mainly attributable to differing methodologies and to the heterogeneous etiology of obesity) and the impact of exercise on the reported effects has not previously been explored.

The aim of the current study was therefore to determine the effect of an acute bout of exercise on the neural P3b response to food cues, and on subsequent appetite feelings and *ad libitum* energy intake in obese adolescent boys. In line with previous results,<sup>11</sup> we expected to observe a reduced post-exercise food consumption with no change in appetite feelings. We hypothesized that exercise (vs the control rest condition) would also lead to a reduced P3b in response to food (vs non-food) cues, reflecting decreased attention towards those cues.

## MATERIALS AND METHODS

### Participants

Nineteen adolescent boys aged 12–15-year-old (Tanner stage 3–4) with obesity (as defined by Cole *et al.*,<sup>25</sup>) took part in this study. The adolescents were recruited through pediatric consultations (Clermont-Ferrand University Hospital and Romagnat Children Medical Center, France). To be included in the study participants had to be free of any medication that could interact with the protocol, could not present any contraindications to physical activity, and had to take part in < 2 h of physical activity per week. Only male adolescents were recruited for the present study to avoid any impact of sex hormones in the control of energy intake. All adolescents and their legal guardian received information sheets and signed consent forms as requested by the ethical authorities (AU1107). This protocol is registered as a clinical trial (clinicaltrials.gov: NCT02100878).

### Overview of the study protocol

After a preliminary medical inclusion visit was completed by a pediatrician to confirm eligibility to participate in the study, the adolescents were asked to perform a submaximal aerobic test and their body composition was assessed by dual-energy X-ray absorptiometry. The participants then visited the laboratory on two different occasions (separated by at least 7 days) following a within-subjects crossover design: (1) a control session consisting of quiet sitting (CON) and (2) a cycling exercise session (EX). Heart rates were recorded during the two sessions (polar technology monitors). Immediately following the resting control or exercise session; the participants were asked to perform a short visual food-related computer task while an electro-encephalogram (EEG) was registered to assess their neural response to food cues. Thirty minutes after the end of the exercise (EX) or resting (CON), the participants were served an *ad libitum* buffet-style meal. Their appetite feelings were assessed using visual analog scales at regular intervals through the day. Energy expenditure was assessed during the exercise and resting conditions using a portable indirect calorimeter (K4b2).

### Anthropometric and body composition measurements

A digital scale was used to measure body weight to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Body mass index was calculated as body weight (kg) divided by height squared (m<sup>2</sup>). Fat mass and fat-free mass were assessed using dual-energy X-ray absorptiometry following standardized procedures (QDR4500A scanner, Hologic, Waltham, MA, USA). These measurements were obtained during the preliminary visit by a trained technician.

### Submaximal aerobic capacity

The participants' submaximal aerobic capacity was assessed during a graded cycling test performed at least 1 week before the experimental session (preliminary visit). The test was composed of 4 stages of 4 min each starting from 30 W with an increment of 15 W each. An electromagnetically braked cycle ergometer (Ergoline, Bitz, Germany) was used to perform the test. VO<sub>2</sub> and VCO<sub>2</sub> were measured breath-by-breath through a mask connected to O<sub>2</sub> and CO<sub>2</sub> analyzers (Oxycon Pro-Delta, Jaeger, Hoechberg, Germany). Calibration of gas analyzers was performed with commercial gases of known concentration. Ventilatory parameters were averaged every 30 s. Electrocardiography was also used for the duration of tests. This test was performed under the supervision of an accredited medical doctor. This test was performed to establish the individual relationship between heart rate and VO<sub>2</sub> and work load (W) and VO<sub>2</sub> in order to calibrate the intensity of the exercise.

### Description of the experimental sessions

Control session (CON): for 45 min (from 1045 to 1130 hours) the participants remained seated on a comfortable chair. They were not allowed to talk, read, watch TV or complete any intellectual tasks. Energy expenditure was assessed by indirect calorimetry.

Exercise session (EX): from 1030 hours the adolescents were asked to complete a cycling exercise set at moderate intensity (65% of their VO<sub>2max</sub>) for 45 min. The intensity was controlled using heart rate records and the workload setting on the cycle ergometer, determined using the results from the submaximal aerobic capacity testing.



### Attentional computer task

Fifteen minutes after exercise (EX) or sitting position (CON), the adolescents were asked to complete a computer task involving the presentation of infrequent food and non-food target visual stimuli among repeated presentations of a non-target item.<sup>14,26</sup> The current task included 288 trials. The frequent, standard item was a colored abstract pattern ( $n=216$ ). The target items ( $n=72$ ) were colored pictures taken from the food.pics database<sup>27</sup> which includes pictures of food and neutral objects on a white background, homogeneous in terms of viewing distance and figure-ground composition. Half of the target items ( $n=36$ ) were pictures of food (food; for example, muffins, candies, sandwiches and hamburger, and so on), the other half neutral household objects (non-food; for example, stapler, ladder, flower bouquets and hairbrushes, and so on.). The sets of food and non-food pictures were chosen in such a way that, based on food.pics scores, they did not significantly differ (two-tailed  $t$ -tests) with regard to global perceptual characteristics (brightness,  $P=0.35$ ; contrast,  $P=0.19$ ) and visual complexity (jpg compression,  $P=0.21$ ; edge detection,  $P=0.22$ ), as well as to subjective ratings for complexity ( $P=0.92$ ).

Each of the target items appeared only once during the experiment. All the stimuli were displayed for 750 ms on the center of a computer screen, on a white background. In between each stimulus, a black fixation cross was shown, with a duration varying randomly between 1200 and 1800 ms (with a mean of 1500 ms). The stimuli were presented in a pseudo-randomized order, different for each participant, so that there were no consecutive Target trials. The experiment was divided into 2 blocks of 144 standard and 36 target stimuli (half food), separated by a rest period which ended when the participant was ready to move on and pressed the space bar.

Participants were asked to press the space bar as quickly as possible every time they saw a picture different from the standard item. Central fixation was required throughout and the participants were encouraged to blink only when the fixation cross was displayed on the screen. The oddball task lasted about 11 min.

### Electrophysiological data recording

Sixty-four active electrodes were used to continuously record the EEG (extended 10–20 system) with BioSemi Active II System (BioSemi, Amsterdam, the Netherlands), with a band pass from 0.16 to 100 Hz and at a rate of 512 Hz. Off-line analyses were realized with BESA 5.2.3. ERPs time-locked to the stimuli ( $-100$  to  $600$  ms) were averaged separately for each channel and for each experimental condition, were digitally filtered at 40 Hz (12 dB per octave, zero phase shift digital filter) and recalculated to the average reference. Trials with blinks, saccades and non-ocular artefacts were rejected from further analysis: trials with signals exceeding  $\pm 100 \mu V$  as well as a gradient criterion with more than  $75 \mu V$  were rejected automatically. A visual inspection of the grand-average waveforms for Target-Food versus Standard and Target-Non-Food versus Standard trials in the CON condition revealed an enhanced posterior positivity for Target trials (P3b), which reached its maximum amplitude at around 460 ms over Pz (cf. Figure 1b). For all the experimental conditions, the P3b was therefore quantified as the mean amplitude from 410 to 510 ms at Cpz, Pz and POz. The data from these electrodes were then averaged together.

### Energy intake assessment

At 0830 hours am, the participants had to consume entirely a standardized breakfast (same composition and caloric content as previously detailed<sup>6,7</sup>). Thirty minutes after the end of the experimental session an *ad libitum* lunch was offered to the participants. The composition of the buffet meal was conformed to the adolescents' tastes as determined by a food preference questionnaire completed before the experimental sessions (that is, during the preliminary visit). Top rated items were avoided to limit overconsumption, as generally seen in *ad libitum* feeding experiments with adolescents and previously published.<sup>6</sup> The buffet offered to the participants was identical for the two experimental sessions. Participants were told to eat until satisfied; additional food was provided if desired. Food consumption was weighed and recorded by investigators (Bilnut 4.0 SCDA Nutrisoft software, Nutrisoft, Paris, France) to calculate total energy intake during lunch. The proportion of the total energy intake derived from fat, carbohydrate and protein was calculated using the same nutritional software used to assess energy intake. *Ad libitum* lunch meal methodology and spontaneous energy intake assessment were previously detailed.<sup>7</sup> Relative energy intake was then calculated as EI-EE for each condition.

