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Exercise stereotypes, fatigue and physical activity in people living with HIV : an identification of psychological and physiological mechanisms at play

Laura Gray

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THÈSE DE DOCTORAT

Stéréotypes liés à l'activité physique et la fatigue
chez les personnes vivant avec le VIH:
Une identification des mécanismes psychologiques
et physiologiques impliqués

Laura GRAY

Laboratoire Motricité Humaine Expertise Sport Santé – EA 6312

**Présentée en vue de l'obtention
du grade de docteur en** Sciences du
Mouvement Humain
de l'Université Côte d'Azur
Dirigée par : Fabienne d'Arripe-Longueville
Co-dirigée par : Serge S. Colson
Soutenue le : 6 Décembre 2018

Devant le jury, composé de :
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Adonai

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GENERAL INTRODUCTION

Over 38 years after Acquired Immunodeficiency Syndrome (AIDS) was first recognised, it is reported that there are an estimated 36.7 million people living with Human Immunodeficiency Virus (World Health Organisation, 2016). Despite information and prevention campaigns, every year, there are more than 2 million new infections worldwide. In France, this figure amounts to 6000 new infections on average every year with approximately 150 000 People Living with HIV (PLHIV). Advances in scientific and clinical research into the development of antiretroviral therapy have helped prevent the development of HIV more or less effectively, and delay the onset of AIDS. The number of new infections has thus decreased by 35%, while the number of HIV-related deaths has fallen by 28% between 2000 and 2015 (WHO, 2016). Indeed, 2017 marked an important advance in HIV/AIDS research and prevention, with, for the first time in AIDS history, more than half of PLHIV worldwide receiving antiretroviral therapy, a record of 19.5 million people. The “*Undetectable=Untransmittable*” anti-stigma slogan was launched by the Prevention Access Campaign based on reliable and robust scientific research (The Lancet HIV, Editorial 2017). This campaign emphasises the advance in antiretroviral treatment efficiency and distribution, with adhering PLHIV revealing undetectable viral loads and thus no longer transmitting HIV. It is hereby evident that treatment can prolong life expectancy and quality of life of PLHIV (Johnson et al., 2013; Lima et al., 2007).

Though antiretroviral treatments are efficient in increasing life expectancy and quality of life, these treatments are costly, making HIV/AIDS a major public health issue. In addition, the antiretroviral treatments cause multiple side effects and accentuate certain HIV-associated symptoms including lipodystrophy, depression and fatigue (Ammassari et al., 2004; Carr & Cooper, 2000; Montessori et al., 2000). Fatigue is one of the most commonly reported symptoms of PLHIV impacting their daily functioning and quality of life (Barroso & Voss, 2013; Pence, Barroso, Leserman, Harmon, & Salahuddin, 2008). Since fatigue contributes

greatly to physical limitations and disability, this symptom must therefore be evaluated and treated (Ferrando et al., 1998). A major challenge for healthcare professionals working with PLHIV is precisely to characterise this fatigue (Adinolfi, 2001). In HIV research and literature, fatigue has been essentially reported and defined as a subjective, unpleasant symptom that incorporates feelings ranging from tiredness to exhaustion, creating an unrelenting overall condition that interferes with individuals' abilities to function to their normal capacities (Ream & Richardson, 1996). Therefore, a better understanding of the characteristics and determinants of fatigue in PLHIV, and the possible strategies to treat or overcome fatigue, is a major focus point in HIV-related research.

Some interventional studies, for instance, have successfully reduced fatigue in PLHIV by using androgen therapies, such as testosterone (Rabkin, Wagner, & Rabkin, 2000) or thyroid hormone supplementation (Derry, 1996). Also, the correlation between depressed mood and fatigue has been strongly established in PLHIV (Barroso & Lynn, 2002; Barroso & Voss, 2013; Breitbart, McDonald, Rosenfeld, Monkman, & Passik, 1998; Voss, 2005). Therefore, implementing strategies to reduce depressed mood could positively influence fatigue. Unfortunately, it is important to note that even if depressed mood is reduced, fatigue remains (Rabkin, Wagner, & Rabkin, 1999), emphasising that multiple factors influence the fatigue of PLHIV (Voss, Dodd, Portillo, & Holzemer, 2006). Relaxation techniques (Fukunishi et al., 1997) and cognitive-behavioural interventions (Lechner et al., 2003) have also been studied as strategies to alleviate the symptom of fatigue in PLHIV. Another strategy studied was supervised exercise interventions (O'Brien, Tynan, Nixon, & Glazier, 2017; O'Brien, Nixon, Tynan, & Glazier, 2010), with the positive effects of exercise for PLHIV now being thoroughly reported in the scientific literature, upon cardiovascular fitness (Dolan et al., 2006), reduced depression (Jaggers et al., 2015; Neidig, Smith, & Brashers, 2003), greater quality of social relationships (Roubenoff, 2000) and better antiretroviral therapy adherence

(Blashill et al., 2013). Importantly, through an interventional study, Webel et al. (2016a) revealed a positive effect of home-based exercise on fatigue. Indeed, PLHIV who met the current recommendations (i.e., 150 minutes of moderate exercise), presented a 17% reduction in fatigue as compared to PLHIV who did not meet the recommendations. Regular physical activity (PA) or exercise thus appears to be a promising strategy to reduce fatigue in PLHIV.

Regardless of the extensive literature related to the benefits of exercise in PLHIV, a large proportion of this population is not sufficiently active according to current recommendations (Fillipas et al., 2008; Frantz & Murenzi, 2013). For adults between 18 and 64 years of age, at least 150 minutes of moderate exercise and two sessions of muscle strengthening workouts per week are required (Clingerman, 2003). These findings are of concern and highlight that further research is required in identifying barriers to exercise participation. Research related to exercise barriers in PLHIV is sparse. Lack of motivation (30.5%), lack of time (25.3%) and fear of worsening the disease (24.3%) are among the main barriers to regular PA (Roos, Myezwa, & van Aswegen, 2015). Low-energy levels, psychological complaints and stress levels, as well as the physical environment, social environment, domestic abuse and crime, were further barriers to PA that appeared in the literature (Montoya, Wing, Knight, Moore, & Henry, 2015). Further prominent exercise barriers include HIV symptoms (i.e., neuropathy, lipoatrophy), antiretroviral therapy effects (lipodystrophy) and fatigue, depression, negative self-perceptions and apprehension concerning the risks of exercise such as sustaining an injury (Montoya et al., 2015; Vader et al., 2017).

Beyond the identified barriers to PA in PLHIV, it is crucial to understand that HIV/AIDS is seen not only as a medical condition but also as a stigmatised state. Despite the fact that society now has a better understanding about the causes and impacts of HIV/AIDS, stigma and discrimination continue to exist (Liamputtong, 2013). Stigma is a socially

constructed concept that finds its origins in “differences” that can be in physical appearance, age, gender, personality, sexuality, illness, disability and specific behaviours which brings forth discontent, abhorrence, panic, or sympathy from others (Mason-Whitehead, & Miers, 2001). It is essential to keep in mind that stigma is a process of devaluation (Goffman, 1963). PLHIV live with the knowledge that their HIV status is a stigma or, in other words, a socially devalued attribute that renders them vulnerable to discrimination and prejudice (Earnshaw & Chaudoir, 2009b). Stigma hereby has negative effects on the life, health and well-being of the individuals and groups who are so labelled (Liamputtong & Kitisriworapan, 2012). Indeed, fear of being identified as having HIV or AIDS has been shown to discourage a person from getting tested, from accessing medical services and medications and from disclosing their HIV status to family and friends (Carr & Gramling, 2004; Clark, Lindner, Armistead, & Austin, 2004; Klitzman et al., 2005). Furthermore, stigma has a negative impact on health-related outcomes including, antiretroviral therapy adherence, health-related quality of life, and increased HIV-associated symptoms and depression (Clark et al., 2004; Rintamaki, Davis, Skripkauskas, Bennett, & Wolf, 2006; Vanable, Carey, Blair, & Littlewood, 2006). Through a multi-component conceptualisation of HIV-stigma, Link and Phelan (Link & Phelan, 2001) suggested that negative stereotypes about PLHIV are created through labelling and shared cultural beliefs.

Research in other vulnerable populations including cancer patients (Falzon, Chalabaev, Schuft, Brizzi, Ganga, & d'Arripe-Longueville, 2012) and the elderly (Emile, Chalabaev, Stephan, Corrion, & d'Arripe-Longueville, 2014; Sánchez Palacios, Trianes Torres, & Blanca Mena, 2009), have revealed a relationship between exercise stereotypes and PA. Exercise stereotypes can be defined as shared beliefs about the characteristics of a group in the specific context of regular PA and exercise. This relationship was based on the stereotype embodiment theory (Levy, 2009) that postulates that internalised stereotypes

would have long-term effects on health-related behaviours in vulnerable populations. Studies observing the role of internalised stereotypes in the PA domain have revealed negative and positive dimensions of exercise stereotypes in vulnerable populations (e.g., Chalabaev, Emile, Corrion, Stephan, Clément-Guillotin, Pradier, & d'Arripe-Longueville, 2013b; Emile et al., 2014; Falzon et al., 2014). Emile et al. (2015) showed that, in older adults, the internalisation mechanism was not the only active construct through which exercise stereotypes may affect health-related behaviours. Indeed, they also showed that exercise stereotypes influenced subjective vitality independently of self-perceptions. This was interpreted as an ego-depletion mechanism, a concept suggesting that engaging in acts of self control to override initial impulses or responses draws from a limited “*reservoir*” which, when depleted, results in reduced capacity for further regulation (Muraven, Tice, & Baumeister, 2000).

In line with this recent research and based on an integrative approach of fatigue (Kluger, Krupp, & Enoka, 2013) the general purpose of this doctoral work was to better understand the relationships between exercise stereotypes, fatigue and PA level in PLHIV, and to identify the psychological and physiological mechanisms at play.

This doctoral work includes two main parts. The first part consists of presenting the general framework of the thesis with the first chapter seeking to bring light to the complex concept of fatigue in PLHIV through a multidimensional approach including perceived fatigue and performance fatigability. The second chapter, focusing on PA in PLHIV, looks at the definitions of PA, the PA recommendations and the relationships towards PA in vulnerable populations including PLHIV. The third and last chapter seek to elucidate the stereotypes related to PA and PLHIV, as well as presenting the mechanisms through which stereotypes influence health-related behaviours. The second part of this thesis presents the six empirical studies through which we sought to answer to our research questions.

THEORETICAL FRAMEWORK

Chapter 1 – The multidimensional aspects of fatigue in PLHIV

The fatigue experienced by PLHIV has been defined as a feeling of exhaustion or a lack of energy (Lee, Lentz, Taylor, Mitchell, & Woods, 1994) and generally refers to perceived fatigue. With prevalence rates ranging from 37% to 88%, fatigue is the most frequently reported symptom in PLHIV (Henderson, Safa, Easterbrook, & Hotopf, 2005; Jong et al., 2010; Phillips et al., 2004; Webel et al., 2016a). As high levels of fatigue are related to lower quality of life (Webel, Sattar, Schreiner, & Phillips, 2016b), several studies have sought to identify the factors that characterise fatigue in PLHIV in order to lessen its impact on patients' quality of life. In this chapter, we look at how fatigue is defined in PLHIV as well as the different underlying known factors of this fatigue. Following which, we examine the different models of fatigue in PLHIV that have emerged in the literature and introduce the concept of performance fatigability, which has not yet been explored in this population.

I. Fatigue among PLHIV

Much the same as in many other chronic diseases, in PLHIV fatigue has been correlated with decreased quality of life and decreased functional status (e.g., Crystal, Fleishman, Hays, Shapiro, & Bozzette, 2000; Duran et al., 2015; Fleishman et al., 2000; Hays

et al., 2000), making it a major health concern. To date, the majority of studies focusing on fatigue in PLHIV are based on subjective evaluations (i.e., questionnaires) and reflect the so-called chronic fatigue or perceived fatigue. Though fatigue has been greatly studied in PLHIV, it remains known and understood only to a limited extent.

I. 1. *Biological factors of fatigue in PLHIV*

Many studies have focused on identifying the link between disease-specific biological factors and the perceived fatigue of PLHIV. Barroso, Carlson, and Meynell (2003) showed that the severity of fatigue is positively correlated with blood platelet count and negatively with thyroid stimulating hormone levels, but not with other factors, such as the duration of antiretroviral treatment. Some studies showed that fatigue was correlated with a low level of CD4 + T lymphocytes (Darko, McCutchan, Kripke, Gillin, & Golshan, 1992; Walker, McGown, Jantos, & Anson, 1997), while other studies did not obtain any significant results (Barroso & Voss, 2013; Ferrando et al., 1998; Vancampfort et al., 2017; Voss, 2005) or even observed the opposite results (Henderson et al., 2005). With regard to other biologic markers of the disease, again, some studies have found a correlation between viral load and fatigue (Lee, Portillo, & Miramontes, 1999; Walker et al., 1997), while others did not observe any such correlation (Barroso et al., 2010; Breitbart et al., 1998; Henderson et al., 2005; Perkins et al., 1996; Vogl et al., 1999). Furthermore, the high prevalence of hepatitis C in PLHIV has an effect on fatigue since co-infected PLHIV showed increased fatigue compared to those who are not co-infected (Braitstein et al., 2005). While antiretroviral-based HIV treatments are prescribed to counteract HIV progression, side effects of these treatments are also considered as factors that may influence perceived fatigue. Thus, the literature is consistent in characterising PLHIV's fatigue as a subjective complaint as no certain links to one or more biomarkers of infection have been observed.

I. 2. *Psychological factors of fatigue in PLHIV*

With regard to psychological factors of fatigue in PLHIV, it is now well established in the literature that depressed mood and fatigue are strongly correlated (Barroso et al., 2003; Barroso & Lynn, 2002; Breitbart et al., 1998; Henderson et al., 2005; Millikin, Rourke, Halman, & Power, 2003; Phillips et al., 2004; Voss, 2005). In advanced stages of the disease, fatigue is a symptom that is associated with depression but is not only a symptom of it (Ferrando et al., 1998). A study by Rabkin et al. (1999) showed that even if depressed mood is reduced, fatigue remains. Barroso et al. (2010) report that being unemployed, having had many childhood traumas, a significant number of stressful events and psychosocial distress (e.g., anxiety, depression and post-traumatic stress disorder), are predictors of severe fatigue and major fatigue-related disorders. Based on these studies, it is clearly recognised that many psychological factors influence the perceived fatigue of PLHIV. Some of these psychological factors have a social component within them and can be considered as and influenced by sociological factors such as a family or the workplace.

I. 3. *Sociological factors of fatigue in PLHIV*

As previously elucidated, fatigue can be considered as a side effect of antiretroviral therapy treatments, as well as being associated to biological and psychological factors. Social support, stressful life events and level of education are factors that have been related to perceptions of fatigue in PLHIV relating to sociological components of fatigue (Barroso, 1999; Barroso & Voss, 2013; Voss, 2005). Social support has also been related to mental health in PLHIV with negative effects of loneliness and limited social ties (Barroso et al., 2010; Honn & Bornstein, 2002; Murphy, Moscicki, Vermund, & Muenz, 2000). In a recent study, the association between socioeconomic status and perceived fatigue was corroborated with age appearing as another factor (Bergamaschi et al., revision). With antiretroviral

therapies being more effective, HIV is considered more and more as a chronic illness in many spheres of research. PLHIV are living longer and facing the natural decline of aging, as well as HIV-related symptoms. Additionally, research revealed that older adults have higher perceived fatigue (Watt et al., 2000), which should be considered in HIV-related research. These studies show significant links between fatigue and sociodemographic characteristics of PLHIV, adding emphasises to the multidimensional characteristic of fatigue in PLHIV including physiological, psychological and sociological factors.

I. 4. *Models of fatigue in chronic diseases*

It is quite clear that a multitude of correlates of perceived fatigue have been explored in PLHIV. (Voss et al., 2006) suggested a multidimensional model of HIV-related fatigue by taking into account the many variables that can influence the intensity and chronicity of patient fatigue (Figure 1). This model displays the four broad areas that may influence HIV-related fatigue, including personal, HIV-related, physiological and psychological variables based on existing fatigue research (Barroso, 1999; Barroso et al., 2003; Barroso & Lynn, 2002). This multidimensional model illustrates that not all fatigue-related variables consistently predict the perceived fatigue reported by PLHIV with such high prevalence. Indeed, where the biological and HIV-related variables reveal conflicting correlations with perceived fatigue, psychological variables recurrently predict HIV-related fatigue. Sociological variables have been the object of more in-depth research in recent studies and appear to be robust predictors of perceived fatigue in PLHIV, as well. It is worth mentioning that this literature, however, has been based on correlational and qualitative designs and do not give causality.

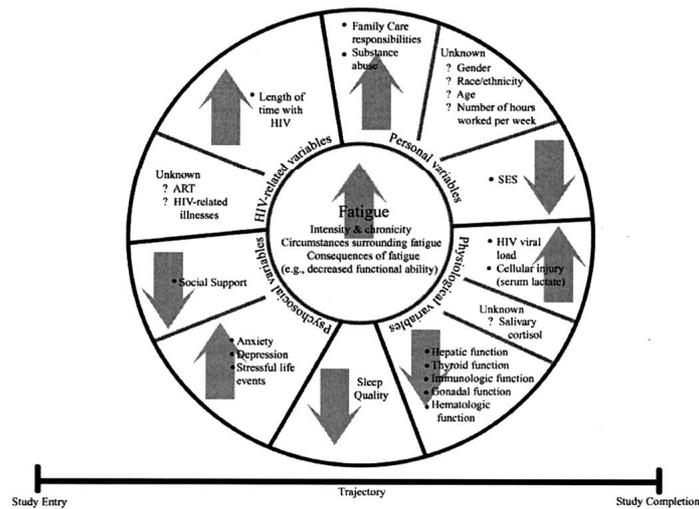


Figure 1. Multidimensional Model of HIV-Related Fatigue from Barroso published by Voss et al. (2006).

Although well acknowledged and investigated, fatigue in PLHIV refers to self-reported perceptions of fatigue. As shown above, the multiplicity of factors involved makes fatigue quite complex to investigate due to the possible interactions between these factors. However, it is surprising that no study has yet sought to explore fatigue in PLHIV with more objective measures, such as performance decline induced by physical exercise. This approach has been a major research sphere in exercise physiology for more than a century (Mosso, 1891), and there are recent evidence that its implementation in chronic diseases such as cancer (Yavuzsen et al., 2009), multiple sclerosis (Sheean, 1997) and cystic fibrosis (Gruet et al., 2016) is useful in understanding fatigue.

In this framework, Kluger et al. (2013) recently suggested that using multiple measures of fatigue would provide clarification to fatigue-related studies, and proposed a unified taxonomy for fatigue. In their proposal, fatigue is therefore considered in terms of “*perceptions of fatigue*” and “*performance fatigability*”. To date, perceptions of fatigue have been the focus of HIV-related fatigue research, and along with the integrated fatigue model (Figure 2) proposed by Kluger et al. (2013), performance fatigability has yet to be examined. Performance fatigability has been used in multiple studies as indicators of exercise-induced

fatigue and investigating central and peripheral factors that contribute to performance fatigability could provide evidence to causal relations and namely, to determine the possible link between perceived fatigue and performance fatigability. For example, in multiple sclerosis a deficit in neural activation influence performance fatigability and contribute to perceived fatigue (Sheean, 1997). Similar observations were found in neuromuscular disorders (De Vries, Hagemans, Bussmann, van der Ploeg, & van Doorn, 2009). Although these relationships were not observed in Parkinson’s disease (Lou, Benice, Kearns, Sexton, & Nutt, 2003) or multiple sclerosis (Bailey, Channon, & Beaumont, 2016; Krupp, Serafin, & Christodoulou, 2010), the possible link between performance fatigability and perceived fatigue in PLHIV is unknown. Consequently, only an integrated approach would make it possible to understand all the dimensions of fatigue and to identify the different factors that explain the perceived fatigue and performance fatigability of PLHIV.