### Subjective appetite sensations

At regular intervals throughout the day from 0800 hours, participants were asked to rate their hunger, fullness and prospective food consumption using visual analog scales (100 mm) whose reliability has been previously reported.<sup>28</sup> Participants filled in visual analog scales before and after the breakfast, before and after the experimental sessions, before and after lunch, and 15, 30, 60, 90 and 120 min after lunch. This method has previously been used among obese adolescents to evaluate appetite feelings.<sup>7,8,29</sup>

### Statistical analysis

Statistical analyses were performed using Statview 5.0 (SAS Institute, Cary, NC, USA). Results are expressed as mean (s.d.). The distribution of the data was tested using the Smirnov-Kolmogorov test prior to analysis and data did not require any transformation before analysis. Paired  $t$ -tests were used to compare total energy intake, relative energy intake and the energy ingested derived from each macronutrient (Protein, CHO and Fat) between EX and CON. A two-way analysis of variance (ANOVA) with repeated measures was used to compare appetite feelings area under the curve between experimental sessions. Regarding the computer oddball task, the effects of the experimental variables on mean percentages of correct responses, mean reaction times to targets, and P3b amplitudes were assessed by  $2 \times 2$  ANOVAs using exercise condition (CON, EX) and target type (Food, Non-Food) as within-subject factors, and appropriate  $t$ -test were used in *post hoc* analysis. The level of significance was set at  $P < 0.05$ .

### RESULTS

Of the 19 enrolled participants, complete data was obtained for 15 adolescents (2 did not complete the whole protocol and data were missing for 2 others). As presented in Table 1, the final sample had a mean age of  $13.8 \pm 1.5$ -year-old and a body mass index of  $31.8 \pm 4.2 \text{ kg m}^{-2}$ . All the anthropometric characteristics and the body composition results are detailed in Table 1.

The energy expenditure induced by the 45-min exercise was  $399 \pm 75 \text{ kcal}$  while the 45-minute rest period (sitting position during CON) induced a  $105 \pm 20 \text{ kcal}$  energy expenditure.

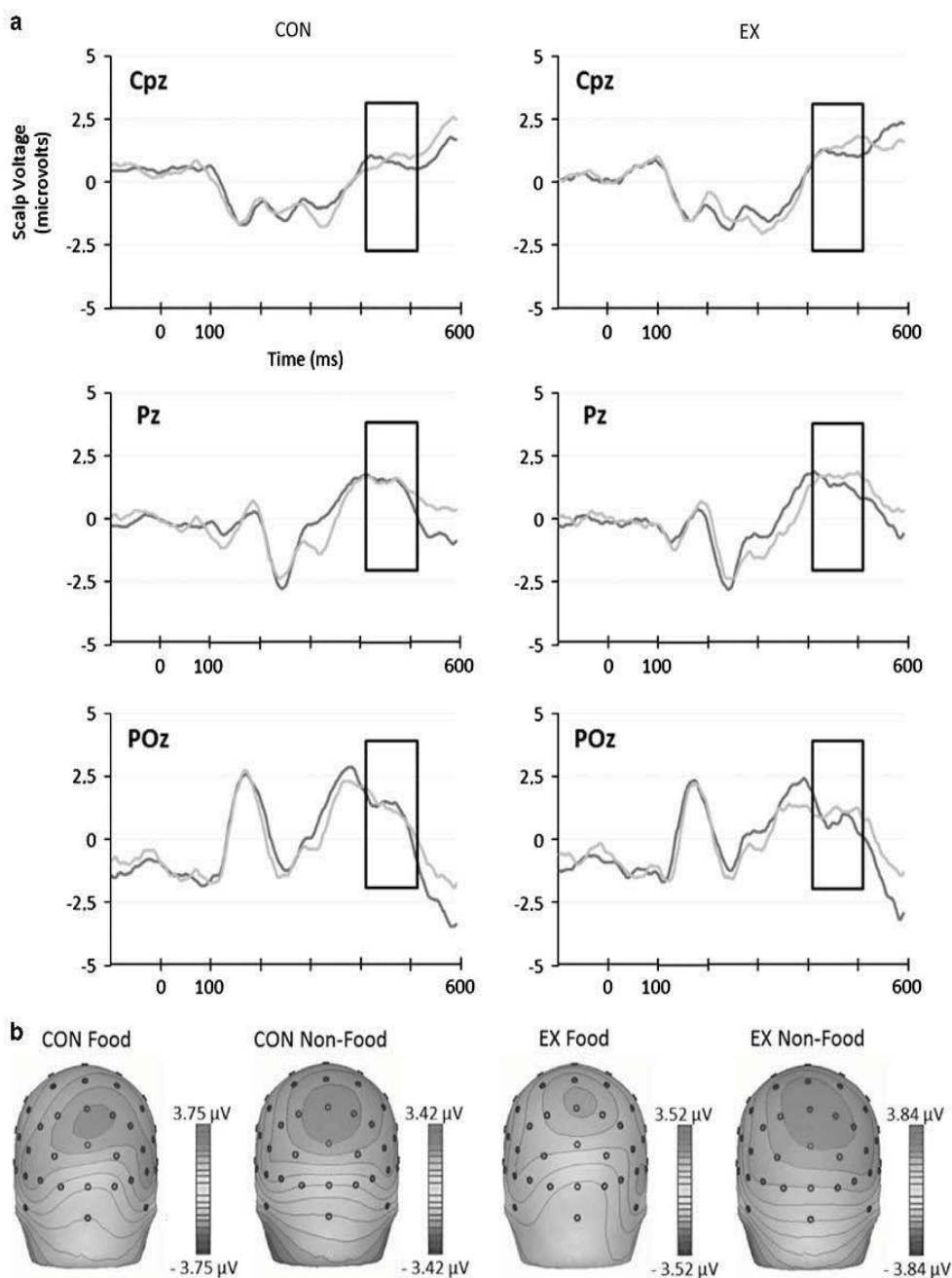
The adolescents' absolute energy ingested during the *ad libitum* lunch meal was significantly lower during EX ( $1037 \pm 260 \text{ kcal}$ ) compared with CON ( $1116 \pm 243$ ;  $P < 0.05$ ). When expressed relative to the energy expended during the 45-exercise (EX) or 45 min the supine position, Relative energy intake is also significantly lower during EX compared with CON ( $P < 0.001$ ). As presented in Table 2, no statistical difference has been found between conditions concerning the ingested energy derived from each macronutrient (Fat, Protein and Carbohydrate).

None of the appetite feelings rated (hunger, satiety or prospective food consumption) were significantly different between conditions.

Regarding the behavioral results of the oddball task, the mean percentage of correct responses (Target stimulus; response given) was very high in both the CON ( $98.8 \pm 1.7\%$ ) and EX ( $99.7 \pm 0.5\%$ ) conditions. The  $2 \times 2$  ANOVA (condition  $\times$  target type) revealed no significant main effects or interaction between the two factors (all  $P > 0.10$ ). The same analysis performed on reactions times to targets (on average  $481 \pm 23 \text{ ms}$ ) also demonstrated non-significant effects (all  $P > 0.24$ ). Finally, false alarms (standard stimulus; response given) were very rare, occurring on only  $1.9 \pm 2.3\%$  and  $1.7 \pm 1.2\%$  of the trials in the CON and EX condition, respectively ( $P > 0.8$ ).

Concerning electrophysiological data, the  $2 \times 2$  ANOVA performed on P3b mean amplitudes revealed no significant main effect of target type or condition (both  $P > 0.13$ ), but the target type  $\times$  condition interaction was close to significance ( $F^{1,14} = 3.15$ ,  $P < 0.09$ ).

As illustrated by Figure 2, planned comparisons showed that while there was no difference between food and non-food targets in the CON condition ( $P > 0.9$ ), the P3b to Food targets was



**Figure 1.** (a). ERP waveforms by exercise condition (CON, EX) and target type (black: food, light gray: non-food) at Cpz, Pz and POz. The framed area represents the time period (410–510 ms) over which the mean amplitude of the P3b was calculated for each experimental condition separately. (b). P3b scalp topographies (at 460 ms) for each experimental condition.