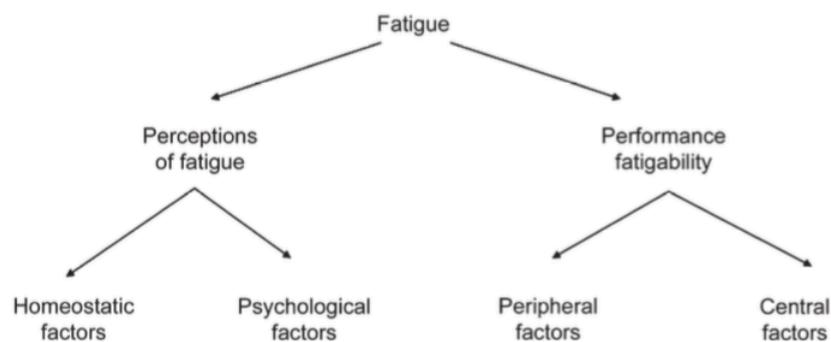


Figure 2. Integrative approach to fatigue including perceptions of fatigue and performance fatigability based on Kluger et al. (2013)

II. Performance fatigability

Although the “*integrated fatigue model*” proposed by Kluger et al. (2013) is quite recent, the concept of “*performance fatigability*” refers to the broad investigated field of the so-called “*neuromuscular fatigue*” in the scientific literature (Enoka et al., 2011; Gandevia, 1992; Gandevia, Enoka, McComas, Stuart, & Thomas, 1995). Neuromuscular fatigue finds its

origin in the concept of decreased performance due to the incapacity to maintain a required force during a task or exercise (Edwards, 1981). Nowadays, we know that this definition is incomplete, since fatigue develops progressively during a task or an exercise. Having this in mind, performance fatigability induced by a task or an exercise can therefore be defined as "*a decrease in the ability of the muscle or musculoskeletal system investigated to produce a required performance criterion (e.g., strength, power, accuracy)*". An addition to this definition is that "*performance fatigability induced by the exercise or task is irreversible with recovery*" (Fitts, 1994). Although the taxonomy has recently been updated, many studies have used this approach to characterise performance fatigability of different populations of individuals under multiple experimental conditions. In this context, it is well accepted that the origin of performance fatigability may depend on peripheral and/or central factors. Bigland-Ritchie (1981) included these notions of peripheral and central fatigue/factors in their definition as the two components that are possibly affected when an individual is required to produce a particular performance. Hence, ranging from the central motor command to the peripheral muscle force production there is a multitude of sites that could be at the origin of performance fatigability. Peripheral factors of fatigability relate to an alteration in the muscles' internal capacity to produce the required force intended for the task, and are characterised by an alteration in the contraction processes situated after the neuromuscular junction (Bigland-Ritchie & Woods, 1984; Gandevia, 2001). Central factors of performance fatigability encompass an alteration in an individuals' capacity to voluntarily activate the working muscle(s) and are characterised by an alteration in the processes situated above the neuromuscular junction (Bigland-Ritchie & Woods, 1984; Gandevia, 2001).

In clinical conditions, the term fatigue is considered to be the result of an underlying pathophysiology or its associated treatment and has been studied through subjective measures and consequently reflects a multidimensional perceived fatigue. Fatigue however, also

comprises performance fatigability (i.e., a decline in performance induced by exercise) with both peripheral and central contributing factors, as well as possible influence of disease pathophysiology on these factors.

II. 1. *Peripheral factors of performance fatigability*

The peripheral contribution to performance fatigability allows apprehending the alterations caused by exercise or a fatiguing task on the mechanisms situated after the neuromuscular junction (Bigland-Ritchie & Woods, 1984). Decrease of performance due to peripheral factors is the result of either a decrease in the neuromuscular transmission, or a decrease in the excitation-contraction coupling, a decrease in the availability of metabolic substrates, a decrease of energy production or an increase of metabolites. The outcome of these factors should avoid involving the central volitional mechanisms of strength production. This can be achieved by producing a muscular contraction through electric or magnetic stimulation of the peripheral nerve (Reid, 1928; Verges et al., 2009). Electrical stimulation allows depolarising the motor nerve, which in turn excites the muscle and recruits all the motor units, as long as optimal stimulation parameters for each individual have been set. The recruitment of motor units evoked an involuntary muscle contraction (i.e., twitch), which can be used for the assessment of non-volitional muscle strength and performance fatigability involving peripheral factors (Reid, 1928; Verges et al., 2009).

As emphasised by Enoka and Duchateau (2008), “*muscle fatigue is not the point of task failure or the moment the muscles become exhausted but rather, muscle fatigue is a decrease in maximal force or power that involved muscles can produce, and it develops gradually soon after the onset of sustained physical activity*”. This suggests that to estimate the decline in maximal force capacity, according to a widely used protocol, the fatiguing exercise could be interrupted with brief maximal contractions, (voluntary or evoked by

stimulation), allowing to quantify the development of muscle fatigue (e.g., Bigland-Ritchie, Furbush, & Woods, 1986; Hunter, Duchateau, & Enoka, 2004; Merton, 1954; Sogaard, Gandevia, Todd, Petersen, & Taylor, 2006). Comparing the force responses to nerve stimulation before and after a fatiguing task or exercise would also allow to measure peripheral factors of performance fatigability (Griffin, Garland, Ivanova, & Gossen, 2004; Hunter et al., 2004; Lévénez, Garland, Klass, & Duchateau, 2008; McNeil, Murray, & Rice, 2006; Taylor, Butler, Allen, & Gandevia, 1996).

Though fatigue-related research warrants for the muscle to be examined *in vivo* (Allen, Lamb, & Westerblad, 2008) as the changes induced by fatigue may occur in parallel at multiple sites, there are still a number of parameters that can be examined from the mechanical responses to single stimulations and high-frequency doublets (Debold, 2012). Indeed, responses to stimulations can be used to deduce fatiguing mechanisms at the cross-bridge cycle (i.e. inhibition of the function of contractile proteins; reduced calcium sensitivity caused by accumulating metabolites). We can hereby expect to see a decrease in both maximal voluntary contractions force as well as a decrease in the evoked involuntary muscle contractions as indicated by the amplitude of the twitches responses. These techniques are sensitive for detecting relatively small disturbances (Jeffery Mador, Kufel, & Pineda, 2000). For example, in incremental intermittent isometric fatigue protocols (e.g., Bachasson et al., 2013), the protocol induced a progressive decline in MVC values as revealed by decreased evoked mechanical responses. Similar results were recently observed in cystic fibrosis patients (Gruet et al., 2016) and could therefore be useful in our population of PLHIV to characterise the influence of peripheral factors involved in performance fatigability.

II. 2. *Central factors of performance fatigability*

Central contributions to performance fatigability generally refer to an alteration of voluntary activation of muscles involved in the task or exercise (Gandevia, 2001). Superimposed stimulation of the peripheral nerve (Merton, 1954) or stimulation of the motor cortex (Gruet et al., 2014; Merton, 1954) are among the techniques classically used to measure central contributions of performance fatigability.

The superimposed stimulation technique consists of superimposing a stimulation of the peripheral nerve over a maximal voluntary contraction (Merton, 1954). The difference between the strength produced and the amplitude of the superimposed twitch varies according to the increase in force production, suggesting that the higher the force production, the smaller the superimposed twitch. This variation in the amplitude of the superimposed twitch is considered to indicate the amount of muscle activated. During exercise though, this variation in superimposed twitch amplitude could be due to peripheral factors or potentiation (Place, Yamada, Bruton, & Westerblad, 2008). Thus, Bellemare and Bigland-Ritchie (1984) suggested comparing the superimposed twitch amplitude with the amplitude of a stimulation evoked on the muscle at rest. Consequently, the following equation was established to calculate voluntary activation (Bellemare & Bigland-Ritchie, 1984; Todd, Taylor, & Gandevia, 2003).

$$VA (\%) = [1 - (\text{Amplitude } Db_{100s} / \text{Amplitude } Db_{100})] \times 100$$

The contribution of central factors in performance fatigability can be represented by the force responses to supramaximal electrical or magnetic stimulations to the nerve superimposed on a sustained maximal voluntary contraction. When the muscle force evoked by the stimulation exceeds the force that can be exerted voluntarily, the decline in muscle

force has been apportioned to central factors of performance fatigability (Allen, Gandevia, & McKenzie, 1995; Behm, St-Pierre, & Perez, 1996; Herbert & Gandevia, 1999; Taylor, 2009). Though the twitch interpolation technique is debated (Taylor, 2009), it remains a widely used technique to assess muscle voluntary activation as a measure of central factors of performance fatigability (Gandevia, 2001).

In fatigue studies using submaximal tasks it is advanced that the fatigue processes are different according to the intensity of the task (i.e., “*low-intensity*” and “*high-intensity*” contraction tasks Place, Bruton, & Westerblad, 2009). Central factors of performance fatigability are significantly greater in prolonged intermittent or sustained contractions at low percentages of MVC force (5-30% MVC) (Smith, Martin, Gandevia, & Taylor, 2007; Sogaard et al., 2006; Yoon, Schlinder Delap, Griffith, & Hunter, 2007), compared to contractions performed at higher percentages of MVC force (Eichelberger & Bilodeau, 2007). Indeed, when submaximal contractions are performed at relatively high intensities (i.e., greater than 30% MVC), impairment of the maximal ability to activate the muscle was minor (5% average decrease at exhaustion). Authors concluded that the reduction in MVC values was mostly due to peripheral factors (Bachasson et al., 2013; Bigland-Ritchie et al., 1986; Bilodeau, 2006; Goodall, Ross, & Romer, 2010; Saugen, Vollestad, Gibson, Martin, & Edwards, 1997).

In contrast, high involvement of central factors, as indicated by decreased VA of up to 29%, were revealed during an intermittent submaximal isometric contraction fatiguing task (Burnley, Vanhatalo, & Jones, 2012). The notion that at different percentages of MVC force, the mechanisms responsible for performance fatigability vary between peripheral and central processes leads to questioning the existence of a transition “*threshold*”, or “*critical torque*” (see Burnley et al., 2012). Indeed, distinct physiological responses are observed, evidencing central and peripheral processes that vary during sustained or repeated contractions, and that

may depend on whether the contractions are performed below or above the *critical torque* (Burnley, Vanhatalo, Fulford, & Jones, 2010; Jones, Wilkerson, DiMenna, Fulford, & Poole, 2008; Vanhatalo, Fulford, DiMenna, & Jones, 2010). Consequently, although the fatiguing protocol chosen to study performance fatigability will inevitably influence the respective contribution of central and peripheral factors, investigating performance fatigability will help the clinician to characterise fatigue more “*objectively*” in a specific population, such as the PLHIV in the present doctoral work.

III. Summary

Identifying the factors to be taken into account in the interpretation of fatigue is a major research topic, specifically in clinical conditions. Research has revealed strong correlations between psychological variables and some sociological variables of HIV-related fatigue based on subjective measures of fatigue. Indeed, no biological factors appear to be recurrent determinants of perceived fatigue (Barroso & Voss, 2013), whereas psychological factors seem to be better predictors of perceived fatigue in PLHIV. The potential influence of performance fatigability on perceived fatigue remains to be determined in this population.

In order to overcome fatigue symptoms in PLHIV, some interventional studies have used, for example, supplementation of thyroid hormones (Derry, 1996), androgen-based therapy (e.g., testosterone supplementation: (Rabkin et al., 2000), cognitive-behavioural interventions (Lechner et al., 2003) and supervised exercise interventions (O'Brien et al., 2010, 2017). Furthermore, through an interventional study, home-based exercise induced a 17% reduction in perceived fatigue in physically active PLHIV compared to less active PLHIV (Webel et al., 2016a). Regular physical activity or exercise thus appears to be promising strategies aimed at reducing perceived fatigue in PLHIV. Physical activity will be the focal point of the next chapter.

Chapter 2 - Physical activity in PLHIV

The objective of this chapter is to give an overall view of the PLHIV's relationship towards PA. First, we define PA and exercise and present the WHO recommendations. Then we look at the state of the art of PA barriers in this population seeking to understand the reasons for which PLHIV remain insufficiently active despite the extensive literature revealing the benefits of regular PA and exercise.

I. Definitions of physical activity, exercise and recommendations

PA, defined as any bodily movement produced by skeletal muscles resulting in energy expenditure (Caspersen, Powell, & Christenson, 1985), is one of the most important health behaviours associated with prevention and management of chronic diseases. PA is measured in kilojoules (kJ) or kilocalories (kcal) and is most often used with time units relating to kcal used per week or per day (Taylor et al., 1978). PA can thus be divided into different categories, with the most frequent being PA that occurs whilst sleeping, at work and at leisure (Montoye, 1971). Leisure activities can be further categorised relating to sports, conditioning

exercises, household tasks and other activities (Folosom et al., 1985). It is of importance to note that though the terms PA and exercise are sometimes used interchangeably in the literature, they describe different concepts while they have a number of common elements. Indeed, both exercise and PA involve bodily movement produced by skeletal muscles and expends energy; exercise and PA can be measured in kilocalories ranging from low to high and are positively correlated with physical fitness as the intensity, duration and frequency of movements increase. Exercise, however, is planned, structured, repetitive and purposive in improving or maintaining physical fitness (Caspersen et al., 1985).

PA and exercise have been researched extensively resulting in health recommendations based on the observed effects of PA and exercise on health suggested by the WHO. The WHO recommendations for adults between 18 and 64 years, in order to improve cardiorespiratory and muscular fitness, bone health, to reduce the risk of noncommunicable diseases and depression, include at least 150 minutes of moderate-intensity aerobic or at least 75 minutes of vigorous-intensity aerobic PA throughout the week or an equivalent combination of moderate and vigorous-intensity activity. The recommendations specify that aerobic activity should be performed in bouts of at least 10 minutes durations and that for additional health benefits adults should increase their moderate-intensity aerobic PA to 300 minutes or their vigorous-intensity PA to 150 minutes per week, or an equivalent combination of both moderate and vigorous-intensity PA.

Furthermore, it is suggested that adults should perform muscle-strengthening activities involving major muscle groups on two or more days a week. Strong evidence shows that more active individuals, as compared to less active adult men and women, have lower rate of all-cause mortality, coronary heart disease, high blood pressure, stroke, type 2 diabetes, metabolic syndrome, colon and breast cancer, and depression. Adults that are more active are also less likely to have a hip or vertebral fracture, exhibit higher levels of cardiorespiratory

and muscular fitness, and are more likely to achieve weight maintenance and have a healthier body mass composition. These beneficial effects of PA apply to adults with noncommunicable chronic conditions, and with the notable improvement in antiretroviral therapies, HIV/AIDS is more and more considered as a chronic condition.

II. PA benefits and health-related effects

It is now well documented in the literature that PA and exercise have a wide range of beneficial effects in PLHIV. Exercise and regular PA are considered as valuable self-management approaches that can promote health for PLHIV and more specifically people aging with HIV (O'Brien et al., 2010, 2017). A recent meta-analysis (O'Brien et al., 2017), indicated that moderate exercise presents beneficial physiological and psychological effects for this population (e.g., improvement of fitness, body composition and quality of life).

II. 1. *Physiological benefits of PA in PLHIV*

Physiological effects noted are the moderation of antiretroviral therapy side effects. Indeed, PA reduces lipodystrophy, a common adverse effect of antiretroviral therapies (Dudgeon, Phillips, Bopp, & Hand, 2004; Hand, Lyerly, Jagers, & Dudgeon, 2009; Malita, Karelis, Toma, & Rabasa-Lhoret, 2005; O'Brien et al., 2010; Shah et al., 2005), although it is often recommended in addition to complementary treatment. Aerobic-type PA is associated with improved lipid status (increased HDL-cholesterol and decreased LDL-cholesterol in particular), decreased fat mass and increased lean body mass (Dudgeon et al., 2004; Hand et al., 2009; Malita et al., 2005; Shah et al., 2005). The effects of an aerobic PA are also felt on a cardiovascular level. Indeed, several studies showed an improvement in cardiovascular function in PLHIV (Fillipas, Cicuttini, Holland, & Cherry, 2012; O'Brien et al., 2010;

O'Brien, Nixon, Tynan, & Glazier, 2004), or even a decrease in the number of cardiovascular risk (O'Brien et al., 2004). PA also increased muscle strength and muscle sectional area (Hand et al., 2009; O'Brien et al., 2004) which, in turn have a significant impact on improving functional abilities. On a more biochemical level, moderate PA would increase CD4 + T lymphocyte levels, while intense PA would decrease the same biomarker (Ciccolo, Jowers, & Bartholomew, 2004; Hand et al., 2009). However, not all studies find these results, suggesting that the effects of PA on immune response mechanisms are not yet clearly established. In addition to these physiological improvements, PA has beneficial psychological effects in PLHIV.

II. 2. *Psychological benefits of PA in PLHIV*

By improving body composition, the quality of life of these individuals is also improved as lipodystrophy plays a major role in the subjective assessment of quality of life by impairing self-image (Préau et al., 2007). Body enhancements, including aesthetical improvements, can also boost physical self-esteem (Dolan et al., 2006). The main effects of PA are a decrease in depressive symptoms, anxiety and mood (Ciccolo et al., 2004; Jagers et al., 2015; O'Brien et al., 2004, 2010, 2017). PA would reduce anxiety and depression, which are major psychological symptoms in PLHIV (Neidig et al., 2003). Explanations for decreased depression and anxiety are of physiological, biochemical and psychological origins. An increase in circulating endorphins would have an effect on anxiety and depression because of their importance in the regulation of emotions but the opinions are divided because of their inability to act directly on the cerebral mood regulation centres in the brain (O'Neal, Smith, & Trivedi, 2000). Biochemical explanations state that the increase of cerebral neurotransmitters (e.g., dopamine, norepinephrine and serotonin) is associated with a decrease in depression that is associated with a disruption of cerebral monoamines (Chaouloff, 1989). Furthermore, by

acting on several factors of fatigue in PLHIV, the practice of a regular PA seems to reduce perceived fatigue. Weibel et al. (2016a) showed that for every 150 minutes of moderate PA practiced, perceived fatigue decreased by 17%, making PA a valuable strategy to consider in symptom management in PLHIV. Furthermore, in a recent study conducted on healthy young adults, Bachasson et al. (2016) reported that training status (i.e. trained vs. untrained), and by extrapolation the amount of PA practiced, significantly influenced the performance fatigability of participants. This observation suggests that physically active PLHIV may experience less perceived fatigue and less performance fatigability than less physically active PLHIV. Further literature shows an improvement in cognitive functions (Hand et al., 2009), antiretroviral therapy adherence (Blashill et al., 2013) and anti-inflammatory consequences (Wirth et al., 2015).

III. Unmet physical activity recommendations in PLHIV

Research has shown that PLHIV unanimously valued exercise as an important health self-care activity, though most PLHIV admitted they did not engage in any form of organised exercise but did identify walking as a preferred physical activity (Clingerman, 2003). Regardless of the extensive literature related to the benefits of exercise in PLHIV, a large proportion of this population is not sufficiently active according to current recommendations for adults between 18 and 64 years of age, requiring at least 150 minutes of moderate-intensity PA or 75 minutes of vigorous-intensity PA per week. Recent studies focusing on PA dropout from PA interventions (Vancampfort, Mugisha, Richards, et al., 2016b), and the readiness for PA in Canadian PLHIV (Simonik et al., 2016), have emphasised the high rate of disengagement from regular PA in PLHIV. Vancampfort et al. (Vancampfort, Mugisha, De Hert, et al., 2016a), in a systematic review and meta-analysis including studies in North

American, South American, African, European, Asian and Australian PLHIV revealed that this population has lower levels of PA than in most other populations with chronic diseases. Indeed, barely half of the groups studied (i.e., 50.7%) complied with the PA guidelines of 150min moderate intensity PA per week. Furthermore, Vancampfort et al. (2016b) highlighted that PA dropout rates, at 29.3%, in PLHIV were higher than in other chronic illnesses such as type 2 diabetes with a dropout percentage of less than 20% (Umpierre et al., 2011), or severe clinical depression at 17.2% (Stubbs et al., 2016). In France, although the percentages of PA participation are, to our knowledge, not available, some data showed decreases in leisure activities including PA after HIV-diagnostic (Ferez, Marin-Duval, Thomas, Héas, & Fougeyrollas, 2014; Thomas, Duval, Perera, & Ferez, 2014).