**Table 1.** Characteristics of the population

	mean	s.d.
Age (years old)	13.8	1.5
Weight (kg)	89.4	17.5
BMI ( $\text{kg m}^{-2}$ )	31.8	4.2
BMIz-score	2.22	0.31
BF (%)	35.3	6.3
FFM (kg)	56.1	11

Abbreviations: BF, body fat; BMI, body mass index; FFM, fat-free mass.

significantly reduced compared with the P3b to non-food targets during the EX condition ( $P < 0.01$ ).

## DISCUSSION

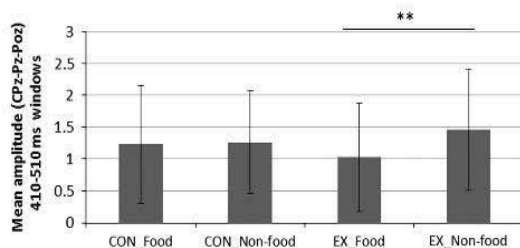
This study addresses an important gap in the available literature by questioning for the first time the potential implication of the neural processing of food cues in the post-exercise nutritional adaptations observed in obese adolescents. The present results show that the neural response reflecting the cognitive effort engaged in response to food stimuli is significantly reduced



**Table 2.** Results from the *ad libitum* lunch meal

	CON		EX	
	mean	s.d.	mean	s.d.
Energy intake (kcal)	1116	243	1037*	260
Relative EI (kcal)	1011	239	639***	256
Protein (%)	29.4	7.2	30.5	6.7
Fat (%)	16.5	4.2	16.6	4.2
CHO (%)	53.4	11.0	52.3	10.5

Abbreviations: CHO, Carbohydrate; CON, condition control; EI, energy intake; EX, condition exercise. \* $P < 0.05$  and \*\*\* $P < 0.001$ .

**Figure 2.** Mean amplitudes of the P3b elicited by food and non-food visual cues during the control (CON) and exercise (EX) sessions. \*\* $P < 0.01$ .

compared with non-food ones after a 45-min cycling exercise set at 65% of their maximal aerobic capacities in 12–15 obese adolescent boys. Importantly, this reduced neural activation is concurrent with a significant decreased energy intake at the following meal compared with a resting condition.

Although it has long been suggested that humans' energy balance was regulated with such flexibility that any calorie expended during physical activities was directly compensated for by an equivalent caloric intake,<sup>30</sup> this approach appears today too simplistic and the control of energy balance much more complex. Blundell *et al.*,<sup>12</sup> recently proposed a new formulation detailing the role of acute exercise and chronic physical activity on the control of energy intake. According to this model, chronic physical activity mainly impacts energy intake through its effects on body composition by modifying fat-free mass (and therefore resting metabolic rate) and fat mass (and therefore adipokines such as leptin and adiponectin that communicate with the arcuate nucleus to modulate energy intake). On the other hand, the modulations of some gastro-peptides in response to acute exercise may also impact food consumption. Although this model clearly details the peripheral-central cross talk responsible for the regulation of energy intake in response to physical exercise, the role for neural and cognitive pathways is missing.

Little is known concerning the impact of physical activity and exercise on the neural response to food cues. Cornier and collaborators showed that, in adults, a 6-month physical activity program was able to reduce the neural response in the posterior attention network as well as in the insula (implicated in food reward, assessed by fMRI), which was positively associated with changes in body weight, but it was not assessed whether this was due to changes in energy intake.<sup>15</sup> Similarly Evero *et al.*,<sup>13</sup> (also using fMRI) showed that an acute bout of cycling exercise (60 min set at 83% HRmax) reduced the response to food vs control images in several regions of the brain that have been found involved in visual attention and the control of energy intake, in

healthy young adults. To our knowledge, Hanlon and colleagues have published the only study assessing both post-exercise neural response to food cues (using the EEG technology) and energy intake.<sup>14</sup> They recorded the late positive potential component that they interpreted as an index of the attentional response to food and/or of food motivation. According to their results, 45 min of moderate-to-vigorous exercise (treadmill) leads to a reduced neural response to visual food cues in both obese and lean premenopausal women, but they did not find any differences in 24-h self-reported energy intake.<sup>14</sup> The limitations of self-reported energy intake may be responsible for this null finding.

While all the above mentioned studies have been conducted in adults, our study seems to be the first conducted in adolescents. Our results mirror those found by Hanlon *et al.*,<sup>14</sup> regarding the reduced post-exercise neural response to food stimuli compared with non-food ones. Moreover, we observed this effect on a more specific component, the P3b elicited during an oddball task. This allows us to interpret it less ambiguously as reflecting a lessened cognitive/attentional engagement for food cues.<sup>24</sup> In addition, we observed a significantly lower absolute and relative post-exercise energy intake at the following *ad libitum* meal compared with the resting session.

Increase attentional processing of food cues may be one potential mechanism contributing to individual differences in vulnerability to obesity.<sup>31</sup> Therefore, it could seem surprising that food cues did not elicit larger P3b than non-food cues in the CON condition of the current study. However, few studies (using very different methodologies for measuring attention) have investigated attentional bias to food cues in overweight/obese persons and the results are inconclusive so far (for a review see Nijs and Franken, 2012<sup>32</sup>). Importantly, the only study involving adolescents to our knowledge reported that neither normal weight nor overweight adolescents show behavioral signs of a preferential attentional processing of food-related relative to neutral words.<sup>33</sup> We think that concluding that obese adolescents do not present an attentional bias toward food cues would be premature. Nonetheless, our study clearly demonstrates that the level of attentional resources allocated to the processing food cues relative to non-food cues can be modulated by acute exercise in obese adolescents. Although the anorexigenic effect of acute exercise in obese adolescents has already been replicated in several studies, it was only observed when the exercise was set above 70% of the adolescent's maximal capacities.<sup>7–9</sup> Indeed, in 2012, Thivel *et al.*, conducted a study whose aim was to compare the effect of high (75%VO<sub>2</sub>max) versus Low (40% VO<sub>2</sub>max) intensity cycling exercises on obese adolescents' energy intake and only found a significant effect on food consumption after the high-intensity trial.<sup>8</sup> Based on this recent study and the rest of the available evidence, it was then concluded that only exercises above 70% of VO<sub>2</sub>max were able to induce such an anorexigenic effect<sup>8</sup> while the present results suggest that not only intensive but moderate-to-intensive exercises might favor subsequent decreased energy intake with an exercise bout set at 65% of the individuals' VO<sub>2</sub>max. The role of certain appetite regulating hormones in this post-exercise regulation of energy intake has been described in adults<sup>12,34</sup> and recently Prado and collaborators published the first data indicating an upregulation of PYY<sub>3-36</sub> after exercise to explain this transient anorexigenic impact of acute physical activity in obese adolescents.<sup>10</sup> Our present results suggest that the neural response to food cues may be involved in the nutritional responses to moderate-to-vigorous exercise in this population.

Although the lack of modification of the energy ingested derived from each macronutrient in response to acute exercise is in accordance with previously published data in similar populations,<sup>35,36</sup> this remains difficult to discuss since the literature in youth is still limited and shows contradictive results so far with other studies showing unchanged Fat and Protein



consumption but reduced carbohydrate intake.<sup>6</sup> The unchanged appetite feelings (hunger, satiety and prospective food consumption) observed in the present work are, however, in line with most of the previous studies that observed unchanged feelings despite modifications of the participants' effective energy intake, suggesting an uncoupling effect of acute exercise on subsequent food consumption and appetite sensations in children and adolescents (for review see Thivel and Chaput<sup>11</sup>) as well as adults.<sup>37</sup>

While this work was designed to explore the potential implication of the neural processing of food-related visual cues in the post-exercise nutritional adaptations described in obese adolescents, it has been shown that these neural responses to food cues are heightened in obese compared to lean youth.<sup>38,39</sup> Further investigation might then also consider involving lean adolescents to examine this potential weight status effect. Understanding differences based on weight status could inform strategies from both prevention and treatment standpoints. Recent studies suggest that regular physical activity might favor reduced spontaneous 24-h energy intake in overweight/obese adolescents.<sup>40</sup> While some authors have shown that regular exercise can improve leptin sensitivity and increase the concentrations of some anorexigenic gastro-peptides<sup>41</sup> and is associated with a decreased-activation in food-responsive reward brain area,<sup>42</sup> deeper explorations are needed to better understand how chronic physical program act on the neural and peripheral pathways involved in the control of energy intake. Better understanding the effects of acute exercise on energy balance is obviously of particular importance, but further studies are needed to determine the impact of chronic physical activity on the neural and peripheral control of energy intake to improve our weight loss strategies among overweight and obese children and adolescents. Future protocols should be elaborate to identify which kind of exercise training (in terms of duration, intensity and modality, and so on) can generate the preferred effect on appetite and food intake control, optimizing the influences on energy balance and overall health.

## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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# Lean adolescents achieve higher intensities but not higher energy expenditure while playing active video games compared with obese ones

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## Summary

**Background:** While decreased physical activity and increased sedentary behaviours are incriminated for their role in the progression of obesity, active video games (AVG) may offer a new alternative to increase energy expenditure in youth. This study is the first to examine the effect of a 1-h AVG play on lean and obese adolescents' energy expenditure.

**Methods:** Body composition and aerobic fitness were assessed in 19 obese and 12 lean adolescent boys (12–15 years old). Participants performed a 1-h AVG session (Kinect Sports technology) while wearing a portable indirect calorimeter (K4b2) to assess their energy expenditure and heart rate.

**Results:** Body weight ( $91.0 \pm 9.5$  vs.  $58.5 \pm 12.4$  kg), body mass index ( $32.2 \pm 3.1$  vs.  $20.3 \pm 1.6$  kg m<sup>-2</sup>) and body fat ( $38.1 \pm 2.7$  vs.  $13.4 \pm 3.9\%$ ) were significantly higher in obese adolescents ( $P < 0.001$ ). Absolute energy expenditure was significantly higher in obese ( $P < 0.05$ ) but not when corrected for body composition. Maximal heart rate reached during AVG was significantly higher in lean adolescents ( $190 \pm 25$  vs.  $183 \pm 28$  bpm,  $P < 0.05$ ). Time spent between 3 and 6 METs (Metabolic Equivalent Task) was not different between groups but time spent above 6 METs was higher in lean adolescents ( $P < 0.05$ ).

**Conclusion:** Although lean and obese adolescent boys experienced similar energy expenditure relative to their body size during a 1-h Kinect AVG session, lean adolescents spent more time in moderate-to-vigorous physical activity.

**Keywords:** Active video game, adolescents, energy expenditure, exercise intensity, paediatric obesity.

## Introduction

The amount of time devoted to daily sedentary activities has been pointed out for its implication in the progression of overweight and obesity (1,2), with screen time representing a large proportion of the time awake spent being physically inactive (3). Video games are among the most common screen-based sedentary activities but the recently developed motion-based video games (requiring body motion to play, named 'exergames' or active video games – AVG) require more research attention because of their potential in increasing daily energy expenditure (4).

Given that overweight and obese youth have been shown to be less active (5,6) and more likely to engage in sedentary pursuits, especially screen-based activities (7), AVG could represent an additional opportunity to enhance daily physical activity levels (8). Some previous studies have questioned the energetic benefit of playing AVG in both lean and obese children and adolescents (9–14). Although obese children and adolescents have been shown to have higher absolute energy expenditure while playing AVG compared with their lean counterparts, this difference generally disappears after correcting for body composition (9,12,13,15). However, conflicting results have been reported by others (10,11,14). Although the



available evidence generally recognizes AVG as a potential strategy to improve lean and obese youth's physical activity level (and/or to decrease their sedentary time), studies to date only explored the physiological effects of 10 to 15 min of AVG and did not compare between lean and obese participants. This issue is particularly important because the influence of AVG on energy expenditure components may be different depending on adiposity level.

Therefore, the aim of this study was to measure the energy required and intensity reached during a 1-h AVG play in lean and obese adolescents. We hypothesized that despite a higher energy expenditure induced by AVG in obese adolescents, their lean counterparts would engage in higher intensities of practice.

## Methods

### Population and design

A total of 19 obese and 12 lean (according to Cole *et al.* (16)) adolescent boys aged 12–15 years old (Tanner stage 3–4) were recruited through paediatric consultations (Clermont-Ferrand University Hospital and Romagnat Children Medical Center, France). All the adolescents had to be free of any medication that could interact with the protocol, could not present any contraindications to physical activity and had to be engaged in less than 2 h of physical activity per week. All the adolescents and their legal representative received information sheets and signed up consent forms as requested by the ethical authorities (AU1033). This protocol is registered as a clinical trial (clinicaltrials.gov: NCT01912300). After a medical inclusion visit to control for the ability of the adolescents to complete the study, they were asked to perform a submaximal aerobic test and their body composition was assessed by dual-energy X-ray absorptiometry (DXA). The adolescents were then asked to visit the laboratory to complete an experimental session where they had to play AVG for 1 h.

### Anthropometric and body composition measurements

A digital scale was used to measure body weight to the nearest 0.1 kg, and barefoot standing height was assessed to the nearest 0.1 cm using a wall-mounted stadiometer. Body mass index (BMI) was calculated as body weight (kg) divided by height squared ( $m^2$ ). Fat mass and fat-free mass were assessed using DXA following standardized procedures (QDR4500A scanner, Hologic, Waltham, MA, USA), as previously described in a similar population (17).

### Submaximal aerobic capacity

The participants' submaximal aerobic capacity was assessed during a graded cycling test performed at least 1 week before the experimental session. The test was composed of four stages of 4 min each starting from 30 W with an increment of 15 W each. An electromagnetically braked cycle ergometer (Ergoline, Blitz, Germany) was used to

perform the test.  $VO_2$  and  $VCO_2$  were measured breath-by-breath through a mask connected to  $O_2$  and  $CO_2$  analysers (Oxycon Pro-Delta, Jaeger, Hoechberg, Germany). Calibration of gases analysers was performed with commercial gases of known concentration. Ventilatory parameters were averaged every 30 s. Electrocardiography was also used for the duration of tests. This test was performed under the supervision of an accredited medical doctor.

### AVG session

The adolescents were asked to join the laboratory at 08:00 am where they received a standardized breakfast (same composition and calorie content as previously detailed (17)). By the end of the morning, they were equipped with a K4b2 portable indirect calorimeter to measure their oxygen consumption. The K4b2 was used to measure  $VO_2$ , energy expenditure and related cardiorespiratory parameters on a breath-by-breath basis. The K4b2 device has been used in similar populations during various kinds of physical activities (18) as well as AVG (19) and provides reliable results. The adolescents were then asked to play the XBOX 360 Kinect Sport Boxing game for 1 h, starting at 10:30 am. All the participants started the game at the same level of difficulty and their level of progression depended on their performance to make sure that it was not too difficult or too easy in order to prevent decreased engagement. Importantly, all the adolescents played against the computer (virtual opponent) to ensure that the difficulty and its progression and adaptation to the adolescent's level were identical between participants. A member of the investigation team was present during the whole 1-h game to ensure that the adolescents properly completed the session and encouraged him to perform its best. It is important to notice that the enrolled participants were non-users of AVG with a very limited ('tried once or twice AVG in their lives') or inexistent experience of X-box Kinect AVG. Just before the 1-h AVG session, the adolescents were instructed on how to play AVG and had a 5- to 10-minute familiarization period before the 1-h test (during this familiarization, their ability to control game was tested but they were not physically engaged in the game).

### Statistical analysis

Age-predicted maximal heart rate was calculated as  $208 - (0.7 \times \text{age})$  (20,21). Energy expenditure was calculated for the entire 1-h AVG duration. The American College of Sports Medicine cut-offs were used to calculate the time spent at moderate ( $>3$  METs and  $>64\%$  HR max) and high ( $>6$  METs) physical activity intensities (22). Unpaired *t*-tests were used to compare anthropometric characteristics, body composition and AVG-related variables (i.e. energy expenditure,  $VO_2$  and physical activity intensities). Statistical analyses were performed using Statview 5.0 (SAS Institute, Cary, NC, USA). Results are expressed as mean (standard deviation). This study is part of a larger one considering the energy intake response to exercise and AVG in obese adolescents boys and the sample size



calculation underlined the need of a minimum of 12 participants per group based on the already observed inter-individual variability ( $\sigma = 6.5\%$ ) in order to obtain a minimal difference of 8% and a power of 90%. The distribution of the data was tested using the Kolmogorov-Smirnov test prior to analysis and data did not require any transformation prior to analysis. The level of significance was set at  $P < 0.05$ .