PA presents many benefits specifically related to disease and treatment side effect management, but PLHIV are not engaging in sufficient levels of PA to benefit from these positive effects. Thus, PA levels and participation are important issues to be addressed in disease and patient quality of life research. With access to antiretroviral therapy increasing worldwide, specifically in developing countries, the need for complementary disease management strategies is significant. Thus, understanding why PLHIV engage or not in PA and/or exercise would allow for better orientation of self-management strategies focusing on PA for health outcomes.

IV. Barriers to physical activity in PLHIV

In PLHIV, main barriers to PA reported until now in the literature relate to physical barriers, specifically fatigue, psychological and environmental barriers.

IV. 1. *Fatigue as a prevalent symptom of HIV and a barrier to PA*

Fatigue is reported as one of the most frequent and distressing symptoms of HIV/AIDS (Barroso et al., 2003; Breitbart et al., 1998; Lee et al., 1999). Unfortunately, perceived fatigue, as an HIV-related symptom and side effect of antiretroviral treatment is also one of the major reasons for the non-involvement of PLHIV in regular PA practice (Jenkin, Koch, & Kralik, 2006; Thomas et al., 2014). This observation is not specific to PLHIV with similar observations made in other chronic diseases, such as multiple sclerosis (Iriarte, Katsamakis, & De Castro, 2016), Parkinson's disease (Garber & Friedman, 2003), cancer (Falzon et al., 2012) and some neuromuscular diseases (Kalkman, Schillings, Zwarts, van Engelen, & Bleijenberg, 2007). This relationship between fatigue and PA contributes to a vicious cycle of physical deconditioning.

IV. 2. *Psychological and environmental barriers to PA*

Research related to exercise barriers in PLHIV is still emerging in the literature. In a study conducted in Rwandan PLHIV receiving high-active antiretroviral therapy (Roos et al., 2015), the main perceived barriers were lack of motivation (30.5%), lack of time (25.3%) and fear of worsening the disease (24.3%). Through a qualitative study conducted on South African PLHIV who took part in a PA intervention, a wide range of barriers to participation, related to both the psychological sphere (e.g., low energy levels, psychological complaints and stress levels) and the environmental and social spheres (e.g., physical environment, social environment, domestic abuse and crime) were isolated (Montoya et al., 2015).

Recently, it has been reported that prominent exercise barriers include HIV-related symptoms (i.e., neuropathy, lipoatrophy), antiretroviral therapy effects (lipodystrophy) and fatigue, but also decreased motivation, depression, negative self-perceptions and apprehension concerning the risks of exercise such as sustaining an injury (Montoya et al., 2015). In a meta-

analysis, Vancampfort et al. (2017) revealed that, older age, a lower educational level, a lower number of CD4 + T cells/mm³, exposure to antiviral therapy, body pain and depression as main barriers to PA participation in PLHIV. Higher cardiorespiratory fitness, higher self-efficacy, more perceived benefits and better health motivation were the dominant facilitators to PA that emerged. correlates of PA participation in PLHIV.

Furthermore, Li et al. (2017) identified factors to consider when developing and implementing exercise programs taking into account exercise experiences of PLHIV. Participants reported perceiving exercise benefits related to the physical, mental, cognitive and social domains. Beyond the factors to consider when developing and implementing exercise programs, Montgomery et al. (2017) sought to describe experiences before, during and after engaging in a community-based exercise program from the perspective of PLHIV, revealing how perceived benefits of exercise programs along with improvements in physical, mental and social health positively influenced adherence to exercise.

The readiness to engage in regular PA and/or exercise among PLHIV and multimorbidity has also been a focal point with Simonik et al. (2016) developing a framework taking into consideration the dynamic and fluctuating construct of readiness to exercise. PLHIV's readiness to exercise was influenced by social support, perceptions and beliefs, experience with exercise and accessibility. Beliefs related to exercise benefits including improved physical and mental functioning and preventing isolation, and exercise risks including risks of physical injury and fear of '*overdoing it*' also emerged (Vader et al., 2017).

These results, focusing mainly on the implementation and effectiveness of PA intervention, suggest that insufficiently physically active PLHIV might have negative beliefs about exercise effects (e.g., perceived risks, lack of capacity for PA), which might limit their participation in exercise.

V. Summary

PA is a valuable self-management therapy in PLHIV with a multitude of beneficial effects on physical, psychological and social aspects of health, and health-related quality of life. Though the benefits of PA are numerous and well established in the literature (e.g., Hand et al., 2009; Jagers et al., 2015; O'Brien et al., 2017), PLHIV are not active enough according to recommendations and thus do not benefit from these health-related advantages of regular PA. Literature on the barriers to PA participation in PLHIV is developing, with fatigue as the main symptom of HIV being a first focus point (Barroso, 1999; Barroso & Voss, 2013). Further barriers are associated with physical, psychological and social aspects of living with HIV, based mainly, on interventional studies (e.g., Li et al., 2017; Montgomery et al., 2017; Montoya et al., 2015). Very few studies have focused on barriers to and facilitators of PA in the daily life of PLHIV, specifically in France. The identification of barriers to and facilitators of PA in PLHIV, along with the presence of exercise stereotypes in other populations (e.g., Emile et al., 2014; Falzon et al., 2012) along with the knowledge that living with HIV is a stigmatised state, suggest that stereotypes are a promising avenue of research in PA participation in PLHIV.

Chapter 3 - Stereotypes and PA in vulnerable populations

Simply put, stereotypes are characteristics imposed upon groups of people because of their gender, ethnicity, nationality and sexual orientation, among others. These characteristics however tend to be oversimplifications of the groups involved. Though stereotypes enable us to respond rapidly to situations in that they allow us to simplify our social world, reducing the need for processing, they remain disadvantages as they ignore individual differences leading to generalised beliefs about a group of people and social categorisation that, in turn, can lead to prejudice, stigmatisation and discrimination. This type of thought process reflects the most traditional conceptualisation of stereotypes within social psychology in which stereotypes are considered to be ‘pictures in the head’ of individuals towards their social environment (Lippmann, 1922). After defining stereotypes, we then focus on the presence of stereotypes among vulnerable populations and more specifically PLHIV. Finally, we look at the different mechanisms at play in the relationship between stereotypes and health behaviours, including stereotype internalisation, ego-depletion and stereotype threat.

I. Definition of stereotypes

It is important to consider that there are implicit and explicit forms of stereotypes. Explicit stereotypes operate in a conscious, intentional and controlled manner, whereas implicit stereotypes operate unconsciously, spontaneously and relatively automatically. Experimental studies have revealed that stereotypes can influence behaviour unconsciously, both through implicit activation (Levy, 1996, 2003) and explicit activation (Hively & El-Alayli, 2014). Thus, independently of the explicit or implicit nature of stereotype activation, individuals' behaviour would seem to be impacted by these stereotypes. But what are stereotypes?

The concept of stereotypes and its definition has come a long way since it was first used in Walter Lippmann's *"Public Opinion"* (1922). The word "stereotype" derives from the Greek words "stereos" meaning firm or solid and "typos" meaning impression, hence "*a solid impression on one or more idea/theory*" (Liddell & Scott, A Greek-English Lexicon). This term was chosen to show the strict and limited "*image*" that individuals have towards different social groups. Later, Katz and Braly (1935) described stereotypes as "*fixed impressions that do not conform to the facts they are supposed to represent*". Allport (1954) defined stereotypes as, "*exaggerated beliefs associated with a category through a hostile attitude or feeling toward a person solely based on their belonging to a group*", these negative and incorrect beliefs become prejudices. In 1981, Ashmore and Del Boca, stated that stereotypes would reference "*a structured ensemble of beliefs as regards to the personal attributes of a group of people*". Leyens, Yzerbyt and Schadrin (1996) defined stereotypes as "*shared beliefs concerning the personal characteristics, generally personality traits but also often behaviours, of a group of people*". It is of importance to note that the definition of this construct differs from author to author. McGarty, Yzerbyt and Spears (2002) suggest that to understand what stereotypes are, one should consider the three principles on which the social

psychology of stereotyping is based with the different perspectives emphasising each principle to a greater or lesser extent. The three principals identified were: (a) stereotypes would be aids to explanation, formed in order to help the perceiver make sense of a situation, (b) stereotypes would be energy-saving devices with the objective to reduce effort on the part of the perceiver and, (c) stereotypes would be shared group beliefs highlighting the importance of stereotypes being formed in line with the accepted views and norms of social groups that the perceiver belongs to.

Here it is of importance to differentiate stereotypes and prejudice as stereotypes would refer to the cognitive component of intergroup attitudes whereas prejudice refers to their affective component. This approach to stereotypes suggests that individuals have limited cognitive ability, compelling them to use “*mental shortcuts*” in order to form an impression of others (Fiske & Taylor, 1991). Hereby, with the objective of rapidly forming an impression stereotypes can have both negative and positive aspects. In fact, the role of stereotypes in impression formation was specifically studied by Fiske and collaborators (Fiske & Neuberg, 1990; Fiske, Cuddy, Glick, & Xu, 2002; Fiske, Xu, Cuddy, & Glick, 1999; Glick & Fiske, 2002) evidencing competence and warmth as the domains used. In their work, they revealed that women were generally perceived as warm but less competent as opposed to men who were perceived as very competent but less warm. Further research related to stereotypes in older adults revealed that competence-related stereotypes were negative compared to the positive characteristic of warmth, with older adults being perceived as warm but not very competent (Donlon, Ashman, & Levy, 2005; Fiske et al., 2002; Kite, Stockdale, Whitley, & Johnson, 2005). Thus, understanding stereotypes from a group perspective and an individual one to consider the intergroup functions on a social level, and the cognitive functions on an interpersonal level (McGarty et al., 2002; Tajfel, 1969) is essential.

II. HIV stigma and stereotypes

PLHIV live with the knowledge that their HIV status is a stigma or, in other words, a socially devalued attribute that renders them vulnerable to discrimination and prejudice (Earnshaw & Chaudoir, 2009). Stigma hereby has negative effects on the life, health and well-being of the individuals and groups who are so labelled (Liamputtong & Kitisriworapan, 2012). The psychological and social consequences of stigma involve the responses, both of the perceivers and of the stigmatised individuals themselves. When an observable characteristic is generalised into a set of assumed traits, the process of stigma becomes an essential process of the more general stereotypes. Thus, stigmatisation involves not only social stereotyping but also the internalisation of these stereotypes by those who are stigmatised (Allport, 1954). Indeed, in the process of stigmatisation, the creation of the “*them and us*” principle is a main element (Mason, Carlisle, Watkins, & Whitehead, 2001). This principle aims to separate individuals perceived as “*good and in favour*” from those who are “*bad and out of favour*” (Foucault, 1973) after which the process of stigmatisation can be initialised.

HIV/AIDS is symbolised as “*sinful*” and “*evil*” according to Sontag (1991). In fact, HIV/AIDS uniquely combine “*sex, drugs, death and contagion*” (Scambler, 2003), making HIV/AIDS a powerfully stigmatising disease (Liamputtong, 2013). This makes PLHIV the socially constructed “*others*” who are considered not only as “*discredited*”, but also as “*threatening*” to the general public (Zhou, 2007). HIV/AIDS-related stigma can be self-stigma, as PLHIV are confronted with “*self-blame*” and “*self-depreciation*”, but also perceived stigma related to the fear of PLHIV on disclosing their HIV status and enacted stigma where PLHIV are actually discriminated against because of their HIV status (Liamputtong, 2013). Within HIV/AIDS research, stigma has been considered to function through different mechanisms, stereotypes, prejudice and discrimination that represent

cognitive, affective and behavioural manifestations of HIV stigma (Earnshaw & Chaudoir, 2009).

HIV stigma research tends to point towards the key role of HIV stereotypes in prevention and HIV-testing, with individuals endorsing greater stereotypes perceiving that they are less at risk of experiencing relevant negative events, including diseases (Earnshaw, Smith, Chaudoir, Lee, & Copenhaver, 2012). HIV/AIDS stigma negatively impacts PLHIV with high perceived stigma being associated with more depressive and other HIV-related symptoms (e.g., Sowell et al., 1997; Vanable et al., 2006) lower adherence to antiretroviral therapy (e.g., Rintamaki et al., 2006; Stirratt et al., 2006) and poor access to medical care (e.g., Kinsler, Wong, Sayles, Davis, & Cunningham, 2007). Throughout this thesis we will specifically focus on HIV stereotypes defined by Earnshaw and Chaudoir (2009) as group-based beliefs about PLHIV that are often applied to individuals (e.g., PLHIV are gay men, prostitutes and drug users). Beyond these HIV-related stereotypes, the existence of context-specific stereotypes in different populations is also of interest. The next section takes a closer look at stereotypes in the more recent PA domain.

III. Stereotypes related to physical activity and exercise

In the present section we successively present the literature related to (a), the nonexerciser stereotype and (b), exercise stereotypes as psychological barriers to PA.

III. 1. *The nonexerciser stereotype*

With PA and exercise being vastly and increasingly studied over the past decades with a focus on their benefits (e.g., Fletcher et al., 1992; Garber et al., 2011; Mothes et al., 2017), exercise promotion for health is a major issue. The different kinds of PA and exercise that

might be beneficial for various pathologies and populations are main elements of current research (e.g., Buffart et al., 2017; Grace, Chan, Giallauria, Graham, & Smart, 2017; O'Brien et al., 2017). Yet the main outcome remains: exercise has many health benefits and we should all adopt a healthy level of PA (e.g., Conn, Hafdahl, & Mehr, 2011). This knowledge leads to perceptions of physically active and inactive people being conveyed by society. Indeed, with less active or inactive individuals being perceived, by both active and inactive individuals, as less healthy, less energetic, unfit, less strong and weaker (Rodgers, Hall, Wilson, & Berry, 2009), a nonexerciser stereotype has emerged (Martin Ginis & Leary, 2006).

Martin Ginis and Leary (2006) suggested that the roots of the nonexerciser stereotype lie within “*healthism*”, defined as health-promoting activities with a moral obligation and considering those who do not practice such behaviour to be weak, deviant and without virtue. The nonexerciser stereotype has, up to now, mainly been studied on impression formation (Lindwall & Martin Ginis, 2006; Martin Ginis & Leary, 2006; Martin, Sinden, & Fleming, 2000) with nonexercisers receiving lower ratings than exercisers on all dimensions (i.e., kind/unkind; lacks confidence/confident; physically sickly/healthy; fit/unfit; etc.). Nonexercisers are also perceived as less healthy, less energetic, slightly fatter, less motivated, less concerned about their health, less strong, less busy, less committed, less happy, less concerned about their appearance, weaker and less disciplined than exercisers (Rodgers et al., 2009). Rodgers et al. (2009) revealed, however, that the exerciser stereotype, fundamentally based on the positive aspects of being physically active, would be endorsed to a greater extent by both exercisers and nonexercisers than its negative form, the “*nonexerciser stereotype*”.

A number of studies have examined if disabled individuals who are physically active may benefit from the positive influence of physical activity on impression formation. A “*normalising*” character was attributed to physical activity by Taub and Greer (2016) as they showed how, through PA, children with disabilities had a social identity and an environment

facilitating their interaction with valid children. In another study, Arbour, Latimer, Ginis, and Jung (2007) asked valid participants to evaluate a fictitious individual who had suffered a spinal-cord injury on both personality trait and physical appearance, in line with work by Martin Ginis and collaborators (2000, 2003, 2006). Physically active disabled individuals were rated more favourably than inactive disabled individuals on both personality traits and physical appearance. Beyond their impact on social judgments, exercise stereotypes might influence health behaviours, including PA participation.

III. 2. *Exercise stereotypes as psychological barriers in vulnerable populations*

An emerging body of literature has focused on the specific influence of exercise stereotypes on different populations, such as the elderly or individuals with chronic diseases. Exercise stereotypes can be defined as shared beliefs about the characteristics of a group in the specific context of regular PA and exercise. Particular measures have been generated to investigate exercise stereotypes in these populations. For example, the “*Aging Stereotypes and Exercise Scale*” was developed and validated to assess different aspects of aging stereotypes in the exercise sphere, such as (a) stereotypes regarding exercise benefits, (b) stereotypes about exercise risks, and (c) stereotypes related to self-efficacy (Chalabaev et al., 2013b). This line of research indicates that endorsement of negative aging exercise stereotypes is related to lower levels of PA among the elderly (Emile et al., 2014; Sánchez Palacios et al., 2009).

Another stereotypes scale is the “*Cancer Exercise Stereotypes Scale*” (CESS) (Falzon et al., 2014), which evaluates stereotypes related to exercise in cancer patients: (a) stereotypes related to the lack of interest in exercise, (b) stereotypes regarding exercise self-efficacy, (c) stereotypes about the side effects of treatment, (d) stereotypes related to the risks of exercise and, (e) stereotypes associated with the benefits of exercise. In both scales, some subscales

refer to negative exercise stereotypes, and others refer to positive exercise stereotypes thus emphasising the presence of both negative and positive exercise stereotypes in vulnerable populations. Through these approaches to exercise stereotypes, researchers suggested that these stereotypes influence health behaviours and more specifically, PA participation through different mechanisms. In the following sections we look at the multiple mechanisms at play in the relationship between stereotypes and health behaviours, including PA.

IV. Stereotype internalisation

IV. 1. *The stereotype embodiment theory*

In psychology, internalisation is defined as the unconscious internalisation of aspects of the world (especially aspects of persons) within the self in such a way that the internalised representation takes over the psychological functions of the external objects (Lawrence & Valsiner, 1993). The study of stereotype internalisation has focused mainly on largely “*discriminating*” factors, such as gender (e.g., Bonnot & Croizet, 2007; Chalabaev, Sarrazin, & Fontayne, 2009; Granié, 2009; Weisgram & Bigler, 2006), age (e.g., Emile et al., 2014; Hale, 1998; Levy, 2009) or level of education (e.g., Grusec & Goodnow, 1994) for example. Stereotype internalisation is considered to effect individuals’ behaviours due to their internalisation throughout socialisation.

According to the Stereotype Embodiment Theory (SET: Levy, 2009), age stereotypes are internalised into self-perceptions of aging and aging experiences are interpreted via this process (Levy & Leifheit-Limson, 2009). The SET (Levy, 2009) focuses on age stereotypes and advances the idea that the stereotype internalisation process is made-up of three steps: (a) ages stereotypes are internalised at a young age, (b) at some point, these age stereotypes

become “self-stereotypes” about oneself as an aging individual, (c) these self-stereotypes are then consciously and unconsciously activated to exert their effect on individual health. Underlying these three steps of the SET are four components: the stereotypes, (a) become internalised across the lifespan, (b) can operate unconsciously, (c) gain salience from self-relevance, and (d) utilise multiple pathways (Levy, 2009).

In a similar way that age-stereotypes gain salience from self-relevance, it is plausible that stereotypes related to different pathological conditions gain salience in the same manner with an important difference that the aging process is inevitable.

Furthermore, stereotypes exert their influence on individual health through different mechanisms. Levy (2009) hypothesised that stereotypes exert their influence according to psychological, behavioural and physiological mechanisms. The psychological mechanism is thought to operate via self-fulfilling expectations with higher, positive self-perceptions of aging at baseline being associated with better functional health and greater longevity (Levy, Slade, & Kasl, 2002; Levy & Banaji, 2002). The behavioural mechanism would operate via health practices. Healthy behaviours are considered as futile when they are seen as inevitable consequences of growing old (Levy & Myers, 2004) and hinder self-efficacy (Levy, Ashman, & Dror, 2000). When older adults have higher positive self-perceptions of aging they are more likely to engage in healthy behaviours (Levy & Myers, 2004). The physiological mechanism would implicate the autonomic nervous system. Using cardiovascular reactivity as a measure of the autonomic nervous system’s response to stress, Levy, Hausdorff, Henecke, and Wei (2000) observed elevated cardiovascular responses to stress when negative age stereotypes were subliminally primed. Repetitive strain on cardiovascular response can lead to detrimental effects on cardiovascular health, with a further study showing that the presence of negative age stereotypes in younger life doubling the risk of having an adverse cardiovascular event after the age of sixty (Levy & Leifheit-Limson, 2009).