## Results

Table 1 presents the characteristics of the sample and shows the significantly higher body weight, BMI and percent body fat in obese compared with lean adolescents ( $P < 0.001$ ).

Extrapolated  $\text{VO}_2$  max was significantly higher in obese adolescents ( $3.6 \pm 0.4$  vs.  $2.9 \pm 0.3 \text{ L min}^{-1}$ ,  $P < 0.01$ ). The obese participants had a higher absolute energy expenditure during the 1-h Kinect AVG session ( $1548 \pm 187 \text{ kJ}$ ) compared with leans ( $1113 \pm 474 \text{ kJ}$ ) ( $P < 0.05$ ) and lower METs ( $3.4 \pm 0.6$  vs.  $4.5 \pm 1.0$ ;  $P < 0.05$ ; Table 2). Mean  $\text{VO}_2$  in  $\text{mL min}^{-1}$  was significantly higher in obese compared with lean adolescents ( $1229 \pm 143$  vs.  $883 \pm 377 \text{ mL min}^{-1}$ ;  $P < 0.05$ ) but no difference was observed when normalized to body weight and fat-free mass. The maximal heart rate reached during the AVG session was significantly higher in lean compared with obese adolescents ( $190 \pm 26$  vs.  $183 \pm 28 \text{ bpm}$ ;  $P < 0.05$ ), but the time spent above 64% of their maximal heart rate (22) was not significantly different. As shown by Fig. 1, the time spent above 3 METs was not significantly different between

groups but the time spent above 6 METs was significantly higher in lean compared with obese adolescents ( $12:53 \pm 8:22 \text{ min}$  vs.  $5:28 \pm 6:03 \text{ min}$ ;  $P < 0.05$ ).

## Discussion

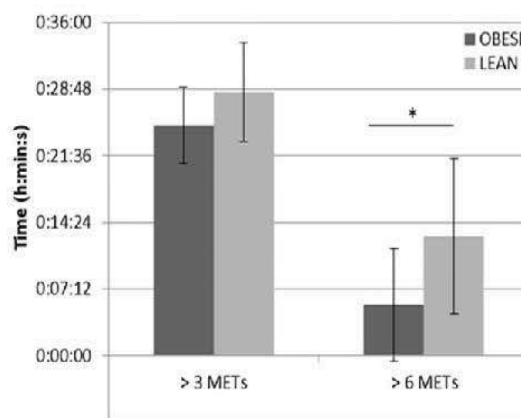
This study aimed to explore the energy expended and the intensity reached during a 1-h Kinect AVG play in male adolescents with obesity and healthy weight. According to our results, 60 min of Kinect AVG induced higher absolute energy expenditure in obese participants compared with their lean counterparts. However, after adjustment for body size, differences were no longer significant. Although this finding agrees with previous observations (using both Wii and Kinect devices) in similar populations (9,12,13,15), it is in contrast to other results showing higher fat-free mass-adjusted energy expenditure in lean children (10,11).

As in the present study, O'Donovan and collaborators recently asked obese and lean 12 years old children to complete a boxing game and obtained similar results in terms of energy expenditure (14). However, they observed that both groups performed the AVG at light-to-moderate

**Table 1** Descriptive characteristics of participants

	Obese (n: 19)	Lean (n: 12)	
Age (years old)	$14.5 \pm 0.8$	$13.5 \pm 1.7$	
Weight (kg)	$91.0 \pm 9.5$	$58.5 \pm 12.4$	***
BMI ( $\text{kg m}^{-2}$ )	$32.1 \pm 3.0$	$20.2 \pm 1.6$	***
FM (%)	$38.0 \pm 2.6$	$13.3 \pm 3.9$	***
FFM (kg)	$55.0 \pm 4.8$	$50.3 \pm 8.2$	**

\*\* $P < 0.01$ ; \*\*\* $P < 0.001$ . BMI, body mass index; FFM, fat-free mass; FM, fat mass.



**Figure 1** Time spent at moderate (3–6 METs) and high (>6 METs) in lean and obese adolescents during a 1-h Kinect video game play. \* is  $p < 0.05$

**Table 2** Physiological impact of a 1-h Kinect video game play in lean and obese adolescents

	Obese (n: 19)	Lean (n: 12)	
EE (kJ per 60 min)	$1547.93 \pm 186.9$	$1113.06 \pm 474.48$	*
METs	$3.49 \pm 0.66$	$4.55 \pm 1.04$	*
Mean HR (bpm)	$119.67 \pm 13.35$	$126.14 \pm 29.89$	
Mean $\text{VO}_2 \text{ mL min}^{-1}$	$1228.52 \pm 148.33$	$883.38 \pm 376.58$	*
Mean $\text{VO}_2 \text{ mL min}^{-1} \text{ kg}^{-1}$	$13.41 \pm 1.62$	$14.65 \pm 3.67$	
Mean $\text{VO}_2 \text{ mL min}^{-1} \text{ kg}^{-1} \text{ FFM}$	$22.2 \pm 2.46$	$17.04 \pm 4.82$	
64% HR max (bpm)	$131.5 \pm 0.5$	$132.1 \pm 1.1$	
Time > 64% HR max (min:s)	$20:59 \pm 19:09$	$24:42 \pm 18:24$	
AVG max HR (bpm)	$182.6 \pm 28.4$	$190 \pm 25.7$	*

\* $P < 0.05$ . AVG, active video game; EE, energy expenditure; HR, heart rate.

intensity physical activity (mean metabolic equivalent of 2.72 METs in obese and 2.99 METs in lean) while in the present work, the lean and obese adolescents spent about 28 and 25 min above 3 METs, respectively. Although the time spent between 3 and 6 METs (moderate intensity) was not significantly different between groups, the lean participants spent significantly more time at higher intensities (above 6 METs) compared with obese ones (respectively  $12:53 \pm 8:22$  min vs.  $5:28 \pm 6:03$  min;  $P < 0.05$ ).

Participating in AVG has been previously shown to favour light (11,15) and moderate intensity activities in children and adolescents (9,10). The present results suggest that both lean and obese adolescents are engaged in moderate-to-vigorous activities while playing a 1-h Kinect AVG, with lean subjects being more engaged. This observation supports previous data suggesting a lower engagement of obese youth into physical activities (23). This is also reinforced by the fact that the lean group reached a significantly higher maximal heart rate while playing ( $190 \pm 26$  bpm) compared with the obese one ( $183 \pm 28$  bpm;  $P < 0.05$ ). Although the present study design is similar to the one proposed by O'Donovan and colleagues (14), the different results obtained (in term of intensities) may be mainly explained by the fact that in their study, they used a Wii technology that might favour movement adaptation and then diminish body engagement and also that the adolescents had to perform the AVG for only 15 min while in the present work, they had to play on a Kinect Sport device for 60 min.

Since AVG increased energy expenditure in both lean and obese children and adolescents, one could be tempted to consider this activity as a new approach to limit sedentary time, increase physical activity level and then prevent or treat overweight and obesity. However, most of the data available so far are based on acute explorations and a recent systematic review points out that AVG do not appear to increase overall physical activity levels and physical fitness and do not result in a sustained increase in physical activity over time in children and adolescents (24,25).

It has to be noticed that the present results rely on a laboratory based setting that might not necessarily reflect free-living conditions. Indeed, one of the limitations of this work is the fact that an investigator was present during the testing to encourage the adolescents and make sure that they were playing the game. This might have impacted their engagement and then not reflect the engagement they might have when playing at home. However, because a portable indirect calorimeter was used to assess energy expenditure, it was necessary for a member of the team to stay with the adolescents.

This study is the first to our knowledge to assess the energetic impact of a 1-h AVG in lean and obese adolescents (reaching then the 60 min of physical activity recommended in this population). Although the results do not show any energy expenditure difference once corrected for body size, Kinect AVG (requiring more body movement than the Wii device) might represent a great opportunity to make lean and obese youth engage in moderate-to-

vigorous intensity activities, especially in the lean ones. This work effectively points out that 60 min of AVG has the potential to make both lean and most importantly obese children engage in about 40 and 30 min of moderate to vigorous activity, respectively. Further studies are needed to explore the sustainability of such activities over the long term and then its real implication in terms of overweight and obesity prevention and treatment.

## Conflict of Interest Statement

The authors have no conflicts of interest to disclose.

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## Author contributions

Dr Chaput and Thivel built the protocol. Prof. Boirie and Duclos were the medical investigators of the study. Dr Thivel, Prof. Duclos, Prof. Boirie, Genin Pauline and Le Moel Benedicte were in charge of the experimental procedures and data collection. Dr Chaput, Thivel and Pereira analysed the data and wrote the paper in accordance with Prof. Boirie and Duclos.

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## Reproducibility of an in-laboratory test meal to assess *ad libitum* energy intake in adolescents with obesity



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### ABSTRACT

**Aim:** The aim of the present work was to test the reproducibility of a personalized in-laboratory *ad libitum* buffet meal in assessing energy and macronutrient intake in obese adolescents.

**Methods:** Twelve 13.5 ± 1.5 years old obese adolescent girls were asked to complete three identical experimental sessions during which an *ad libitum* buffet meal was presented at lunch time. The buffet was personalized based on food preference questionnaires, presented usually consumed food items and excluded preferred foods. Total energy intake and the energy ingested derived from each macronutrient were assessed by investigators using the Bilnuts nutritional software.

**Results:** Mean body mass was 87.0 ± 13.7 kg and mean BMI was 32.2 ± 4.9 kg/m<sup>2</sup>. Mean FM percentage was 39.1 ± 4.4% and FFM was 50.6 ± 7.7 kg. There was no significant difference between total energy intake, the percentage of intake related to fat, protein or Carbohydrates (CHO) between the three sessions. The Intraclass Correlations (ICC) observed for total energy intake was 0.99. ICC for Protein, Fat and CHO were 0.38; 0.96 and 0.81 respectively. The Bland & Altman visual analysis revealed an important agreement between meals.

**Conclusion:** The proposed personalized in-laboratory *ad libitum* test meal produces a reproducible methods to assess energy and macronutrients intake in obese adolescent girls.

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### 1. Introduction

Investigating eating behaviors and food intake is of main importance in obesity research, however it remains particularly difficult to measure and methodologically debated (Schoeller et al., 2013). Employing a reproducible method to accurately assess energy intake is of particular importance, especially when it comes to energy balance studies that tend to identify the effect of acute

stimuli on food intake. Indeed, many studies have been questioning the impact of several acute stimuli (exercise, sedentary behaviors, cognitive tasks, etc) on subsequent energy intake but this rests on the hypothesis that food consumption remains stable in absence of the stimulus, which remains uncertain in children and adolescents.

In healthy adults, *ad libitum* test meals have been shown to be a reproducible method to assess in-laboratory energy intake and macronutrient preferences, with food consumption remaining stable from one session to the other (Arvaniti, Richard, & Tremblay, 2000). Similarly, McNeil and collaborators lately showed the reproducibility of a multi-choice menu (62-food items) to measure in-laboratory energy and macronutrient intakes in healthy adults (McNeil, Riou, Razmjou, Cadieux, & Doucet, 2012). In a recent study, Chaput et al. also showed the reproducibility of an in-laboratory 74-item menu in healthy adolescents, independently of gender and body mass index (Chaput et al., 2016). Although such menus

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proposed a multitude of choices, it may sometimes be difficult for researchers to employ such extensive buffets and this might also lead to food wastage. Moreover, such menus do not consider participants' food preferences, which may induce some bias in the subsequently measured energy intake.

Many energy balance related researchers have been measuring the nutritional responses (total energy and macronutrient consumptions) to different physical (Bellissimo et al., 2008; Thivel, Metz, Julien, Morio, & Duche, 2014) or sedentary activities (Chaput et al., 2015; Thivel et al., 2013) with some of them proposing *ad libitum* buffets based on *a priori* food choices such as yogurts or pizzas (Bellissimo, Thomas, Pencharz, Goode, & Anderson, 2008). Although Bellissimo and collaborators showed the reproducibility of their pizza-based buffet in healthy adolescent boys (Bellissimo, Thomas, et al., 2008), the high palatability of such items may influence the participants' consumption, leading them to eat above satiety (Thivel, Duché, & Morio, 2012). When such a meal is used to investigate the nutritional response to an acute stimulus (such as exercise or sedentary behaviors), the subsequently assessed energy intake might be more affected by the degree of palatability of the proposed food than the real effects of the studied stimulus.

The aim of the present work was to test the reproducibility of a personalized in-laboratory *ad libitum* buffet meal in assessing energy and macronutrient intake in obese adolescents.

## 2. Material and methods

### 2.1. Participants

Twelve adolescent girls aged 12–16 years old (Tanner stages 3–5) with obesity (as defined by Cole, Bellizzi, Flegal, & Dietz, 2000 (Cole et al., 2000)) took part in this study. The adolescents were recruited through pediatric consultations (Clermont-Ferrand University Hospital and Romagnat Children Medical Center, France). To be included in the study, participants had to be free of any medication that could interact with the protocol and had to take part in less than 2 h of physical activity per week. All adolescents and their legal guardian received information sheets and signed consent forms as requested by the ethical authorities (Local Human Protection Committee, CPP Sud Est VI, agreement AU1178).

### 2.2. Study design and procedure

After the medical inclusion, anthropometric measurements were obtained and body composition was assessed. A digital scale was used to measure weight to the nearest 0.1 kg and height to the nearest 0.5 cm using a stadiometer. Body mass index was calculated as BM (kg) divided by height squared ( $m^2$ ). Fat-Mass (FM) and Fat-Free Mass (FFM) were assessed using DXA (QDR4500A scanner, Hologic, Waltham, MA, USA).

Participants then took part in three identical experimental sessions in our laboratory separated by at least seven days. They were asked to maintain a similar balanced diet prior to the three sessions and to avoid any intensive physical activity for the prior 48 h (a member of the investigation team contacted the adolescents and their legal representative two days before each session to remind them to keep to this balanced diet and to avoid intensive exercise). The three experimental days were similar: the adolescents arrived between 08:00 a.m. and 08:30 a.m. in the laboratory in a fasting state and received a standardized breakfast of 500 kcal (as previously detailed (Thivel et al., 2014)). They were then asked to remain quiet in the laboratory until lunch time. In the mean time they were allowed to perform their homework or read but no electronic or video devices were allowed. They were required to

remain seated quietly without any physical or cognitive (reading, watching TV, doing their homework) activity for the last hour of the morning, right before lunch that was proposed *ad libitum* at 12:00.

The content of the buffet meal was composed based on a food preference questionnaire filled in by the adolescents, assisted by the investigator, before the experimental sessions. This questionnaire documents the type of food the participant cannot eat because of allergies, cultural issues, or just because they do not like the food. The type of food preferred was also identified with the questionnaire. By identifying and then excluding preferred and not consumed items, under- and over-consumptions were avoided. The adolescents were then asked to rate food items from a list of about 75 usually served at lunch (from 1 to 5, (1 meaning "don't like" and 5 "like very much") (listed food items were adapted from previously published ones (Chaput et al., 2016; McNeil et al., 2012)). The adolescents were also asked to indicate if they were used to eating each remaining item, then rarely consumed items that were indicated as liked by the adolescents were not included in the buffet to avoid "occasional eating". Employing this food preference questionnaire, an *ad libitum* buffet meal was composed, including usually consumed foods but not preferred types of food. Two choices were available at each meal course. The Table 1 gives an example of a buffet meal for one of the participants.