IV. 2. *Stereotype internalisation and physical activity*

In the physical activity domain, most stereotype internalisation studies have focused on women and older adults. Indeed, research has shown that the internalisation of sex-stereotypes would prompt women to feel less competent, attribute less importance to sports practices and take part in sports activities to a lesser extent than men (e.g., Biddle, Atkin, Cavill, & Foster, 2011; Fredricks & Eccles, 2005). These negative perceptions impact PA participation among the targeted groups (i.e., girls). Therefore, taking into consideration the psychosocial determinants of PA participation are essential.

PA is one of the most important health behaviours associated with prevention of frailty and disease management. Thus, research has focused on the role of stereotype internalisation on PA participation in vulnerable populations. Sanchez Palacios et al. (2009) suggested that PA participation would be negatively impacted by negative age stereotypes whereas positive views of aging contributed to higher levels of PA (Wurm, Tomasik, & Tesch-Romer, 2010). Further studies have looked more specifically at the influence of exercise stereotypes, with both negative and positive exercise stereotypes being endorsed or adhered to among vulnerable populations, including older adults (Emile et al., 2014) and cancer patients (Falzon et al., 2014). An active mechanism in the relation between exercise stereotypes and PA level in older adults was internalisation as indexed by physical self-worth (Emile et al., 2014).

In a subsequent study these authors (Emile et al., 2015) showed that self-perceptions of aging as the active construct in internalisation may not be the only mechanism through which exercise stereotype endorsement impacts health behaviours.

V. The ego depletion account and stereotypes

In a longitudinal study including 192 older adults who regularly participated in organised PA, Emile et al. (2015) showed that age stereotypes endorsement across waves predicted subjective vitality, after controlling for self-perceptions of aging and relevant covariates. These results suggest that stereotypes might be related to health-behaviours in active older adults through an ego depletion mechanism.

Ego depletion is a self-regulatory mechanism based on the idea that engaging in acts of self-control, referring to the mental effort individuals use to regulate their own behaviour (Muraven & Baumeister, 2000), draws from a limited ‘reservoir’ which, when depleted, results in reduced capacity for further self-regulation (Muraven, Tice, & Baumeister, 2000). Thus monitoring your impressions, controlling your emotions, eating and drinking in moderation, and engaging in regular exercise are all actions requiring self-control (e.g., Vohs, Baumeister, & Ciarocco, 2005). Ego depletion specifically refers to the exertion of self-control on one task that drains self-control strength and impairs performance on subsequent tasks that require this same resource, according to the strength model of self-control (Muraven, Tice, & Baumeister, 2000).

Inzlicht, McKay, and Aronson (2006) suggested that stigmatised individuals use and deplete self-control to manage their devalued social identity, reducing their self-regulatory resources. Thus, stigma could weaken the fundamental ability to control and regulate one’s actions and behaviours. Suppressing stereotypes may require an effortful act of self-regulation as stereotypes can be activated automatically upon contact with a person in the target category (e.g., Devine, 1989) Thus, Gailliot, Plant, Butz, and Baumeister (2016) suggested that self-regulation plays a role in stereotype suppression with stereotype suppression resulting in poorer subsequent self-control performance. They do however, come to an encouraging

conclusion that *“increasing self-control strength through self-regulatory exercise can reduce the intrapsychic cost of suppressing stereotypes”* (Gailliot, Plant, Butz, & Baumeister, 2007).

In their meta-analysis, Hagger, Wood, Stiff, and Chatzisarantis (2010) looked at possible alternative explanations to the self-regulatory failure that leads to ego depletion and are either consistent with, compete with, or complement the predictions of the strength model of self-control. Skill, affect, self-efficacy, motivation and fatigue were considered as plausible alternative explanations of ego depletion. As a consistent detriment in self-control task performance was observed independently of the level of difficulty of the task in ego depletion experiments; skill was rejected as a possible explanation (Muraven, Tice, & Baumeister, 1998).

Regulating affect requires an individual to overcome the intuitive tendency to display emotions in response to environmental stimuli; therefore, the active regulation of emotion or mood has been shown to deplete self-control resources (Bruyneel & Dewitte, 2012; Bruyneel, Dewitte, Franses, & Dekimpe, 2009; Muraven et al., 1998). Negative affect was shown to be significantly related to ego depletion, regardless of whether the task required affect regulation (Tice & Bratslavsky, 2000). Ego depletion is thus suggested to be a result of coping with negative affect and presents an alternative explanation.

Self-efficacy, as measured through task goal perception (i.e., attractive or important) and the belief in one’s ability to achieve the goal supposing the required effort is exerted, was thought to be reduced when in a state of depletion (e.g., Baumeister, Gailliot, DeWall, & Oaten, 2006). However, due to self-efficacy not necessarily being transferable across task domains, no relationship between self-efficacy and ego depletion was observed (e.g., Baumeister et al., 2006; Finkel et al., 2006).

Motivation, and more specifically decreased motivation, could provide an alternative explanation for ego depletion. Muraven and Baumeister (2000) suggested that the effects of

self-control resource availability and motivation on task performance might be interactive. Performing difficult and effortful tasks would lead to a state of mental fatigue and reduce the perceived importance of subsequent task goals relative to the expected effort required, resulting in decreased motivation to perform subsequent tasks that are perceived to be difficult, effortful and fatiguing. Nevertheless, this “*motivation-only*” explanation is not incompatible with the strength model of self-control and provides an alternative explanation through its close association with fatigue. Indeed, incentives such as rewards may moderate the effects of self-control resource depletion on task performance (Muraven & Slessareva, 2016), but this can only be temporary as fatigue is inevitable (Baumeister, Vohs, & Tice, 2007).

With regard to fatigue, Cameron (1973) suggested that subjective fatigue is experienced when mental resources are taxed. In ego depletion experiments, people engaging in depleting tasks showed increased subjective fatigue (e.g., Friese, Hofmann, & Wänke, 2008; Hagger, Wood, Stiff, & Chatzisarantis, 2010). Furthermore, in cognitively demanding tasks the fatigue induced lead to elevated physiological responses of general fatigue and reduced performance on subsequent tasks (e.g., Segerstrom & Nes, 2016; Wright et al., 2007). Fatigue can thus be considered as an indicator of ego depletion, but also as a mediator of the effects of self-regulatory resource depletion on subsequent task performance (Muraven et al., 2000). In this thesis, we will focus specifically on the fatigue explanation for ego depletion as the population of people living with HIV report fatigue as the most prevalent symptom. Beyond internalisation mechanisms stereotypes can be activated by the context and be a threat.

VI. The stereotype threat theory

Activating a stereotype is typically thought to lead to people behaving in a stereotype-consistent way. “*Stereotype activation* was defined as *the increased accessibility of the constellation of attributes that are believed to characterise members of a given social category*” (Wheeler & Petty, 2001). Activated stereotypes could concern one’s own group memberships and are referred to as self-stereotypes, or stereotypes could concern groups to which one does not belong, referred to as other-stereotypes. The impact of self-stereotypes has been explained mainly through the stereotype threat mechanism and will be the focus of this section.

VI. 1. *Stereotype threat*

The first observation of stereotype threat was made by Steele and Aronson (1995) who activated the African American stereotype and revealed performance decreases on academic tasks in this population. From this observation, “a threat in the air” was pinned as the definition of the stereotype threat model (Steele, 1997). A threat that is present in certain situations and impacts performance. Stereotype threat was defined as the pressure an individual face when they may be at risk of confirming negative self-relevant group stereotypes (Steele, 1997), this threat would interfere with the intellectual functioning of the threatened individual, which, in turn, would alter the performance on a given task. Thus, simply being conscious of a negative group stereotype could be sufficient to have a negative impact (Steele & Aronson, 1995).

As stipulated above, stereotype threat is situation dependant, implying that certain elements need to be present for stereotype threat to take effect (Roberson & Kulik, 2007). Firstly, the threat has to be task relevant, for example, an intellectual task for African Americans (Steele & Aronson, 1995) or a maths test for women (Spencer, Steele, & Quinn,

1999). In addition, tasks need to be difficult for stereotype threat to be observed. Performance is unaltered (Spencer, Steele, & Quinn, 1999) or even increased (O'Brien & Crandall, 2003) when the task is perceived as too easy. On the contrary, if a task is perceived as too difficult, participants would realise that the task is above their capabilities and disengage (Spencer et al., 1999). Furthermore, the task domain needs to be important to the threatened individuals. Domain identification was considered to moderate the effects of stereotype threat (Nguyen & Ryan, 2008). Lastly, the threatened individual needs to have knowledge of the stereotype associated to their group for the stereotype to be activated and take effect. Indeed, one of the precepts of stereotype threat are that stereotypes do not need to be internalised or considered true to take effect; knowledge of the stereotype would be enough to take effect and impact performance (Steele, 1997; Chalabaev, Sarrazin, Stone, & Cury, 2008).

Stereotype threat has been vastly studied in the cognitive domain, focusing largely on maths tasks and other scientific tasks. These studies focused on ethnical or race differences as well as the sex-stereotype. Beyond the possible genetic or sociocultural explanations advanced to justify decreased performance among women on a maths task, for example, Spencer et al., (1999) suggests that the differences observed in women's performances as compared to men would be due to stereotype threat. Further studies have corroborated the detrimental effects of stereotype threat on women's performance on cognitive tasks (e.g., Inzlicht & Ben Zeev, 2000). Among the plausible mechanisms through which stereotype threat would affect performance was memory, specifically among older adults (Barber & Mather, 2013). Anxiety (Spencer et al., 1999), felt self-efficacy (Spencer et al., 1999), evaluation apprehension (Aronson et al., 1999; Spencer et al., 1999) and performance expectations were also among the main mechanisms in the cognitive domain. Schmader, Jones and Forbes (2008) proposed the working memory model to explain how stereotype threat influences performance on cognitive tasks. They took into consideration three distinct

yet interrelated mechanisms: (a) a physiological response to stress that directly impairs prefrontal processing, (b) a tendency to actively monitor performance, and (c) efforts aiming to suppress negative thoughts and emotions in the service of self-regulation (pointing in the same direction as the mere effort account by Harkins, 2006).

Fewer studies have focused on stereotype threat within the physical activity domain identified in the literature as the sensorimotor domain. Golf putting (e.g., Stone & McWhinnie, 2008; Stone, Lynch, Sjomeling, & Darley, 1999), soccer dribbles (e.g., Chalabaev et al., 2008), basketball shooting and tennis (e.g., Hively & El-Alayli, 2014) are the main tasks on which stereotype threat was studied in the sensorimotor domain, with the main population concerned being women. In the following section, we will focus on stereotype threat in the PA domain.

VI. 2. *Stereotype threat in the PA domain*

“Blacks have greater athletic abilities than Whites”, this is a widely shared stereotype. In their study, Stone et al. (1999) showed that formulating an athletic task as diagnostic of negative racial stereotypes about Black or White athletes (i.e. Blacks have greater athletic abilities than Whites and Whites have greater sports intelligence than Blacks), can hinder their performance on sports tasks (i.e. golf). Consequently, stereotype threat can influence performance on sports tasks when a negative stereotype is relevant. Further studies looked at the effects of stereotype threat on different tasks. Beilock and Carr (2001) observed that men’s performance on a golf-putting task was decreased when a stereotype on the superiority of women was induced. Furthermore, women’s performance on a golf-putting task was decreased when the study was framed as measuring gender differences compared to racial differences in athletic ability, and performed less accurately when in the presence of a male experimenter as compared to a female experimenter (Stone & McWhinnie, 2008). This same detrimental effect was observed in women’s performance in different tasks such as, soccer

tasks (Chalabaev, Sarrazin, Stone, & Cury, 2008; Heidrich & Chiviawowsky, 2015; Hermann & Vollmeyer, 2016), basketball shooting tasks (Hively & El-Alayli, 2014; Laurin, 2013), a stride jumps task (Raphael, 2016), a tennis serving task (Hively & El-Alayli, 2014) and a strength task (Chalabaev et al., 2013) in which women were said to have lower physical abilities compared to men.

The mechanisms of stereotype threat in the sensorimotor domain have, to date, not been the object of much exploration. “*Anxiety*” or “*arousal*” (e.g., Ben-Zeev, Fein, & Inzlicht, 2005; Stone et al., 1999) among others, were considered as plausible mechanisms of stereotype threat in the sensorimotor domain but none emerged as meaningful mediators. Contrary to the cognitive domain, (Beilock, Jellison, Rydell, McConnell, & Carr, 2006) showed that performance alteration in the sensorimotor domain was not mediated by working memory. Hence, it is suggested, that although stereotype threat may damage working memory for demanding tasks by reducing the resources available for execution, it may impair procedural skills by prompting too much attention to execution processes that function in a relatively automatic manner outside of conscious control. The pressure caused by the stereotype leads the threatened individual to focus on task-specific components demanding separate activation and execution of each component and increasing the opportunities for error. It is would be this breakdown of the integrated control system that may result in decreased performance. Furthermore, tasks demanding greater levels of coordination would not be influenced by the integrated control system and thus stereotype threat would have no effect on performance (Beilock & Carr, 2001; Beilock et al., 2006; Chalabaev et al., 2013).

These studies show that stereotype threat has a detrimental effect on the performance of threatened individuals. However, a number of studies did not observe a decrease in threatened individuals’ performance when under stereotype threat (e.g., Chalabaev et al., 2008; Huber, Brown, & Sternad, 2016; Huber, Seitchik, Brown, Sternad, & Harkins, 2015).

Furthermore, an increase in task performance of the non-stereotyped group was also observed in some studies (e.g., Chalabaev et al., 2013; Walton & Cohen, 2003). The plausible explanations for these different effects of stereotype threat are explored in terms of other stereotype effects, including the mere effort account and the stereotype lift theory concerning non-threatened individuals' performance increase.

VII. Other stereotype effects

Since a “threat in the air” was brought to light, the detrimental effects of stereotype threat on the threatened group have been well documented, notably in the cognitive domain (e.g., Inzlicht & Ben Zeev, 2000; Spencer et al., 1999), but also in the PA domain (e.g., Hively & El-Alayli, 2014; Stone et al., 1999; Stone & McWhinnie, 2008). Though, recent studies have shown that the effects of stereotype threat on the threatened group are not always detrimental, a study by Chalabaev et al. (2013) revealed no effect on performance when under stereotype threat of the threatened group. Specifically, when women were negatively threatened, their force on an isometric task did not suffer negatively. This result could be explained by the task considered as it had a low demand for coordination, in line with Beilock and Carr (2001). These authors suggested that tasks demanding no or little coordination would not be affected by the integrated control system and thus might not be affected by stereotype threat.

On the other hand, Huber et al. (2015) noted that in certain conditions performance increased for the threatened group when under threat. Here the authors showed that when a simple rhythmic motor skill was learned, the threatened group improved their performance when under stereotype threat. Training can thus positively affect performance of a threatened group when under threat. These authors suggested that the mere effort account could be

implicated. This account argues that motivation is the core process producing stereotype threat effects on performance (Jamieson & Harkins, 2007). Hereby, the potential for evaluation motivates participants to want to perform would potentiate the prepotent or most likely response to the task (Harkins, 2006). When under stereotype threat, participants perceive this potential for evaluation potentiating the prepotent response on the task. If the prepotent response is incorrect, performance is debilitated, but if the prepotent response is correct and that the participants knew the correct response, performance is facilitated.

This model has been used to explain the effect of stereotype threat in the cognitive domain using various tasks (e.g., Jamieson & Harkins, 2007, 2009, 2011). However, in the sensorimotor domain only two studies tested the predictions of the mere effort account (Huber et al., 2015, 2016). They observed that when the prepotent response was correct after a practice period (Huber et al., 2015) or from the beginning of the task (Huber et al., 2016), inducing a negative stereotype about women lead to an increase in women's performance. The mere effort account could thus be a plausible explanation for performance alteration when confronted with stereotypical conditions.

VIII. Stereotype lift

In their meta-analysis comprising 43 stereotype threat studies, Walton and Cohen (2003) noted that in 30 studies the individuals in the non-threatened group increased their task performance as compared to control conditions. This performance increase observed in non-targeted groups was thus referred to as "*stereotype lift*". When men, for instance, were exposed to a negative stereotype with regard to women's lower physical abilities, their performance improved, as compared to the control condition where no stereotype was induced (e.g., Hively & El-Ayali, 2014). According to the stereotype lift effect, the

performance increase observed in the non-threatened group would be due to a downward comparison with the threatened group (Walton & Cohen, 2003). Results from a study by Chalabaev et al. (2008) on the stereotype lift effect on a balancing task suggested that self-confidence boosts task adherence and, in turn, increases task performance. Thus, self-confidence was considered as a mediator of the stereotype lift effect on task performance, but only in the non-threatened group (i.e. men).

IX. Summary

In this chapter, we highlighted that even though stereotypes may be defined in different manners, their detrimental or beneficial effect on health-related behaviours are uncontested. Stereotype endorsement acts through different pathways and underlying mechanisms, including stereotype internalisation and ego-depletion. Furthermore, from a contextual perspective, stereotype activation through stereotype threat by which a threatened groups' performance would be negatively affected, revealed an interesting avenue for research on PA in vulnerable populations.

RESEARCH PROBLEM
AND QUESTIONS

Fatigue is by far the most prevalent symptom in PLHIV (Barroso, 1999) and has a multitude of correlates (Barroso & Voss, 2013; Voss et al., 2006). In addition, the stereotypes related to PLHIV are anchored in stigma, a process of devaluation, making PLHIV vulnerable to discrimination, and prejudice (Earnshaw & Chaudoir, 2009b). HIV stigma has a negative impact on PLHIV as it is associated with depression (e.g., Sowell et al., 1997), lower adherence to antiretroviral therapy (e.g., Rintamaki et al., 2006) and poor access to medical care (e.g., Kinsler et al., 2007). It is thus plausible that HIV stigma may influence health-related behaviours in PLHIV, including PA. Based on contemporary theories applied to health behaviours (e.g., *Stereotype Embodiment Theory*, Levy, 2009; *Stereotype Threat Theory*, Steele & Aronson, 1995) and an integrative approach of fatigue (Kluger et al., 2013), this thesis defends the postulate that exercise stereotypes exist in PLHIV and that these stereotypes influence PLHIV's PA level and performance in fatiguing tasks via multiple mechanisms. The rationale of this thesis finds its roots in the three following main questions that have, to date, not been examined in the literature.

What is the stereotype content among PLHIV specific to exercise and regular PA?

Though HIV-stereotypes have been shown to play a role in depression and other HIV-related symptoms, the content of exercise stereotypes related to PLHIV has yet to be elucidated. HIV-related literature has pointed out a number of barriers to and facilitators of PA participation in PLHIV based mainly on interventional PA studies (e.g., Li et al., 2017; Montgomery et al., 2017; Montoya et al., 2015; Roos et al., 2015; Vancampfort et al., 2017). The main objective of the first part of this thesis was to identify the negative and positive exercise stereotypes behind these barriers to and facilitators of PA in PLHIV through a qualitative approach, and to develop a psychometric tool to measure the negative and positive exercise stereotypes. This constituted the early studies within this doctoral work.

What are the mechanisms at play in the relationship between exercise stereotypes endorsement and PA level among PLHIV? Does fatigue play a role?

Based on previous research showing that stereotype internalisation and ego depletion could affect health-related behaviours, the main goal of the next part of this doctoral work was to identify the mechanisms at play in the relationship between exercise stereotypes and PA level in PLHIV. Research has shown that stereotype internalisation plays a role in health-related behaviours in vulnerable populations, specifically in older adults. The internalisation mechanism was indexed by self-perceptions of aging, in line with the stereotype embodiment theory (Levy, 2009). Older adults, through self-perceptions of aging, are led to view health behaviours as futile (Levy & Myers, 2004), with research showing that this could also hinder self-efficacy (Levy, Hausdorff, Hencke, & Wei, 2000). A study by Emile et al. (2015) advanced that internalisation may not be the only active mechanism in the relationship between exercise stereotypes and health behaviours. Indeed, results from their study revealed that after controlling for self-perceptions, the endorsement of negative exercise stereotypes negatively predicted subjective vitality, giving support to the ego depletion mechanism. Based on this research, and the prevalence of fatigue as a main symptom in PLHIV, we focused on perceived fatigue as an indicator of ego depletion in the relationship between exercise stereotypes and PA in PLHIV.

Having placed fatigue as the focal point, in an attempt to enrich the multidimensional model of HIV-related fatigue based on Barroso and colleagues' work (Barroso, 1999; Barroso & Lynn, 2002; Barroso et al., 2003; Voss et al., 2006), we sought to investigate the possible relationships between perceived fatigue and performance fatigability in PLHIV considering their level of PA. Although fatigue is clinically significant in PLHIV, it has so far been studied only from a perceived perspective, it is of importance, therefore, to characterise fatigue in PLHIV by including measurements of performance fatigability. For a better

understanding, the present approach considered the unified taxonomy about fatigue-related research recently proposed in the literature (Kluger et al. 2013).

As stereotypes might also be contextual, another important question was to examine their impact on performance fatigability while performing fatiguing tasks.

How does stereotype threat influence performance on a fatiguing task in PLHIV and healthy adults? The role of the nonexerciser stereotype.

Stereotype threat has shown to have a detrimental effect on performance in a large number of studies in the cognitive domain (e.g., Inzlicht & Ben-Zeev, 2000; Spencer et al., 1999; Steele, 1997; Steele & Aronson, 1995), and in some studies in the physical activity domain (e.g., Chalabaev et al., 2008; Hively & El-Alayli, 2014; Stone & McWhinnie, 2008). The effects of stereotype threat have, in some studies, not been congruent with the classical detrimental effect, with some research showing no effect on the performance (Chalabaev, Brisswalter, et al., 2013a) or even an increase in performance (Huber et al., 2015) of the threatened group. Research has mainly focused on the sex-stereotype in the physical activity domain. Yet with the perceptions of active and inactive people being largely conveyed by society, a new stereotype has emerged in the literature, the exerciser stereotype and nonexerciser stereotypes in their positive and negative form respectively (Lindwall & Martin Ginis, 2006; Martin Ginis, Latimer, & Jung, 2003; Rodgers et al., 2009). The effects of this stereotype have mainly been examined on social judgments and not, to date, on health behaviours or performance fatigability of vulnerable populations.

The final part of this doctoral work sought to observe the effects of the nonexerciser stereotype on performance during a fatiguing task in PLHIV and in healthy adults. Manipulating stereotype threat would allow concluding on a causal effect of exercise stereotypes on performance during a fatiguing task. Observing the effect of the nonexerciser

stereotype in healthy adults would allow enriching the stereotype threat literature by discerning the role of such stereotypes in different populations.

EMPIRICAL STUDIES

Study 1

Perceived barriers to and facilitators of physical activity in people living with HIV: A qualitative study in a French sample

(Manuscript in Revision in *Chronic Illness*)

Perceived barriers to and facilitators of physical activity in people living
with HIV: A qualitative study in a French sample

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Conflict of interest declaration

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Abstract

The benefits of physical activity (PA) in people living with HIV (PLHIV) are numerous and are largely reported in the literature. Understanding why PLHIV engage or not in PA is key to better accompanying health behaviors. Through a qualitative approach our study sought to identify barriers to and facilitators of PA participation in PLHIV. For this purpose, 15 semi-structured interviews from Center and Southern France were analyzed using thematic analyses. The data were analyzed following the principals of thematic analysis. A multidimensional perspective of PA barriers and facilitators emerged and is discussed.

Key words: Physical activity; Attitudes; Fatigue; Self-efficacy; Social support.

Introduction

For people living with HIV (PLHIV) who have access to antiretroviral therapies, HIV is increasingly considered a chronic disease. PLHIV are living longer and are faced with health-related consequences of HIV and associated multi-morbidity^{1,2}. With life expectancy increasing, quality of life and the prevention of possible co-morbidities are of increased importance. Physical activity (PA), defined as any bodily movement produced by skeletal muscles resulting in energy expenditure³, has been widely praised as a means of improving quality of life^{4,5} but also of improving and sustaining the health of PLHIV⁶. There is now an extensive volume of data revealing the benefits of regular PA for PLHIV, such as increased fitness, cardiorespiratory outcomes⁷⁻⁹, improved body composition^{9,10}, immunological and virological outcomes⁹, self-efficacy¹¹ and life satisfaction¹².

Despite the multiple benefits of PA, however, PLHIV are not active enough according to WHO recommendations consisting of at least 150 minutes of moderate-intensity aerobic PA per week and two muscle-strengthening activities twice a week^{13,14}. Moreover, PLHIV have among the highest levels of sedentary behavior reported in the literature, with sedentary behavior levels averaging at 9 hours a day¹⁵. According to one study, 53% of PLHIV walked between 10 and 30 minutes up to five times a week and only 28% reported meeting moderate intensity exercise recommendations¹⁶. Walking was the preferred form of exercise¹⁷, but did not provide all the health benefits related to moderate and vigorous exercise⁹. To encourage PA participation it is important understand why or why not PLHIV engage in PA.

Several studies have identified barriers and facilitators to PA in PLHIV through qualitative or quantitative methods. A study by Roos et al.¹⁸ in South Africa seeking to address PA adherence challenges in a home-based walking program highlighted physical, psychological, and environmental barriers to PA among PLHIV. Physical barriers included respiratory complaints and low-energy levels, while poor motivation and stress were

considered as psychological barriers. Family responsibilities, sedentary jobs, weather and the social environment were identified among the environmental barriers to PA. As regards to facilitators of PA, fewer items were identified, but these included the involvement of family and friends (walking with a partner or children) or the community environment (i.e. access to parks or sports fields). Research by Montoya et al.¹⁹ on the development of a personalized interactive mobile health intervention to promote PA among PLHIV provided further support for previously identified barriers and more thoroughly revealed PA facilitators. HIV-related symptoms and medications, financial concerns, screen time (time spent using a device such as a computer, television or games console) and exercise concerns, such as not knowing how to use gym equipment, were among the additional barriers identified. Self-motivation, self-care, animal care and personal incentives including self-motivation were among the facilitators. A recent review by Vancampfort et al.¹⁵ revealed that dropout from PA programs for PLHIV was higher among men, among those with a higher body mass index (BMI), and among those with lower cardiorespiratory fitness, and in aerobic training interventions as compared to resistance training interventions for which higher adherence was noted. Furthermore, Vancampfort et al.¹⁵ highlighted the correlates of PA participation in PLHIV. Older age, a lower educational level, a lower number of CD4 + T cells/mm³, exposure to antiviral therapy, body pain and depression were the main barriers. In contrast, higher cardiorespiratory fitness, higher self-efficacy, more perceived benefits and better health motivation were the dominant facilitators to PA that emerged.

Through a qualitative approach Li et al.²⁰ identified factors to consider when developing and implementing exercise programs taking into account exercise experiences of PLHIV. Participants reported perceiving exercise benefits related to the physical, mental, cognitive and social domains. Furthermore they identified facilitators and barriers to accessing and participating in PA including structured exercise routines, low cost of the

program and group-based exercise as facilitators, with lack of knowledge of how to exercise safely, periods of physical or mental illness such as fatigue or depression, other responsibilities resulting in lack of time (i.e. parenting, employment) and cost of gym membership emerging as barriers to PA participation and perseverance. Beyond the factors to consider when developing and implementing exercise programs, a qualitative study by Montgomery et al.²¹ sought to describe experiences before, during and after engaging in a community-based exercise program from the perspective of PLHIV. Results highlighted how perceived benefits of exercise programs along with improvements in physical, mental and social health positively influenced adherence to exercise. The episodic nature of HIV and multimorbidity emerged as important factors to consider in PA promotion and sustainability among PLHIV suggesting that PA programs should include strategies to accommodate potential fluctuations in health.

On the notion of sustainability, Simonik et al.²² explored the readiness to engage in exercise among PLHIV and multimorbidity through a qualitative approach. They established a framework taking into consideration the dynamic and fluctuating construct of readiness to exercise. Social support, perceptions and beliefs, experience with exercise and accessibility influenced PLHIVs' readiness to exercise. Vader et al.,²³ enriched these findings by looking at the perceptions and attitudes of PLHIV towards exercise revealing, beliefs related to exercise benefits including improved physical and mental functioning and preventing isolation, and exercise risks including risks of physical injury and fear of '*overdoing it*'. Here the authors emphasized the importance of adopting an individualized approach to PA prescription in PLHIV

The aforementioned studies were mainly related to PA program protocols such as a home-based exercise programs¹⁸, the development of a mobile application for PA interventions¹⁹, or other protocols that used quantitative¹⁵ or qualitative²⁰ data. The in-depth

factors of PA in the everyday life of PLHIV have yet to be fully explored from a multidimensional approach to add to the existing literature and emphasize the focus areas for intervention protocols and promotion of regular PA.

The aim of our study was thus to get a deeper understanding of perceived barriers to and facilitators of PA in a group of French PLHIV through a qualitative approach. Specifically, our study sought to look at structured and unstructured PA in everyday life in active and less active PLHIV, to describe their attitudes toward PA and identify the facilitating and hindering factors for an active lifestyle and PA participation.

Methods

Participants

Participants were recruited by purposive sampling. The inclusion criteria were as follows: PLHIV who were able to speak French; between the ages of 40 and 65; currently under antiretroviral therapy and followed by doctors in one of the participating hospitals. All potential participants were contacted by telephone or e-mail and were informed of the study purpose and the topics that would be discussed during the interview. Interviews were conducted one-to-one by two different researchers.

Procedure

For data collection, individual semi-structured interviews were conducted between September 2014 and March 2015. Interviews were conducted in French at a location deemed appropriate by the participant. This was either the participant's home or at one of the recruiting hospitals. Interviewees were given written informed consent forms and guarantees of their privacy for data before the interviews. Interviews were guided by a structured protocol of interview topics with follow-up probes drafted in collaboration with other members of the research team on the basis of the literature and previous research conducted

on the role of PA in the daily life of PLHIV. The interviewer started the interview with a brief overview of the study purpose, then discussed confidentiality, reiterated that participation was voluntary and formally requested that the interview be recorded. Participants were asked to say whether or not they were currently physically active and describe their physical activities. They were then asked if they felt that their PA participation was influenced by their HIV diagnosis with the objective of observing whether their health behaviors were modified as a consequence of their diagnosis. Hereafter, they were asked their opinion about the importance of PA in their lifestyle and what helps them to remain physically active or in the absence of PA what causes this inactivity ('Do you do any physical activities now that you are taking an active treatment?'; 'What makes it easy/hard for you to be physically active?'). We prompted participants with more specific questions as to identify the different subthemes of barriers and facilitators.

After interview completion, participants were asked to fill-out a demographic survey indicating gender, age, PA level, sexual orientation, country of birth, marital status, highest educational status, employment status and date of diagnosis.

This study received ethical approval along national standards by the University of Nice Sophia Antipolis (n°CNIL/UNS/2015/0007). The context in which our study was conducted was the population of French PLHIV from the Center and South of France. All participants signed a voluntary informed consent form.

Data analysis

The audio recordings and notes were transcribed verbatim in French by the researchers who conducted the interviews. The transcripts were numbered to ensure interviewee confidentiality. The analysis was performed following the main principles of thematic analytic procedures examining transcripts line by line to create codes that were interpreted as

main concepts related to PA barriers and facilitators²⁴. After data immersion, two researchers respectively coded the transcripts in French to identify the main themes and met to collectively review codes and establish an initial coding scheme. Once coded, the research team reviewed the coding interpretations together and created an analysis layout. The codes were then separated into subthemes and grouped into broader themes verifying that they were representative. Member checking and inter-coder agreement were respected to develop rigor²⁵. During the analysis process, the themes and subthemes were revised several times. The initial analysis and classification were discussed, critiqued and repeatedly modified to obtain a satisfactory version for all the authors. Data was analyzed until data saturation was reached²⁶. Data was coded and analyzed in French then translated into English and translated back into French to ensure translation equivalence of the results.

For PA level based on Robert et al.'s²⁷ valid questionnaire we calculated participants' PA score by adding the score given for each question related to PA participation and sedentary activity as suggested by Robert et al.²⁷. Scores were based on 30 points in total scattered over 9 questions. PLHIV scoring 15 out of 30 or less were considered as less active or inactive. PLHIV with scores ranging from 16 to 22 were considered as seasonal or "*part-time*" exercisers and scores above 22 were indicators of active PLHIV. Participants were categorized as less active/inactive, seasonal exercisers or active not only based on their PA score but also taking into account verbal information given during the interview based on WHO recommendation for PA (150 minutes of moderate-intensity aerobic PA per week and two muscle-strengthening activities twice a week) and their own perception of their PA status.

Results

Twenty interviews were conducted with PLHIV who met our inclusion criteria. Fifteen interviewed PLHIVs' transcriptions were used for data analysis as saturation was

reached (7 men and 8 women; mean age 46.6 ± 10.3 years). Sixty percent of participants were heterosexual. Thirty three point three percent of participants were considered to be physically active, 46.7% of participants were physically inactive and 20% were seasonal exercisers (meaning they only exercise in the summer months) based on the WHO recommendations and their reported physical activity discussed during the interview and calculated using PA score questionnaire²⁷. Most participants were French and received higher education (degrees=60%). Forty percent of participants were diagnosed before 1996 and 40% between 1996 and 2005. All socio-demographic information for study participants can be found in Table I. Each interview lasted on average 110 minutes (ranging from 57-170 minutes). All transcribed interviews were analyzed line by line and content analysis led to the identification of 387 coded units related to the study purpose including the characteristics of perceived barriers, and the characteristics of perceived facilitators. All the identified themes and subthemes are presented in Table II.

Table I: Socio-demographic details of study participants

Socio-demographic details	Total sample (n = 15)
Gender, n (%)	
Men	7 (46.7%)
Women	8 (53.3%)
PA level n (%)	
Active	5 (33.3%)
Inactive	7 (46.7%)
Seasonal exercisers	3 (20%)
Sexual orientation n (%)	
Heterosexual	9 (60%)
Homosexual	6 (40%)
Age (years), mean \pm SD (range)	
Country of birth	46.6 \pm 10.3
France	13 (86.7%)
Guinea	1 (6.7%)
Canada	1 (6.7%)
Marital status n (%)	
Single/never married	3 (20%)
Married/living with partner	6 (40%)
Separated from partner	3 (20%)
Divorced	2 (13.3%)
Widow	1 (6.7%)
Highest educational status n (%)	
Degree or higher degree	9 (60%)
Higher education below degree	2 (13.7%)
Secondary school qualifications	3 (20%)
No formal qualifications	1 (6.7%)
Employment status n (%)	
Employed full-time	6 (40%)
Employed part-time	2 (13.3%)
Retired	3 (20%)
Disabled or unemployed	4 (26.7%)
Date of seropositive Diagnosis n (%)	
< 5 years ago	1 (6.7%)
5 – 10 years ago	2 (13.3%)
11 – 20 years ago	6 (40%)
> 20 years ago	6 (40%)

NOTES: Percentages were calculated based on the total number of participants; n: number; PA: physical activity; SD: standard deviation.

Table II. Themes and subthemes of PA barriers and facilitators in physically active and less/non active PLHIV

	<i>N</i>	<i>N</i>		<i>N</i>	<i>N</i>
Barriers to PA	<i>citations</i>	<i>participants</i>	Facilitators to PA	<i>citations</i>	<i>participants</i>
Fatigue	35	13	Benefits of PA		
Breathlessness	14	7	Improved physical condition	13	11
Gastric disturbances	6	4	Good fatigue	9	5
Muscular and articular pain	8	3	Reduced pain	7	5
Emaciation	5	2	Fight against aging	8	4
Negative physical self-perceptions			Improved physical self-perceptions		
Lack of perceived physical capacity			Improved self-efficacy		
Lack of perceived physical appearance	11	9	To feel admired	9	5
	9	5		6	3
Perceived risks of PA			Perceived benefits for health		
Risk of injury	13	8	Well-being	8	7
Contamination	7	4	PA as therapy	7	4
Fear of germs	5	2	PA as a way to normalization	5	2
Lack of PA motivation			PA motivation		
Lack of eagerness	11	5	Pleasure related to PA	8	4
PA not a priority	8	4	PA as achievement	7	4
			Determination to overcome the illness	11	4
			PA as a distraction	7	3
Lack of social support			Social facilitators		
No one to exercise with	10	8	Social ties/ affiliations	15	7
Overprotective medical staff/ relatives	14	7	Encouraging medical staff/ relatives	13	6
Time constraints			Obligations/ activities		
Professional	10	6	Associative involvement	9	4
Other activities	13	5	Children/ Grandchildren	8	4
Studies	11	4	Pet to walk	7	3
Financial constraints	16	7	Financial aid for PA	7	4
Climate constraints	9	5	Adapted PA offers		
Lack of adapted PA offers	8	5	PA adapted to fatigue	7	5

Notes. PA: Physical activity; N: number.

Perceived barriers to PA

People living with HIV are faced with a number of consequences of the disease and treatment side effects. These consequences are multi-dimensional, affecting the physical, psychological and socio-environmental domains.

Physical health barriers. Five subthemes of physical health barriers were identified: (a) fatigue, (b) breathlessness, (c) gastric disturbance, (d) muscular and articular pain, and (e) emaciation defined here as a state of abnormal thinness. Perceived physical fatigue appeared as a main obstacle in physical activity practice and was expressed by almost all participants whether they were active or less active. One less active patient said:

“But maybe, if I didn’t have this... this illness, I would have more energy, I don’t know, but... it’s difficult to do more than what I currently do.” (Inactive woman)

Another frequently reported barrier among less active PLHIV was breathlessness as this quote reveals:

“It is exhausting, just going up a few stairs and I’m already out of breath”. (Inactive woman)

Gastric disturbances and muscular and articular pain were also notable among less active PLHIV. For example, this man spoke about pain:

“Yes, I ache all over, I always have pain everywhere, in my joints and everywhere; so this does not encourage me to do physical exercise, you see what I mean.” (Inactive man)

Emaciation or thinness was also a characteristic of the physical health barriers to PA identified by less active PLHIV.

Psychological barriers to PA. Three subthemes of psychological barriers emerged from the analysis: (a) negative self-perceptions, (b) perceived risks of PA, and (c) lack of PA motivation. Among the psychological barriers to PA emerged negative physical self-

perceptions related to lack of perceived physical capacity as illustrated in the following quote and mentioned by almost all less active participants but also by a few active PLHIV:

“I can’t run like I did before, you see... I don’t feel capable of running... of running around the track like I did before, I just don’t... really” (Inactive woman)

Perceived risks of PA related to risk of injury was a barrier for less active and some seasonal exercisers and active PLHIV, one person said: “Because you see... when I play... I can get injured”. (Inactive woman)

Contamination was also a perceived barrier with the fear of contaminating a training partner due to an injury. For example this seasonal exercising woman said: “It’s that if I get hurt, bleed or something, that I’m with other people, I’m really careful huh”. (Seasonal exercising woman)

Lastly, fear of germs appeared as a barrier to exercise among a few less active PLHIV. For example at the swimming pool as one inactive woman stated:

“I can’t go to the hammam (steam room) anymore as I can’t sit on my mat where everyone has sat... I’ll catch all the germs there are...” (Inactive woman).