The adolescents were asked to eat until satisfied, but were not informed that the aim of the study was to assess their food consumption. The adolescents received their meal and ate on separate tables. All the items were individually offered at the same time in large platters (plate-warmers were used to keep some items warm). No mixed food was presented to the adolescents. The content of the buffet was known before lunch by the investigators and each remaining items was weighted after lunch using a digital kitchen scale (Tristar Europe, Firminy, France) to assess the adolescent's intake. Total intake (in kcal) and intake relative to each macronutrient was assessed using the nutritional software Bilnuts (4.0 SCDA, Nutrisoft, Software, France).

### 2.3. Statistical analyses

Statistical analysis was performed using Stata software version 13 (StataCorp, College Station, US). Quantitative variables were expressed as mean and standard deviation (SD). The assumption of normality was checked by the Shapiro-Wilk test. To measure the concordance for total energy intake and the energy derived from each macronutrient (Fat, Carbohydrate and Protein) between the three methods, Pearson and Spearman correlation coefficients were estimated according to statistical distribution. This study of correlation was completed by estimation of Lin concordance coefficients and the Bland-Altman graphical representations. Finally, random-effect regression models were performed to complete these usual analyses taking into account within and between subject variability (random-effects). Following these models, the intra-class correlation coefficients (ICC) were expressed to evaluate the reproducibility of methods (Bonett, 2002; Kottner et al., 2011). Concordance was considered satisfactory according to usual rules and recommendations. A value greater than 0.9 indicated a high concordance (Barnhart, Song, & Haber, 2005; Lin, Hedayat, Sinha, &

**Table 1**  
Buffet meal example.

Food items	
Ham and Turkey	Cheese and yogurts
Salads and crudities	Fruits and compotes
Mashed potatoes and beans	Bread
Mince meat and chicken	



Yang, 2002). The tests were two-tailed and the significance level was set at 5%. The number of subjects was fixed on the basis of our previous experience, feasibility, and simulations of statistical power (Giraudeau & Mary, 2001).

### 3. Results

Our sample was aged  $13.5 \pm 1.5$  years old with a mean body mass of  $87.0 \pm 13.7$  kg and mean BMI of  $32.2 \pm 4.9$  kg/m<sup>2</sup>. Mean FM percentage was  $39.1 \pm 4.4\%$  and FFM was  $50.6 \pm 7.7$  kg.

Table 2 details mean values for total energy intake (S1:  $815 \pm 374$ ; S2:  $842 \pm 387$ ; S3:  $834 \pm 383$  kcal) and for the energy ingested derived from fat (S1:  $17.5 \pm 12.9$ ; S2:  $20.0 \pm 12.7$ ; S3:  $19.4 \pm 12.5\%$ ), protein (S1:  $17.1 \pm 4.4$ ; S2:  $23.9 \pm 9.1$ ; S3:  $20.5 \pm 5.0\%$ ) and carbohydrate (S1:  $64.4 \pm 17.0$ ; S2:  $55.8 \pm 17.7$ ; S3:  $60.1 \pm 15.4\%$ ) consumption. There was no significant difference between total energy intake, the percentage of intake related to either fat, protein or CHO between the three sessions.

The Intraclass Correlations (ICC) observed for total energy intake was 0.99 with a variation coefficient of 0.45. ICC and CV for the energy ingested derived from protein were 0.38 and 0.34 respectively, while they were 0.96 and 0.65 for fat and 0.81 and 0.28 for carbohydrate respectively (Table 2).

Lin coefficient revealed an important agreement between the three *ad libitum* meals for total calorie intake and for the energy ingested derived from each macronutrient, which was confirmed by the Bland & Altman plots, as illustrated for total EI (Fig. 1). The important range observed in terms of Bland & Altman 95% confidence limits has however to be noticed, illustrating the important inter-individual variability usually observed when studying energy intake. For EI lunch 1 vs. EI lunch 2 the Bland & Altman mean was  $-27.25$  with 95% limits of agreement of  $[-112.916-58.416]$  (Fig. 1A). Means and 95% limits of agreement for EI lunch 1 vs. EI lunch 3 and EI lunch 2 vs. EI lunch 3 were respectively  $-18.667$   $[-62.312-24.978]$  and  $8.583$   $[-50.337-67.504]$  (Fig. 1B and C).

### 4. Discussion

Energy consumption is one of the most difficult variables to measure and its assessment remains highly debated (Schoeller et al., 2013). Clinical researchers need accurate and precise evaluations of food intake and generally use in-laboratory *ad libitum* test meals. The present results show that an in-laboratory *ad libitum* buffet meal whose composition is based on individual food preferences is a reproducible way to assess energy intake in obese adolescents. According to our analysis, total energy intake's measurement is highly reproducible between sessions (with an ICC of 0.99).

Chaput and collaborators recently showed the reproducibility of a 75-food items menu proposed under laboratory conditions in assessing *ad libitum* energy consumption in healthy normal-weight adolescents (Chaput et al., 2016). Our results are comparable to those from Chaput and collaborators showing an ICC of 0.83 for

their in-lab *ad libitum* total energy intake assessment in healthy adolescents (Chaput et al., 2016), and confirm then that the proposed “reduced” *ad libitum* buffet is an accurate tool to evaluate food consumption under experimental conditions in youth. The higher ICC value obtained in the present work compared with the one observed in Chaput and al.'s study (0.99 vs. 0.83 for total energy intake) might be directly explained by the smaller number of food items proposed here (two choices per courses against up to 75 items), reducing the potential variations in energy intake. Although this observed high reproducibility was confirmed by the Bland & Altman plots showed by the Fig. 1 (for total energy intake), this has to be considered in light of the important range of the 95% confidence interval observed (Table 3), illustrating the important inter-individual variability usually observed when measuring energy intake.

Although the menu proposed by Chaput et al. appears as a useful tool to evaluate daily food intake using in-laboratory buffets in adolescents, it requires a large choice of food items and might be difficult to implement in clinical research (Chaput et al., 2016). On the other hand, some energy balance studies examining the nutritional response to exercise and sedentary activities in such a population employed standardized *ad libitum* buffets composed of single items such as yogurts or pizzas (Bellissimo, Thomas, et al., 2008). Yet Bellissimo et al. found their pizza-based buffet to be a reproducible way to assess lunch-time total energy intake (in kcal) in adolescent boys (ICC: 0.96); their analyses are based on two test-sessions only (while usually at least three repetitions are required) (Bellissimo, Thomas, et al., 2008) and such buffets suffer from a high degree of palatability, which might favor overconsumption in youth (Thivel et al., 2012).

In their previously cited study, Chaput and collaborators also tested the reproducibility of their in-laboratory menu to measure macronutrient consumption in normal weight adolescents, and showed reproducibility for both lipids (ICC: 0.69), proteins (ICC: 0.80) and CHO (ICC: 0.81) (Chaput et al., 2016). Again the present study shows a high reproducibility when it comes to the percentage of energy ingested derived from fat and carbohydrate consumption in obese adolescent females (with respectively ICC: 0.96 and 0.81). However, this needs to be nuanced for proteins that present a lower reproducibility despite a great within subjects and sessions homogeneity of its measure. Once more these results have to be interpreted in lights of the 95% confidence intervals with the Bland & Altman plots, as detailed in Table 3.

By proposing a buffet meal composed of usually consumed food items that avoids preferred foods (and obviously disliked or not consumed items), and considering individuals' eating habits, the present study provides a reproducible method to assess total energy and macronutrient intake (to an acceptable but lesser extent, especially for protein) of obese adolescents for clinical and energy balance research. This method avoids occasional food item consumptions, food wastage, and offers clinicians and researchers a more manageable way to conduct studies based on *ad libitum* buffet meals. Although this study does not compare in-laboratory measures of EI with free living ones, this method of personalizing the food menu may be more representative of the participant's habitual (or free-living intakes), as only items that they usually consume were offered.

Some limitations have to be underlined. First this work only involved obese female and this menu should also be tested among participants with other weight status (normal weight and overweight) and among boys. Moreover, we did not control for the participants menstrual cycle, which might affect energy intake (Gorczyca et al., 2015). Although the adolescents had to be free of any dietary disturbance as investigated during the inclusion visit, a deeper exploration of their dietary status (such as their level of

**Table 2**  
Total and macronutrient-relative energy intake.

	Session 1		Session 2		Session 3		ICC	CV
	Mean	SD	Mean	SD	Mean	SD		
Total EI (kcal)	815	374	842	387	834	383	0.99	0.45
Protein (%)	17.1	4.4	23.9	9.1	20.5	5.0	0.38	0.34
Fat (%)	17.5	12.9	20.0	12.7	19.4	12.5	0.96	0.65
CHO (%)	64.4	17.0	55.8	17.7	60.1	15.4	0.81	0.28

ICC: Intra-Class Coefficient; CV: Coefficient of Variation; CHO: Carbohydrates; SD: Standard Deviations.

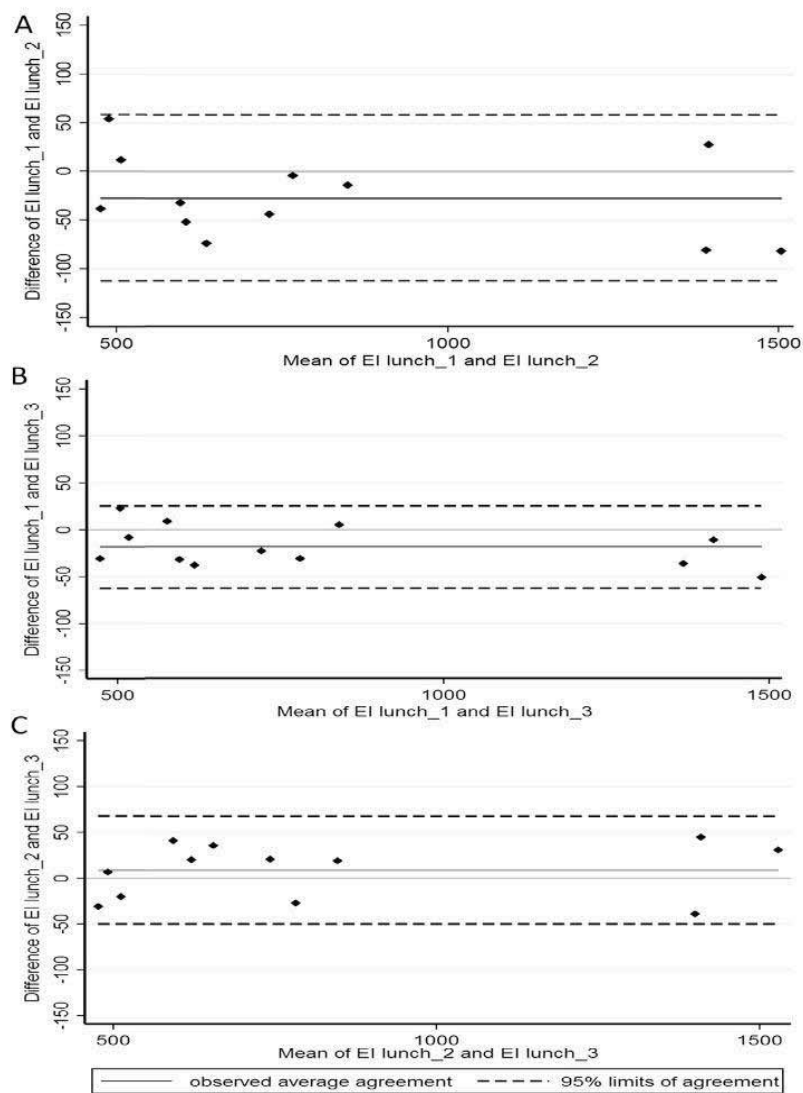


Fig. 1. Bland & Altman diagram for total energy intake between the sessions 1 and 2 (A), 1 and 3 (B) and 2 and 3 (C).

Table 3

Bland & Altman mean and 95%CI and Lin coefficient for total energy and macronutrients intake.

	1 vs. 2 Mean [95% CI]	1 vs. 3 Mean [95% CI]	2 vs. 3 Mean [95% CI]
<b>Bland &amp; Altman</b>			
Total EI (kcal)	−27.25 [−112.916–58.416]	−18.667 [−62.312–24.978]	8.583 [−50.337–67.504]
Protein (%)	−6.867 [−25.376–11.643]	−3.408 [−12.055–5.238]	3.458 [−6.791–13.708]
Fat (%)	−2.475 [−11.695–6.745]	−1.875 [−6.433–2.683]	0.6 [−4.316–5.516]
CHO (%)	8.642 [−17.083–34.367]	4.325 [−7.305–15.955]	−4.317 [−18.825–10.192]
	1 vs. 2 R [95% CI]	1 vs. 3 R [95% CI]	2 vs. 3 R [95% CI]
<b>Lin coefficients</b>			
Total EI (kcal)	0.991 [0.97–0.997]	0.997 [0.991–0.999]	0.997 [0.989–0.999]
Protein (%)	0.086 [−0.237–0.391]	0.44 [−0.016–0.745]	0.665 [0.39–0.831]
Fat (%)	0.914 [0.738–0.973]	0.972 [0.912–0.991]	0.979 [0.930–0.994]
CHO (%)	0.628 [0.186–0.859]	0.899 [0.714–0.966]	0.868 [0.638–0.956]

ICC: Intra-Class Coefficient; CHO: Carbohydrates.

desinhibition or restriction for instance) could add to the present results.

Although such in-laboratory meals have been shown

reproducible in measuring energy and macronutrients intake in adults (Arvaniti et al., 2000) and youth (Chaput et al., 2016), this remained unstudied so far in youth with obesity. The present work



provides then evidence that a personalized in-laboratory *ad libitum* test meal produces a reproducible measure of total energy and macronutrients intake (although not as great as for total energy intake) in adolescent girls with obesity, which is of main importance for studies that tend to explore the impact of several kinds of activities (exercise or sedentary for instance) or conditions (temperature, altitude, etc) on food consumption.

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#### Conflict of interest

The authors have no conflicts of interest to disclose.

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## Résumé

Les sociétés actuelles montrent un déclin toujours plus important du niveau d'activité physique, associé à une progression alarmante des comportements sédentaires. Compte tenu de la mutation inéluctable des activités professionnelles, le milieu du travail a récemment été suggéré comme un environnement pertinent et intéressant pour favoriser l'activité physique. Dans ce contexte, l'objectif principal de ce travail de doctorat était d'évaluer la faisabilité de mise en place et l'efficacité de programmes d'activité physique conduits en entreprise sur les principaux indicateurs de santé d'employés du secteur tertiaire. Si les premiers résultats soulignent bien la faisabilité de ce type d'approche et viennent confirmer leurs bienfaits sur la santé, ce travail vient enrichir la littérature dans le domaine de nouveaux résultats particulièrement importants à considérer : i) le haut niveau de sédentarité semble influencer le niveau de santé des employés ; ii) la mise en place de ce type de programme se confronte à un faible taux d'adhésion qui semble déterminé à la fois par le profil initial de participant et par les effets à court terme du programme. De manière importante, nos résultats mettent clairement en avant que la santé générale des employés de ce secteur tertiaire ne peut pas être uniquement améliorée par l'accroissement du niveau d'activité physique, mais également très certainement par la réduction concomitante de leur temps de sédentarité. Si les travaux conduits jusqu'alors se sont intéressés de manière isolée à la promotion du niveau d'activité physique ou à cette rupture de sédentarité, des approches combinées doivent être maintenant conduites et ce de manière individualisée.

## Abstract

Current societies show a continuous decline of physical activity level associated with an alarming progression of sedentary behaviors. Considering the inevitable shift in professional activities, workplace has recently been suggested as a relevant and interesting setting for the promotion of physical activity. In this context, the main objective of this PhD thesis was to evaluate the feasibility, implementation and effectiveness of physical activity programs conducted within companies on the main health indicators of tertiary employees. If our first results underline the feasibility of such an approaches and confirm their health benefits, this work enriches the literature in the field of new results particularly important to consider : i) the high level of sedentary time seems to influence the employees' health level despite increased physical practice ; ii) the introduction of this program type is confronted to a high attrition rate which seems determined by both the initial participants' profile and the short-term effects of the program. Importantly, our results clearly point out that the employees' general health in the tertiary sector can not only be improved by increasing the physical activity level, but needs a concomitant reduction of their sedentary time. If the work carried out until now has been independently focusing on the promotion of physical activity or on anti-sedentary time strategies, combined individualized approaches must now be carried out.