Furthermore, psychological barriers to PA included lack of PA motivation illustrated by lack of eagerness, which was relevant among seasonal and less active PLHIV:

“Well you see I’m quite lazy, and even though I think of going for a walk, I just don’t feel like it...” (Inactive man)

Social environmental barriers to PA. Five socio-environmental barriers appeared: (a) lack of social support, (b) time constraints, (c) financial constraints, (d) climate constraints, and (e) lack of adapted PA offers. Lack of social support included not having someone to exercise with stated by a large proportion of less active PLHIV but also a couple of active participants. Overprotective medical staff/relatives was relevant to the less active and seasonal exercisers:

“My relatives, if they could put me in a jar... (laughter) to protect me huh... mostly, not moving, so that I can last the longest possible, perfuse me with food, so that I fatten-up, mother me huh... yes.” (Inactive woman)

Time constraints related to profession or studies are also perceived barriers brought forth by active and less active PLHIV, and illustrated in the following quote:

“Well, at the moment, I’m working on my classes, because I have exams in February (...) so, I don’t go to do sport, because... I’m not in the mindset to go to do sport”. (Inactive woman)

Furthermore, other activities and climate constraints were also important socio-environmental barriers observed among seasonal exercisers but also one or two active and less active participants. This quote as an example of climate constraints:

“Then in winter... at 6 o’clock it’s dark (laughter), like that, you have less desire to go (laughter), whereas in summer... when you finish work at 3 o’clock, you go... you go do your sport, and afterwards, you go to the beach, it’s different.” (Seasonal exercising man)

Lastly, lack of adapted PA offers and financial constraints were also part of the socio-environmental barriers and seemed to be present among the active, less active and seasonal exercisers though a greater proportion of less active participants referred to these barriers:

“There are plenty of people who would like to do something, and I don’t mean weight lifting, maybe it’s swimming, it’s... cycling, maybe it was something, yoga or... but... they can’t afford it, it’s difficult to devote 50€ per month to... to subscribe to sports gyms or to go to the pool” (Active man)

Facilitators to PA

The perceived facilitators of PA identified also referred to the physical, psychological and socio-environmental domains.

Facilitators of PA in the physical domain. This subtheme of facilitators was mainly related to physical benefits of PA including, improved physical condition, ‘good’ fatigue, reduced pain and fighting against aging.

Improved physical condition was seen as a benefit of PA by both active and less active PLHIV. This less active woman said:

“I know, I know it would be good for my physical conditioning. I... I just don’t go out and do it... exercise”. (Inactive woman)

‘Good’ fatigue was evoked as PA generated. For example, an active patient said:

“It’s a good fatigue and I like it! I prefer this fatigue... to the one that hangs around for nothing huh, as I don’t know why I’m tired...”. (Active man)

Another active patient explained how PA is a means to fight against the disease and aging:

“and combat age, as well huh, ... I don’t want... to be old...”. (Active man)

Psychological facilitators to PA. Three main subthemes of psychological facilitators were identified as (a) improved physical self-perceptions, (b) positive attitudes towards PA, and (c) PA motivation.

Improved physical self-perceptions included increased exercise self-efficacy as this active patient said:

“And there’s this motivation, to show myself that I’m still capable of doing everything (...) it gives me confidence”. (Active man)

Social recognition was also reported as another active patient explained:

“I attract admiration from youngsters as well because of... my sports career, huh, who don’t know my status, of course, my viral status”. (Active man)

Perceived benefits for health were considered by seasonal exercisers and active PLHIV as a means of increasing well-being or feeling normal:

“Doing sport, I feel good, (...) sport has always increased my well-being, it helps me to relax” (Active man) and even as therapy: “and physically as well... It’s an extraordinary... therapy!”. (Active woman)

PA motivation was identified through pleasure related to PA, PA as an achievement, PA as a distraction and a determination to overcome the illness with active and seasonal exercisers relating to these motivations as facilitators. One active man said: “I wanted to prove to myself that... it [HIV] isn’t beating me! (...) Phew! More than that! It [PA] has saved my life! It’s what... psychologically, physically, I think it’s the most important things I’ve ever done, to... to stay very active (...) I won’t let it beat me!”. (Active man)

Socio-environmental facilitators to PA. Four subthemes of environmental facilitators emerged from the analysis: (a) social facilitators, (b) obligations and activities, (c) adapted PA offers, and (d) financial aid for PA. Social facilitators included encouragement from medical staff/relatives and social ties/affiliations mentioned mainly by active PLHIV but also a few less active PLHIV. This active woman said:

“Yes. Well, it’s yoga, that’s all huh; I’ve always felt really welcome, seeing the others... it’s a bond huh!” (Active woman)

Other obligations and activities also acted as environmental facilitators, such as, associative involvement, taking care of children and/or grandchildren and walking a pet. These facilitators encouraged PA participation, as related by active PLHIV such as this woman:

“Because my dogs need it! (laughter) Yeah. Yeah, at one point... as I got big dogs, well actually, I got big dogs and... well, a big dog, you can’t just take it out for a wee and go back inside huh; they need exercise and everything. So I started, I got

big dogs, and afterwards, I started... walking, walking, and it does me good, I am happy; when I'm outdoors, when I walk with my dogs, I'm happy". (Active woman)

Moreover, adapting PA to fatigue emerged as an environmental facilitator in active and even less active and seasonal exercisers, as illustrated in the following quote:

"It's a... it's a fight to manage everyday, so the... uh... the jetlag... the fatigue, and then, the training. I adapt myself and I have an understanding trainer who also adapts, who adapts, adapts my training sessions". (Active man)

Also, financial aid from relatives or associations encouraged PA participation, as stated by active but also less active PLHIV, revealing that though they may perceive this aid as a facilitator they still remain insufficiently active. As one inactive woman said:

"It's my family who gave me my Nordic walking poles". (Inactive woman)

Discussion

This study sought to get a deeper understanding of PLHIVs' beliefs and attitudes towards PA through identifying perceived barriers to and facilitators of PA participation by using semi-directive interviews. Physically active and less/non active PLHIV according to the WHO recommendations were interviewed. Interestingly, in our study, PA was overall viewed as beneficial on many levels by both active and less active PLHIV. Yet still only one third (5/15) of our participants were regularly active with almost half (7/15) considered as insufficiently active according to recommendations and less than a third (3/15) considered as seasonal exercisers as they were active only during the warmer months of the year. Our study pointed towards physical, psychological and socio-environmental barriers to and facilitators of PA. On the one hand fatigue was by far the most predominant physical barrier. Improved physical condition on the other hand was a largely noted facilitator to PA. In the psychological domain, risk of injury as well as low perceived physical capacity and lack of PA motivation due to illness status were frequently cited. On the other hand, determination and the will to overcome the illness stood out as psychological facilitators to PA. Finally, in the socio-environmental domain financial constraints were perceived as hindering PA participation. Relatives and medical staff played a conflicting role either as encouraging PA participation or having an overprotective attitude perceived as a barrier to PA. In the same vein other activities including leisure and association-based activities, could hinder PA participation whereas social ties and affiliations were also largely noted as they encouraged PA.

In regard to the physical domain, we noted that several constructs emerged both in the perceived barriers and in the facilitators, with different meanings. Fatigue, for example, was considered to be a barrier to PA, whereas good PA-related fatigue was seen as a facilitator and a perceived benefit in physically active PLHIV. The prevalent status of fatigue

highlighted in our study is in line with previous research where fatigue was reported as the most frequent symptom among PLHIV^{28,29}. Similarly, physical barriers such as breathlessness, muscular and articular pain and emaciation also found themselves among the facilitators, when PA was a way of alleviating pain or improving physical condition. These physical barriers and facilitators emerged in previous literature, with muscular pain as part of bodily pain being reported³⁰, and higher cardiovascular fitness, as an index of improved physical condition, being associated with higher PA participation¹⁵. Beyond the specificities of PLHIV, comparable physical barriers and facilitators to PA have been reported in elderly or in other populations with chronic diseases. For example, fatigue was an important barrier to PA participation in older people³¹ and in cancer patients^{32,33}.

As regards to the psychological domain, lack of PA motivation was an important factor acting as a barrier reinforcing existing literature in PLHIV^{18,19} and in other vulnerable populations such as older adults³¹ and more widely in the general population³⁴. However motivation was seen as a main psychological facilitator for PA when increased and aimed at PA as illustrated by PA related pleasure, PA as a distraction or achievement and the will to overcome the illness. Motivation to be active consistently emerged as a PA facilitator in the literature, whatever the population studied, such as children with disabilities³⁵, and more generally among adults³⁶.

Beyond motivation, our study pointed out further psychological factors related to perceived risks and benefits related to PA, and physical self-perceptions. As part of perceived benefits of PA for health, PA being used as therapy, was concomitant with¹⁹, whose results revealed a self-care aspect of PA for many PLHIV. Perceived risks such as fear of injury, fear of contamination and fear of germs appeared to be another specific PA barrier in PLHIV. This result enriches Montoya et al.'s¹⁹ findings in which only fear of sustaining an exercise-related injury as a perceived risk was identified as a barrier to PA participation in PLHIV.

In their negative form, physical self-perceptions concerned lack of perceived capacity to be physically active and lack of perceived physical appearance categorized as PA barriers. This lack of perceived capacity for exercise was also identified as a main psychological barrier to PA participation among cancer patients^{32,37} and older adults³⁸. Physical self-perceptions that facilitated PA among PLHIV included increased self-efficacy and body image and were in line with Phillipas et al.³⁹, who also showed that increased body fitness improved body image and PA participation. Beyond the effects of self-efficacy in PLHIV, perceived exercise self-efficacy plays an important role in PA promotion in people with other chronic illness (multiple sclerosis⁴⁰), and more widely in the general population⁴¹.

Lastly, the socio-environmental domain was largely characterized by social support in our research. When related to as a barrier, lack of social support was illustrated by not having anyone to exercise with as well as overprotective medical staff and/or relatives. This is largely consistent with other research revealing that lack of social support negatively impacts PA participation among PLHIV^{39,42}. In its positive form, social support from friend, family and medical staff was an essential facilitator towards PA participation in our research. Here again, social support has been positively related to increased PA participation among PLHIV^{16,39}. Support or lack of support from family, friends and medical staff was a persistent facilitator or barrier to PA in age- or illness-specific populations such as multiple sclerosis patients⁴³, asthma patients⁴⁴ or older people³¹, but also in the general population⁴⁵. Financial, time and climate constraints interfered with PA participation in the present study. Financial concerns and other activities were reported in previous research as prominent PA deterrents among PLHIV¹⁹. On the contrary, a stable income or financial aid from relatives or even associations have encouraged PA among PLHIV¹⁶. Other activities or obligations including walking a pet or walking children to school increased PA in PLHIV and is consistent with the literature^{18,19}. Financial accessibility was also found to improve PA participation among older adults for

example⁴⁶. Beyond PLHIV, lack of time and weather conditions appear as generalizable and dominant environmental barriers to PA participation in the general population⁴⁵ and in other vulnerable populations such as the elderly⁴⁶ and asthma patients⁴⁴.

Conclusion and implications

This qualitative study pointed towards physical, psychological and socio-environmental barriers and facilitators to PA in PLHIV, thus providing a multidimensional understanding of PA attitudes and beliefs in PLHIV enriching the existing literature¹⁵. Furthermore, our research identified these barriers and facilitators among active and less active PLHIV, allowing to gain insight into how PLHIV at various levels of PA participation perceive PA. Beyond the physical barriers to and facilitators of PA, largely reported in the literature, psychological and socio-environmental barriers and facilitators emerged from our research as important factors. Particularly, active and inactive PLHIV identified PA as being beneficial not only physically (feeling better physically; reducing the effects of the illness) but also psychologically with facilitators illustrated by positive self-perceptions including well-being and improved self-image. Additionally, fear of sustaining an injury and fear of contamination were main barriers to PA and can be identified as PA risks contingent with the literature¹⁹. PLHIV also had negative physical self-perceptions as exemplified by lack of perceived capacity for PA and lack of perceived physical appearance. Increased motivation or lack of motivation were important psychological factors brought forth in our research and along with social support should be highly considered in clinical implications encouraging relatives and medical staff to take part in PA practices and to convey positive attitudes towards the beneficial effects of regular PA.

Our research revealed a higher presence of barriers among less active PLHIV and of facilitators in active PLHIV, in line with evidence of perceived benefits being influential in

the promotion and adoption of exercise as a long-term self-management strategy according to the qualitative study by Montgomery et al.²¹ provided support to some of the Transtheoretical Model of Behavior Change (TTM) constructs such as the decisional balance⁴⁷. Future work might consider looking at the exercise stages of change of participants based on this model, to better capture the dynamics and processes of change. It would be of interest to use a more comprehensive and in-depth qualitative approach, that inserts the barriers and facilitators to PA within life trajectories and/or within social relations (gender, age, social status) allowing to further adapt PA promotion to the highly diverse profiles of PLHIV. Finally, our study was based on qualitative data, which limits the generalizability of our findings. A more quantitative approach to the attitudes and beliefs of PLHIV toward PA by developing a specific scale to measure PA barriers and facilitators among this population would be of value.

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Summary of Study 1

“I can’t run like I did before, you see... I don’t feel capable of running (...)”

The objective of the first study of this thesis was to characterise perceived barriers to and facilitators of PA through a qualitative approach. The semi-directive interviews of 15 active and less active men and women living with HIV were analysed using thematic analyses and a multidimensional outlook of barriers to and facilitators of PA participation was revealed. Indeed, physical, psychological and socio-environmental barriers and facilitators emerged. Through this multidimensional approach, our research allowed us to gain understanding of PA attitudes and beliefs in PLHIV enriching the existing literature (Vancampfort et al., 2017). Taking into account the PA level of participants further allowed to have a comprehensive view of the effects PA might have on PLHIVs’ perceptions of PA.

PA was considered beneficial by both active and less active PLHIV, with participants mentioning improved physical condition, good fatigue as well as well-being, and improved self-image. The positive physical effects of PA are well established in the literature (e.g., O’Brien et al., 2010, 2017) and our research confirms these results, with psychological facilitators being brought to light through positive self-perceptions (i.e., well-being and self-image). Despite these positive beliefs about PA, almost all participants reported fatigue as the main physical barrier to PA participation. As fatigue is the most prevalent symptom in PLHIV (e.g., Barroso et al., 2003), this result emphasises the impact of physical fatigue on daily life and activities across all levels of PA participation.

Furthermore, the most commonly cited barriers to PA participation were not only physical but also psychological, with negative physical self-perceptions such as lack of perceived capacity for PA and lack of perceived physical appearance emerging from our research. Also, risks of PA were brought forth with, for example, the fear of sustaining an injury, reinforcing existing literature (Montoya et al., 2015), and risk of contamination.

Lastly, on the socio-environmental level, lack of social support was highly mentioned as a barrier to PA participation.

It is important to note that though all participants perceived PA as beneficial, only a third could be considered as physically active. This suggests that the positive beliefs related to PA do not seem to be enough for PLHIV to be physically active as they do not outweigh the negative self-perceptions and risks related to PA. As these positive and negative beliefs seem to be shared by PLHIV, they could be referred to as stereotypes related to PA and HIV. These stereotypes seem to be endorsed by the majority of our participants and they may have an important role in PA non-participation. To better capture this relationship and its underlying mechanisms, the development and validation of a scale measuring this construct was deemed relevant.

In line with the results from our qualitative study as well as existing measures in other populations, including the elderly (Chalabaev et al., 2013 and cancer patients (Falzon et al., 2014), the objective of the second study of this thesis was to develop and validate a scale allowing the measurement of the negative and positive stereotypes related to PA and HIV.

Study 2

Exercise stereotypes and health-related outcomes in French people living with HIV: Development and validation of the HIV Exercise Stereotype Scale (HIVESS)

(Published in *Health and Quality of Life Outcomes*)

RESEARCH

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Exercise stereotypes and health-related outcomes in French people living with HIV: development and validation of an HIV Exercise Stereotypes Scale (HIVESS)

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Abstract

Background: The main objective of the current study was to develop and validate a French exercise stereotype scale for people living with HIV (PLHIV) in order to gain visibility to the possible barriers and facilitators for exercise in PLHIV and thus enhance their quality of life.

Methods: A series of four complementary studies was carried out with a total sample of 524 participants to: (a) develop a preliminary version of the HIV Exercise Stereotype Scale (HIVESS) (Stage 1), (b) confirm the factorial structure of the instrument (Stage 2), (c) evaluate the stability of the instrument (Stage 3), and (d) examine the construct and divergent validity of the scale (Stage 4).

Results: Results provided support for a 14-item scale with three sub-scales reporting stereotypes related to exercise benefits, exercise risks and lack of capacity for exercise with Cronbach's alphas of .77, .69 and .76 respectively. Results showed good factorial structure, strong reliability and indicators of convergent validity relating to self-efficacy, exercise and quality of life.

Conclusion: The HIVESS presented satisfactory psychometric properties, constitutes a reliable and valid instrument to measure exercise stereotypes among PLHIV and has applications for future research and clinical practice.

Keywords: HIV/AIDS, Stereotypes, Exercise, Scale development

Background

The positive effects of exercise for people living with HIV (PLHIV) are now thoroughly reported in scientific literature. A recent meta-analysis [1], indicated that moderate exercise presents beneficial physical and psychological effects for this population (e.g., improvement of fitness, body composition and quality of life). Further physical effects noted are the moderation of the side effects of anti-retroviral therapy (e.g., reducing and/or preventing uneven distribution of body fat) [2], and of cardiopulmonary fitness [3]. These physical effects coexist with notable psychological benefits such as reduced depression [4, 5] or improved self-perceptions and self-esteem [6]. Greater

quality of social relationships [7] and life satisfaction has also been reported comparably to non-exercising PLHIV [8]. Lastly, some studies evidenced the ability of exercise to better antiretroviral therapy adherence [9] and to hinder anti-inflammatory consequences [10].

Regardless of the extensive literature related to the benefits of exercise in PLHIV, a large proportion of this population is not sufficiently active according to current recommendations [11, 12], for adults between 18 and 64 years of age, requiring at least, 150 min of moderate exercise and two sessions of muscle strengthening workout per week [13]. These findings are of concern and encourage further identifying barriers to exercise participation. Research related to exercise barriers in PLHIV is sparse.

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In a study conducted in Rwandan PLHIV receiving high active antiretroviral therapy [14], the main perceived barriers were lack of motivation (30.5 %), lack of time (25.3 %) and fear of worsening the disease (24.3 %). Through a qualitative study conducted on South African PLHIV, a wide range of obstacles to participation, related to both the psychological sphere (e.g., low-energy levels, psychological complaints and stress levels) and the environmental and social spheres (e.g., physical environment, social environment, domestic abuse and crime) were isolated [15]. More recently, it has been reported that prominent exercise barriers include HIV symptoms (i.e., neuropathy, lipodystrophy), antiretroviral therapy effects (lipodystrophy) and fatigue, but also decreased motivation, depression, negative self-perceptions, and apprehension concerning the risks of exercise such as sustaining an injury [15].

These last results suggest that insufficiently physically active PLHIV might have negative beliefs about exercise effects (e.g., perceived risks), which might limit their participation in exercise. Furthermore, these negative beliefs might reflect the internalization of stereotypes related to physical weakness and decline due to HIV disease. Stereotypes refer to shared beliefs concerning personal characteristics, generally personality traits, and the behaviors of a group of persons [16]. According to the stereotype embodiment theory [17], stereotypes are embodied when their assimilation from the surrounding culture leads to self-definitions that, in turn, influence functioning and health. In the case of HIV, internalized stigma has shown a relation to lower mental health and social support, and greater HIV symptoms [18].

An emerging body of literature has focused on the specific influence of exercise stereotypes on different populations such as the elderly or individuals with chronic diseases. Particular measures have been generated to investigate exercise stereotypes in these populations. For example, the “Aging Stereotypes and Exercise Scale” was developed and validated to assess different aspects of aging stereotypes in the exercise sphere such as (a) stereotypes regarding exercise benefits, (b) stereotypes about exercise risks, and (c) stereotypes related to self-efficacy [19]. This line of research indicates that endorsement of negative aging exercise stereotypes is related to lower levels of exercise among the elderly [20, 21]. Another stereotypes-type scale is the “Cancer Exercise Stereotypes Scale” (CESS) [22], which evaluates stereotypes related to exercise in cancer patients: (a) stereotypes related to the lack of interest in exercise; (b) stereotypes regarding exercise self-efficacy; (c) stereotypes about the side effects of treatment; (d) stereotypes related to the risks of exercise and; (e) stereotypes associated with the benefits of exercise. In both scales, some subscales refer to negative exercise stereotypes and others refer to positive exercise stereotypes.

HIV/AIDS-related stigma is continuously brought to mind, in any discussion about effective responses to the epidemic, as a problem of detrimental and tenacious nature [23], several internalized AIDS-stigma scales have hereby been developed [24, 25]. However, no valid tool is currently available to measure stereotypes related to exercise in PLHIV. Taking into consideration the theoretical and conceptual link between exercise stereotypes and behaviors, there is a need to measure stereotypes that act as barriers or facilitators to exercise in PLHIV. This study’s main objective was thus to develop and validate the HIV Exercise Stereotypes Scale (HIVESS). The HIVESS could be used (1) in research to better explain the psychosocial factors related to exercise in PLHIV, and (2) in practice to enable health and exercise professionals to conceive effective intervention strategies that take into account exercise barriers and how to modify them favorably.

Methods

The HIVESS was developed and validated following Vallerand’s procedure [26], including: (i) developing an initial version and assessing the clarity of the items, (ii) analyzing and confirming the factorial structure of the instrument, (iii) analyzing the stability of the tool over time, and (iv) evidencing proof of construct validity by testing the convergent validity and discriminant validity of the scale.

To perform the successive stages in developing and validating the scale, a total of 420 voluntary French-speaking PLHIV ($M_{\text{age}} = 52.51$; $SD = 11.44$), 154 voluntary French-speaking healthy individuals ($M_{\text{age}} = 28.04$; $SD = 10.45$), including 50 French-speaking faculty students ($M_{\text{age}} = 23.08$; $SD = 2.25$) were recruited. Participants were informed of the study during routine consultations or various announcements on social media and in a local newspaper. PLHIV were recruited from three French hospitals by hospital staff and researchers following certain inclusion criteria (i.e., at least 10 years of therapy; no co-infection or other diseases). Healthy individuals and students were recruited in the local area by researchers. Ethical approval as well as participants’ informed written consent was obtained for these studies.

Stage 1: exploratory version and content clarity

In the first stage of this study the aim was to compile an initial version of the HIVESS. Three researchers specialized in the field of health psychology and four PLHIV formed an ad hoc committee and stipulated a series of items based on (i) content analyses of previous semi-structured interviews focused on exercise beliefs in PLHIV and (ii) two validated scales measuring different dimensions of exercise stereotypes in older adults and cancer patients [19, 22]. Items were thus theoretically

prompted and formulated using conventional recommendations for understanding and wording literacy [27]. The concepts of qualitative saturation decided the number of initial items. Saturation was deemed attained when no new relevant item emerged [28]. During this process and in anticipation of items being deleted during the refinement process, items were added to each stereotype category [29]. The Delphi method was then used to select items [30]. The list of items was presented repeatedly until at least 80 % of the raters came to a consensus [31]. A first panel of PLHIV was asked to complete an assessment of the investigative version of the instrument after an initial expert panel review. Participants were invited to assess the clarity of each item on a six-point Likert scale ranging from 1 = “not at all clear” to 6 = “completely clear”. Each participant was interviewed as this qualitative procedure allowed discussing each item as to its pertinence, endorsement and highlighting possible needs for alterations. As suggested by Morey (2003) [29] participants were explicitly encouraged to provide feedback on items rated as being low in quality. The evaluated items, to which mean scores of “4 and/or less” were attributed, were considered as ambiguous or misunderstood. These items were then modified or reformulated according to participant comments and suggestions made by the researchers [26]. A second panel of PLHIV in a method comparable to the first evaluation protocol then assessed the revised version of the instrument.

Stage 2: factorial structure analysis

This stage aimed at examining the factorial structure of the HIVESS. As item generation was theory driven and based on existing exercise stereotypes scales (e.g., ASES [19]; CESS [22]), the number of factors was predefined. Therefore, maximum likelihood estimation confirmatory factorial analysis (CFA) was conducted in AMOS v7.0 to test the validity of the factor model [32]. Factor analysis is considered possible with a minimal sample of questionnaire items amounting to five times the number of items [33]. Each item was identified as an indicator of a single underlying stereotype sub-scale, and no items were specified to cross-load. The following indicators: chi square (χ^2 ; significant values $p \leq .05$), the Comparative Fit Index (CFI; values above 0.90), the Tucker-Lewis Index (TLI; values above 0.90), the Root Mean Square Error of Approximation (RMSEA; values below 0.08), and the 90 % Confidence Interval of the RMSEA (RMSEA 90 % CI; values ranging from 0 to 0.08) were used to assess competence of the model fit [34–36]. Sources of poor fit were examined through modification indices [37]. Cronbach's alphas [38] were also determined to test the internal consistency of each subscale, with convention recommending values greater than 0.70.

Stage 3: temporal stability

Temporal stability, or “test-retest”, is an important measure of reliability for a psychometric instrument [39]. The purpose of this stage was to assess the temporal accuracy of the HIVESS. An instrument is considered relevant when a reasonable level of temporal stability can be associated to the determined construct measures. For assessment of test-retest reliability at least 50 participants is required for the sample [40].

An interval of 4 weeks was considered to be an acceptable compromise between an attempt to reduce recall bias and test reliability independent of significant clinical change [41]. The 17-item questionnaire was hereby administered to participants twice over a 4-week period. Intraclass correlation coefficients (ICCs) and the 95 % confidence interval of the ICCs (ICC 95 % CI), as well as paired/dependent sample *t*-tests were conducted as data analyses to examine significant differences in subscale scores from time 1 to time 2. Cronbach's alphas were calculated at both time points to examine internal consistency of the scale.

Stage 4: convergent validity and discriminant validity

Stage 4 was intended to test the construct validity of the HIVESS. Here we considered the extent to which inferences can be made permissibly in the process of rigorously defining variables into measurable factors. For construct validity the theoretical constructs on which the process was based need to be empirically and qualitatively measured. Construct validity is said to be satisfied when both convergent and discriminant validities are satisfied [42]. A significant correlation of 0.3 is desired between the scale and other theoretically appropriate measures to test validity [43]. Using an alpha of 0.05 and a 1-beta equal to 0.2, 85 participants were needed to obtain a significant correlation of 0.3 or more.

Based on research on exercise stereotypes in vulnerable populations [21, 44], convergent validity of the scale was tested by examining the relationships between the three subscales of the HIVESS and a physical activity score [45], exercise self-efficacy [46] and patient-reported health-related quality of life [47]. Pearson correlation coefficients were used to measure the association between variables. Cronbach's alphas were examined as internal consistency coefficients.

As past research has reported differences between exercise stereotypes in healthy individuals and people with chronic diseases [22] or older adults [19], we examined discriminant validity by evaluating mean differences on the HIVESS for PLHIV and healthy individuals. Specifically, significant differences were tested using univariate analyses of covariance (ANCOVAs) while controlling for level of exercise, age and gender. Based on the ANCOVA result, the two groups were expected to differ in terms of

HIV exercise stereotypes. To assess level of exercise, all participants completed the “Physical Activity Score” [45]. The internal consistency of the items scores was examined using Cronbach’s alpha coefficients.

Results

Stage 1: preliminary version and content clarity

Based on previous literature and content analysis of semi-structured interviews with PLHIV, to begin with the ad hoc committee created a pool of 30 items, ten items for each of the three following categories of stereotypes: (i) stereotypes related to exercise benefits, (ii) stereotypes related to risks of exercise, and (iii) stereotypes related to lack of capacity for exercise. The committee followed the Delphi method and retained 5 items for the benefits of exercise subscale and 6 items for the subscales related to the risks of exercise and to lack of capacity for exercise. The examination of the 17 items from the first panel of PLHIV ($N = 15$; $M_{age} = 50.25$; $SD = 9.96$) reported some low scores for clarity across four items ($3.62 < M < 3.93$). The evaluation interviews brought to light comments enabling modifications to be made to two items related to risks of exercise and two items related to lack of capacity for exercise. Higher mean clarity scores across all items ($M = 5.01$; $SD = .85$) were produced following evaluation of item clarity with the second sample of PLHIV ($N = 15$; $M_{age} = 50.83$; $SD = 10.21$) and discussions instigated no further modifications to the items (see Table 1). Stage 1 provided the initial 17-item HIVESS that required psychometric testing. Items were rated on a 6-point Likert scale in order to emphasize the discrimination and reliability and to reduce the risks of deviation linked to personal decision-making [48].

Stage 2: factorial structure analysis

A total of 96 PLHIV ($M_{age} = 49.95$; $SD = 10.61$) completed the scale. A second sample of 133 PLHIV ($M_{age} = 50.46$; $SD = 10.88$) was recruited to complete a modified version of the scale.

The first CFA results did not display a good fit [i.e., $\chi^2 (116, N = 96) = 267.83$; $CFI = .74$; $TLI = .78$; $RMSEA = .12$ (90 % CI = .10, .14)]. Retained items should saturate with a weight greater than .55 as stated by Guttman [49]. Hereby, 3 of the 17 initial items were removed (i.e., two items on the subscale related to exercise risks and one item on the subscale related to lack of capacity for exercise). Using data from the same sample, a second CFA was conducted with the 14-item scale and showed a better fit [i.e., $\chi^2 (74, N = 96) = 98.99$; $CFI = .94$; $TLI = .93$; $RMSEA = .06$ (90 % CI = .02, .09)] (see Table 1). The model was then tested with a second sample of 133 PLHIV and also showed a satisfactory fit

[i.e., $\chi^2 (74, N = 133) = 126.51$; $CFI = .92$; $TLI = .91$; $RMSEA = .07$ (90 % CI = .05, .09)]. Cronbach’s alphas were .81 for exercise benefits, .71 for exercise risks and .85 for lack of capacity for exercise. Stage 2 rendered and supported the factorial structure of a 14-item, three-factor model of the HIVESS instrument representing HIV exercise stereotype categories related to (i) exercise benefits, (ii) exercise risks, and (iii) lack of capacity for exercise.

Stage 3: temporal stability

In this stage, 50 faculty students ($M_{age} = 23.08$; $SD = 2.25$) were recruited to test the temporal stability of the tool. This population was selected as the questionnaire is not only destined to PLHIV as a targeted group, but also to healthy individuals as the targeters. The t -tests results are presented in Table 2. No significant differences were found between time 1 and time 2 in the scores within subscales. Cronbach’s alpha coefficients for all three factors at time 1 were .71, .78, .76 for exercise benefits, exercise risks and lack of capacity for exercise respectively. At time 2, Cronbach’s alpha coefficients were .80 for exercise benefits, .82 for exercise risks and .75 for lack of capacity for exercise. Based on these findings, the HIVESS was stable over a 4-week period and internal reliability was persistently demonstrated.

Stage 4: convergent validity and discriminant validity

In this stage, 107 (81 men and 26 women) PLHIV ($M_{age} = 52.51$; $SD = 11.42$) were recruited to test convergent validity. The discriminant validity of the scale was assessed using the same sample of PLHIV and a sample of 104 (62 men and 45 women) healthy adults ($M_{age} = 28.04$; $SD = 10.45$).

Convergent validity

Correlational analyses indicated that stereotypes related to lack of capacity for exercise and exercise risks among PLHIV were negatively related to exercise self-efficacy and level of physical activity. Exercise risks and lack of capacity for exercise were negatively related to patient-reported health-related quality of life. The exercise benefits stereotypes subscale was positively related to self-efficacy and level of physical activity (see Table 3). Quality of life did not reveal a significant relation to the exercise benefits subscale. Cronbach’s alphas were .77, .69 and .76 for exercise benefits, risks and lack of capacity for exercise respectively.

Discriminant validity

ANCOVA analyses including control for level of exercise (see Table 4) revealed significant differences between PLHIV and healthy individuals for subscales related to the HIVESS. Cronbach’s alphas were all satisfactory (.77 for

Table 1 Items and Clarity Scores for the Preliminary Version of the HIVESS

Dimensions	Items	Clarity Scores (M)
Stereotypes related to benefits of exercise	1. La pratique d'une activité physique permet d'améliorer le moral des patients atteints de VIH ^b <i>Exercise improves the morale of HIV-infected patients</i>	5.6
	2. La pratique d'une activité physique réduit les effets de la maladie chez les patients atteints de VIH ^b <i>Exercise reduces the effects of the disease in HIV-infected patients</i>	4.8
	3. La pratique d'une activité physique améliore le bien-être des patients atteints de VIH ^b <i>Exercise enhances well-being in HIV-infected patients</i>	5.6
	4. La pratique d'une activité physique permet aux patients atteints de VIH de se sentir mieux physiquement ^b <i>Exercise allows HIV-infected patients to feel better physically</i>	5.3
	5. La pratique d'une activité physique améliore la survie chez les patients atteints de VIH ^b <i>Exercise betters the chances of survival in HIV-infected patients</i>	4.1
Stereotypes related to risks of exercise	1. Les patients atteints de VIH ne font pas d'activité physique car ils peuvent contaminer quelqu'un au cours de la pratique ^b <i>HIV-infected patients do not exercise because they can contaminate someone during the activity</i>	4.2
	2. La pratique d'une activité physique doit être évitée par les patients atteints de VIH car elle provoque des blessures ^b <i>Exercising should be avoided by HIV-infected patients because it causes injuries</i>	4.1
	3. Les patients atteints de VIH ne font pas d'activité physique car ils redoutent de contaminer quelqu'un au cours de la pratique ^b <i>HIV-infected patients do not exercise because they fear contaminating someone during this activity</i>	4.8
	4. La pratique d'une activité physique est dangereuse pour les patients atteints de VIH car elle entraîne trop d'essoufflements ^a <i>Exercising should be avoided by HIV-infected patients because it causes too much breathlessness</i>	5.1
	5. Les patients atteints de VIH ne font pas d'activité physique car ils peuvent contaminer quelqu'un suite à une blessure ^b <i>HIV-infected patients do not exercise because they could contaminate someone after getting injured</i>	4.9
	6. La pratique d'une activité physique entraîne trop de fatigue chez les patients atteints de VIH ^a <i>Exercising causes too much fatigue for HIV-infected patients</i>	5.5
Stereotypes related to lack of capacity for exercise	1. Les patients atteints de VIH n'ont pas les ressources physiques suffisantes pour faire de l'activité physique ^b <i>HIV-infected patients do not have enough physical resources to exercise</i>	5.1
	2. Les patients atteints de VIH ont des capacités physiques trop limitées pour faire de l'activité physique à cause des traitements ^a <i>HIV-infected patients' physical capacities are too limited to exercise due to their treatments</i>	5.2
	3. Les patients atteints de VIH ne sont pas capables physiquement de faire de l'activité physique ^b <i>HIV-infected patients are not physically apt to exercise</i>	4.9
	4. A cause des traitements, les patients atteints de VIH n'ont plus assez d'énergie pour faire de l'activité physique ^b <i>Because of treatments, HIV-infected patients do not have enough energy to exercise</i>	5.3
	5. Les douleurs musculaires et articulaires causées par les traitements empêchent les patients atteints de VIH de faire de l'activité physique ^b <i>Muscle and joint pain caused by the treatments prevent HIV-infected patients from exercising</i>	5.2
	6. Les patients atteints de VIH ne font pas d'activité physique car ils sont trop fatigués par les traitements ^b <i>HIV-infected patients do not exercise because they are too tired due to their treatments</i>	5.6

Notes: English translations are in italics. For each item, the participant had to answer on a 6-point Likert-type scale from 1 (*do not agree at all*) to 6 (*totally agree*).

M = Mean clarity scores

^aDeleted items following the first CFA

^bRetained items in the final model

exercise benefits; .69 for exercise risks; and .77 for lack of capacity for exercise) in PLVIH and in healthy individuals (.71 for exercise benefits; .80 for exercise risks; and .80 for lack of capacity for exercise).

Assessments for convergent and discriminant validity, founded on the construct validity, displayed the HIVESS as being significantly related to exercise, exercise self-efficacy and quality of life in the anticipated directions.

Table 2 Descriptive Statistics for the Questionnaire Structure in Stage 3

	Time 1 (N = 50)		Time 2 (N = 50)		t-tests
	M (SD)	α	M (SD)	α	
LCE	3.05 (.81)	.77	3.18 (.78)	.75	t(98) = -.83, p = .41
RE	2.50 (1.09)	.78	2.42 (1.12)	.82	t(98) = .34, p = .73
BE	4.45 (.85)	.71	4.50 (.79)	.80	t(98) = -.26, p = .80

Notes: LCE Stereotypes related to lack of capacity for exercise, RE Stereotypes related to risks of exercise, BE Stereotypes related to benefits of exercise, M Mean, SD Standard Deviation; t-tests: Student's t-test; α: Cronbach's alpha

In addition the expected differences between PLHIV and healthy individuals were evidenced as regards to negative stereotypes related to exercise risks and lack of capacity for exercise.

Discussion

Although several scales have been developed to measure psychological constructs in people living with HIV [50], the HIV Exercise Stereotype Scale is the first scale to record exercise stereotypes in this population. This scale was developed based both on literature related to psychological barriers to exercise among PLHIV [51, 52] and existing scales measuring exercise stereotypes in the elderly [19] and cancer patients [22]. The scale consists of 14 items divided into three subscales: (a) stereotypes related to exercise benefits, (b) stereotypes related to exercise risks and, (c) stereotypes related to lack of capacity for exercise. The instrument tested in this study demonstrated good structure, strong reliability and indicators of validity.

Stereotypes related to benefits of exercise were assessed by items focused on the positive effects of exercise (e.g., "Physical activity improves the morale of HIV-infected patients"). This subscale was the most highly endorsed by the HIVESS. However, we do not observe a significant positive effect of exercise benefits on exercise self-efficacy and self-reported level of physical activity. This discordance encourages questioning the gap between acknowledging the benefits of exercise and actually being physically active [52]. Nonetheless, this gap is not

specific to PLHIV but is noted in the general population [51]. Some studies link the coexistence of positive views of exercise and the lack of exercise among PLHIV to: lack of motivation or lack of time [14, 15], but also to population-specific barriers such as fear of worsening the illness [12], which seems to reflect exercise risks stereotypes.

The items describing stereotypes related to the risks of exercise for PLHIV conveys the idea that exercise increases the risk of injury (e.g., "Practicing a physical activity should be avoided by HIV-infected patients because it causes injuries") and the risk of contamination (e.g., "HIV-infected patients do not practice physical activities because they could contaminate someone during the activity"). PLHIV showed the least agreement to this subscale, whereas healthy individuals revealed higher scores for exercise risk stereotypes for PLHIV. Furthermore, exercise risks were negatively related to exercise self-efficacy, self-reported level of physical activity and patient-reported health-related quality of life. This suggests that, although PLHIV present barriers to exercise linked to exercise risk such as fear of sustaining an injury during exercise [15], there is a certain resistance to exercise risk stereotype embodiment [17] by PLHIV as already evidenced in older adults [19].

Items describing stereotypes related to lack of capacity for exercise included items pertaining to exercise self-efficacy in PLHIV, treatment side effects, as well as perceptions of physical fatigue (e.g., "HIV-infected patients do not have enough physical resources to practice a physical activity"). This type of stereotype is consistent with existing exercise barriers previously reported in the literature in terms of low levels of exercise capacity and energy [14, 15]. Stereotypes linked to lack of capacity for exercise were negatively related to exercise self-efficacy, self-reported level of physical activity and health-related quality of life. Here again, we note that healthy individuals had a slightly higher level of endorsement than PLHIV. The moderate-level agreement of this type of stereotype is consistent with findings among cancer patients [22] and older adults [19], whereby a stereotype pertaining to loss of physical capabilities was also reported. These findings provide support to the assumption that individuals are more likely to develop negative stereotypes when the latter have no strong self-referential implications [52].

The scale indicated good internal consistency and stable test-retest reliability. The correlations and regression analyses confirm convergent validity of the HIVESS with a measure of exercise self-efficacy, the level of physical activity and patient-reported health-related quality of life. The negative HIV exercise stereotypes related to the risks of exercise and to the lack of capacity for exercise were inversely related to exercise self-efficacy, level of physical activity and health-related quality of life. No significant

Table 3 Matrix of Pearson's r Correlations in Stage 4 (N = 109)

	BE	RE	LCE	SE	PAS	QoL
BE	-					
RE	-.15*	-				
LCE	.07	.32	-			
SE	.28	-.32*	-.48*	-		
PAS	.21	-.11*	-.18*	.41**	-	
QoL	.14	-.32**	-.45**	-.32**	-.03	-

Notes: BE: Stereotypes related to benefits of exercise; RE: Stereotypes related to risks of exercise; LCE: Stereotypes related to lack of capacity for exercise; SE: Self-efficacy; PAS: Physical activity score; QoL: Quality of life; *p < .05; **p < .001

Table 4 Mean (SD) Differences Between PLHIV and Healthy Individuals

	PLHIV (N = 108)	Healthy individuals (N = 104)	Between-Group Difference
LCE	2.91 (1.14)	3.20 (.90)	$F(1, 209) = 8.45, \eta^2 = .04, p < .001$
RE	2.00 (1.10)	2.52 (1.05)	$F(1, 209) = 15.62, \eta^2 = .07, p < .001$
BE	4.51 (1.20)	4.50 (.80)	$F(1, 209) = 2.40, \eta^2 = .01, p > .05$

Notes: LCE Stereotypes related to lack of capacity for exercise, RE Stereotypes related to risks of exercise, BE Stereotypes related to benefits of exercise, SD Standard deviation, η^2 Partial eta-squared

results were observed for positive HIV exercise stereotypes evaluating the benefits of exercise warranting further investigation. Divergent validity was supported by significant differences noted between healthy individuals and PLHIV for subscales related to lack of capacity for exercise and exercise risks with healthy individuals scoring higher for both these subscales.

Conclusion

The HIVESS is a reliable and valid tool to measure HIV exercise stereotypes in PLHIV. However, it is important to point out some limitations of the scale. The procedure reported in this paper is limited by the sociodemographic characteristics of the samples. For example, our data includes a majority of men and it would be interesting to have a more balanced gender distribution. Moreover, test-retest reliability was run in a sample of faculty students and not PLHIV. This could possibly lead to some limits in the generalizability of the scale. In addition, the HIVESS, which was first developed in French, would need to be translated in other languages in order to be used internationally.

The HIVESS allows for further investigation on psychological barriers to exercise in PLHIV. A first line of further research could try to identify the relationship between HIV exercise stereotypes and level of exercise. A second line of research could examine the moderators of HIV exercise stereotypes endorsement (such as being physically active vs. inactive and being healthy vs. HIV-positive). A third line of research could focus on the consequences of exercise stereotypes embodiment on levels of exercise and the potential role of fatigue which has been identified as prevalent complaint among PLHIV [50, 53] affecting quality of life. The French-language HIVESS is a concise multi-item scale facilitating completion and enabling extensive use both in clinical and research environments.

Abbreviations

CFA: Confirmatory factor analysis; CFI: Comparative fit index; HIV: Human immunodeficiency virus; HIVESS: HIV exercise stereotypes scale; ICC: Intra-class correlation coefficient; PLHIV: People living with HIV; RMSEA: Root mean square error of approximation; TL: Tucker-Lewis index

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Availability of data and materials

The dataset supporting the conclusions of this article is included within the article and its additional file.

Authors' contributions

LG oversaw collection of the experimental data, performed the statistical analysis, contributed to the interpretation of the results, and drafted the manuscript; CF contributed to the development of the scale, performed the statistical analysis, interpreted the results, and drafted the manuscript; AB contributed to the development of the scale, contributed to the interpretation of the results, drafted the manuscript, and collaborated on the general project to obtain funding; LS contributed to the development of the scale, contributed to the interpretation of the results, and collaborated on the general project to obtain funding; JD contributed to the collection of the data, provided knowledge related to HIV/AIDS, and collaborated on the general project to obtain funding; ER contributed to the collection of the data, provided knowledge related to HIV/AIDS, and collaborated on the general project to obtain funding; CP, MD and IR contributed to the collection of data, provided specific knowledge related to HIV/AIDS, and collaborated on the general project to obtain funding; SSC contributed to the development of the scale, and collaborated on the general project to obtain funding; FdAL was responsible for the scientific project and oversaw funding obtainment, oversaw the collection of data and the development of the scale, contributed to the interpretation of the results, and helped writing the manuscript. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

Competing interests

On behalf of all authors, the corresponding author states that there are no competing interests.

Consent for publication

Participants were informed that all data collected would remain anonymous. That data would be treated statistically only and remain confidential.

Ethics approval and consent to participate

Ethical Approval: All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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Summary of Study 2

The objective of this study was to develop and validate a psychometric tool allowing the measurement of stereotypes relative to PA and PLHIV. To this purpose, 420 PLHIV and 154 healthy individuals were recruited to carry out the four steps of Vallerand's (1989) transcultural validation procedure. A preliminary version of the HIV Exercise Stereotypes Scale (HIVESS), was developed and then factorial structure was confirmed. Following this the instrument revealed strong reliability, as well as convergent and discriminant validity, and good temporal stability.

A 14-item scale, divided into three sub-scales was retained. The first sub-scale corresponded to stereotypes related to exercise benefits (5 items: e.g., "*Exercise allows HIV-infected patients to feel better physically*"). The second referred to stereotypes related to exercise risks (4 items: e.g., "*Exercise should be avoided by HIV-infected patients because it causes injuries*"). The third to stereotypes related to lack of capacity for exercise (5 items: e.g., "*HIV-infected patients are not physically apt to exercise*").

Psychological constructs have been the focus of several validated scales in PLHIV (e.g., Barroso, 1999), but the HIVESS is the first scale to measure negative and positive exercise stereotypes in PLHIV. Based on literature on psychological barriers to PA (Rothermund & Brandstädter, 2003; Sniehotta, Scholz, & Schwarzer, 2007) and existing exercise stereotype scales in the elderly (Chalabaev et al., 2013), and cancer patients (Falzon et al., 2014), the HIVESS allows to measure the exercise stereotypes in PLHIV and gives valuable information to understand the gap between perceived PA benefits and the lack of PA participation in this population.

With internalisation and ego depletion mechanisms being reported as active mechanisms in the relationship between exercise stereotypes and health behaviours in recent

research (Emile et al., 2014, 2015), the aim of the third study of this thesis was to apprehend the mechanisms through which exercise stereotypes are related to PA level in PLHIV.

Study 3

Exercise stereotypes and fatigue in people living with HIV: does self-efficacy play a mediating or moderating role?

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RESEARCH

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Exercise stereotypes and fatigue in people living with HIV: does self-efficacy play a mediating or a moderating role?



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Abstract

Background: Recent research suggests that exercise stereotypes may influence physical activity through ego depletion and internalization mechanisms. The objective of this study was to better understand exercise stereotypes mechanisms among people living with HIV (PLHIV) by further examining the role of exercise self-efficacy and perceived physical fatigue in the relationship between exercise stereotypes and physical activity.

Methods: Three hundred five people living with HIV were recruited to provide data on their stereotypes related to exercise, exercise self-efficacy, perceived physical fatigue as well as their level of physical activity (PA).

Results: From the different models tested, the serial mediation model with exercise self-efficacy and perceived physical fatigue as mediators of the relationship between exercise stereotypes and PA, as well as the moderated mediation model with exercise self-efficacy as a moderator of exercise stereotypes and perceived physical fatigue a mediator, provided good fits to the data. However, the moderated mediation model (with indirect associations between negative exercise stereotypes and PA via perceived physical fatigue being moderated by exercise self-efficacy) explained the most variance in PA ($R^2 = .27$).

Conclusion: The moderated mediation model suggests that exercise stereotypes might influence PA through ego depletion mechanisms and be tempered by exercise self-efficacy.

Background

Stereotypes are defined as shared beliefs concerning personal characteristics and behaviors of a group of persons [1]. Researchers have identified numerous pathways through which stereotypes impact health behaviors, primarily through internalization into the self, stereotype threat, downward social comparison/resilience, stereotype boost and upward social comparison/role models [2]. For example, according to the Stereotype Embodiment Theory (SET) [3], in older adults the relationships between aging stereotypes and health outcomes can be explained by the stereotype internalization hypothesis. This suggests that age stereotypes are internalized into self-perceptions of aging,

and aging experiences are interpreted via this process [4]. Older adults who have negative perceptions of their aging consider that health problems are inevitable consequences of aging. This, in turn, could lead older adults to view health behaviors as futile [5] and hinder self-efficacy [6]. Indeed, self-efficacy was a potential mediator in the relationship between aging stereotypes and task performance [6]. In contrast positive views of aging may enhance adoption of preventive health behaviors in older adults entailing that the higher positive self-perceptions of aging the more older adults engage in healthy practices as opposed to those with more negative aging self-perceptions [5].

Physical activity (PA) is one of the most important health behaviors associated with prevention and management of chronic diseases, and stereotypes appear as an important factor of this behavior. For example, Wurm, Tomasik, and Tesch-Romer [7] showed that positive views of aging contributed to a higher level of PA. Besides age stereotypes, exercise stereotypes have been identified in

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recent literature, as playing a major role in the relation to PA [8, 9]. These exercise stereotypes, which different populations endorse, or adhere to, to varying degrees, can be both positive and negative and have been the source of specific exercise stereotype scales being developed for the elderly [10], cancer patients [8], and more recently for people affected by HIV/AIDS [9]. These scales allowed to identify two categories of stereotypes. The positive stereotypes category included shared beliefs about exercise benefits (e.g., "Exercise improves the morale of HIV-infected patients"). The negative exercise stereotypes category was composed of shared beliefs about lack of capacity for exercise (e.g., "HIV-infected patients do not have enough physical resources to exercise"), exercise risks (e.g., "Exercise should be avoided by HIV-infected patients because it causes injuries"), and treatment side effects (e.g., "Because of treatments, HIV-infected patients do not have enough energy to exercise").

In order to develop effective interventions, it is crucial to identify the mechanisms through which exercise stereotypes influence PA among people viewed as vulnerable such as the elderly or people living with chronic disease. A first mechanism, through which exercise stereotypes would influence PA, is stereotype internalization. In their cross-sectional study, Emile et al. [11] reported that exercise stereotypes were related to older adults' engagement in PA through physical self-worth, suggesting such an internalization process. In a further longitudinal study, Emile et al. [12] emphasized the importance of distinguishing between general self-perceptions and more domain-specific perceptions indexed by physical self-worth and the role of this physical self-worth in health behaviors. While the stereotype internalization mechanism was supported in their study, the results revealed a direct relationship between exercise stereotype endorsement and adoption of an active lifestyle, independently of how people perceived their own aging. Thus, these results suggested that self-perceptions of aging, the active construct in internalization, may not be the only pathway through which stereotype endorsement may affect older adults' health-related behaviors.

Another pathway through which exercise stereotypes could affect PA and health-related outcomes is ego depletion. Ego depletion corresponds to the idea that engaging in acts of self-control (i.e., overriding initial impulses or responses such as resting on a couch to watch TV to engage in regular exercise) draws from a limited "reservoir" which, when depleted, results in reduced capacity for further self-regulation [13]. Negative stereotypes have been shown to reduce self-control and affect one's ability to self-regulate [14] because coping with such stereotypes requires mental energy, reducing in turn subjective vitality (i.e., the energy one can harness or regulate for purposive actions) or increasing

perceived fatigue (i.e., fatigue that is consciously felt). Likewise, Emile et al. [12] reported that the endorsement of negative exercise stereotypes in older adults negatively predicted subjective vitality, suggesting that ego depletion could be a pathway through which exercise stereotypes affect older adults' health, complementing the internalization pathway. In the same way, a meta-analysis by Hagger, Wood, Stiff & Chatzisarantis [15] showed a significant effect with medium to large magnitudes of exerting self-control on acute subjective or perceived fatigue.

In sum, the recent literature suggests that exercise stereotypes could influence health behaviors including PA through different pathways or mechanisms: (a) stereotype internalization and (b) ego depletion. Yet, it is necessary to further elucidate the relationships and/or role played by each mechanism. Our study takes a closer look at internalization and ego depletion mechanisms in people living with HIV (PLHIV). This population was selected as fatigue is one of the most reported recurrent symptoms with a prevalence rate varying from 33% to 88% [16, 17]. In addition PLHIV do not engage enough in regular PA according to World Health Organization standards [18, 19]. Although some possible reasons are shared by the general population (e.g., lack of interest; lack of time), other reasons might be more specifically related to chronic illness, such as the endorsement of negative exercise stereotypes acting as psychological barriers. In line with previous studies having considered self-perceptions as an index of stereotypes internalization in vulnerable populations [5, 11, 12, 20], we looked at exercise self-efficacy, defined as an individual's belief in his or her ability to succeed in a specific situation to accomplish a task [21], as a situational indicator of the internalization mechanism. In addition, based on Hagger et al. [15], we considered perceived physical fatigue as an index of the ego depletion mechanism. Based on existing literature, this study argues that exercise self-efficacy and perceived physical fatigue would mediate relationships between exercise stereotypes and PA variables in PLHIV, and aims at determining the nature of this mediation. For this purpose, several competing mediation models were tested.

Methods

Study design

A quantitative cross-sectional study design was employed from 1st of September 2016 to 30th of June 2017 in hospitals in three populated regions of France including the capitoul.

Participants

A sample of 344 men ($n = 245$) and women ($n = 99$) living with HIV participated in this study. The staff of the

three French hospitals' departments of infectious diseases screened and assessed patients for eligibility. Participants were included in the study if they were between 40 and 65 years old, were under treatment for at least 10 years and were followed by doctors of one of the three hospitals. As fatigue seems to be more common among co-infected individuals [22], we did not include PLHIV affected by other diseases such as hepatitis C, cancer, renal dysfunction and sclerosis; for the same reason pregnant women were excluded. The participants could read and understand the questionnaires of the survey written in French, and they were not affected by cognitive impairment. The response rate was $54\% \pm 9\%$. After data cleaning, a complete analytic sample of $n = 305$ (men, $n = 228$; women, $n = 77$; $M = 53.5$; $SD = 9.58$) was retained for statistical analysis. All participants were informed that the survey was voluntary and that all responses would remain anonymous and confidential. The study complied with national ethical standards (n°CNIL/UNS/2015/0007).

Procedure

The survey was distributed by staff from the virology services of the three participating hospitals. The staff member presented the study objectives and project partners and assured the anonymity of participants. A room was made available by the hospital for completing the questionnaires. The staff member remained in the room to respond to any requests for clarification. The average time of completion was 20 min.

Measures

HIV exercise stereotypes

We used the HIV Exercise Stereotype Scale (HIVESS) developed and validated by Gray et al. [9] to assess endorsement of exercise stereotypes in PLHIV. The HIVESS consists of 14 items divided into three subscales: (a) five items measured stereotypes related to exercise benefits for PLHIV (e.g., "Physical activity improves the morale of HIV-infected patients"), (b) four items measured stereotypes related to exercise risks linked to injury (e.g., "Practicing a physical activity should be avoided by HIV-infected patients because it causes injuries") and linked to contamination (e.g., "HIV-infected patients do not practice physical activities because they could contaminate someone during the activity") and (c) five items measured stereotypes related to a lack of capacity of PLHIV for exercise (e.g., "HIV-infected patients do not have enough physical resources to practice a physical activity"). Participants answered on a 6-point Likert scale ranging from 1 ("do not agree at all") to 6 ("totally agree").

Perceived physical fatigue

We used the physical fatigue sub-scale of the Fatigue Intensity Scale (FIS) [23], a valid scale previously used in French individuals [24, 25]. An example item was: "I have trouble maintaining physical effort for long periods". Participants responded on a 6-point Likert scale ranging from 1 ("do not agree at all") to 6 ("totally agree"). This subscale was selected because it is specifically related to physical fatigue characteristics as opposed to other used scales such as the HIV-Related Fatigue Scale [26] in which the characteristics are confounded with their consequences, circumstances and triggers.

Exercise self-efficacy

Exercise self-efficacy was measured using six items adapted from Bandura et al. [21, 27] guidelines (e.g., "I can be physically active regularly"). Participants answered on a 6-point Likert scale ranging from 1 ("do not agree at all") to 6 ("totally agree").

Physical activity

We used the Dijon Physical Activity Score [28], developed and validated to measure PA level. This scale contains 9 items and assesses participants' level of PA via: (a) an overall appraisal of one's PA ("Do you consider yourself to be physically: from (1) very active and athletic, to (4) completely sedentary?"); (b) two items on everyday activities ("On a weekly basis, your everyday activities take you: from (1) more than 10 hours, to (5) no time spent"); (c) five items on sport and leisure activities (e.g., "For how many months of the year do you engage in these activities (sport or leisure)?"); and (d) one item on rest ("On a daily basis, you rest (sleep, nap or wakeful rest): from (1) less than 12 hours, to (4) more than 20 hours"). The scores on each item are totaled, with the total score out of 30 points indicating a participant's level of PA (individuals who score below 18 being considered as inactive). This measure, which has been shown to be a reproducible and valid measure of PA both among older adults and among patients with coronary artery disease [29], was deemed relevant to our population with chronic illness.

Covariates

Age and previous level of physical activity were the covariates assessed in this study. These variables were chosen based on validated previous research suggesting that they are related to PA participation. Studies on older adults have revealed age differences in health related behaviors [20] and recently in PA participation [30]. Furthermore, evidence reveals an association between participation in PA in later years and earlier PA

behaviors, previous participation in PA positively predicting future engagement [31, 32].

Age

Age was recorded in a standard manner with the following item: "Thank you for stating your date of birth (dd/mm/yyyy)".

Previous level of physical activity

Previous level of physical activity (PPA) was assessed with a question asking to consider one's level of physical activity, including daily PA such as leisure or competitive sports and active commuting (i.e., walking or cycling to work), before being diagnosed as HIV-positive [31]. This question was stated as follows: This question is related to your physical activity before the condition. "You consider yourself as having been...". Participants were then asked to rate their answer on a Likert scale from 1 "very sportive/physically active" to 6 "not physically active at all".

Data analyses

Data analyses were performed using SPSS.22 and AMOS 20.0. The analysis allowed for missing values to be replaced by using multiple imputation [33]. Statistical analyses included several methods. Descriptive analyses (i.e., mean, standard deviation) were run and the reliability of the questionnaires was assessed with Cronbach's alpha indicating internal consistency. The significance of the relationships between all variables was calculated using Pearson bivariate correlations. To determine the variables significantly contributing to PA variance a stepwise regression analysis was computed. Then three competing mediation models were tested with SEM using AMOS 20.0. Three indexes were selected to express model fit: chi-square (χ^2), the Root-Mean Square Error of Approximation (RMSEA), the Bentler Comparative Fit Index (CFI), Tucker Lewis Index (TLI) and the Normed Fit index (NFI). RMSEA values ≤ 0.08 at 90% Confidence Interval (RMSEA CI 90%) in combination with values for CFI, TLI and NFI ≥ 0.90 suggest an acceptable model fit. The hypothesized mediation effects of perceived physical fatigue and exercise self-efficacy were tested by mediation analyses following the bootstrap procedure recommendations proposed by MacKinnon and colleagues [34]. The bootstrap procedure resampled the data 5000 times and calculated the indirect effect for each sample in this study. The bias corrected 95% confidence intervals (CI) indicated significant or non-significant indirect effects when they did not contain zero.

The first model tested was a parallel mediation model in which the independent variables (IV) were the three dimensions of exercise stereotypes (i.e., exercise benefits; exercise risks; lack of capacity for

exercise), exercise self-efficacy and perceived physical fatigue were the mediators, and level of PA was the dependent variable (DV) (see Fig. 1).

The second model tested was a sequential mediation model in which constructs function as a causal chain. Exercise stereotypes (IV) would hereby predict perceived self-efficacy (first mediator), which would in turn predict perceived physical fatigue (second mediator) with an overall effect on level of PA (DV) (see Fig. 2).

The third model tested examined whether the mediation of the exercise stereotypes – PA relationship by perceived physical fatigue was moderated by self-efficacy. Here the IV remained exercise stereotypes, with perceived physical fatigue as a mediator and exercise self-efficacy as a moderator and level of PA the DV (see Fig. 3).

Moderated mediation was run following recommendations from Muller et al. [35], suggesting the assessment of the overall treatment effect of the independent variable (i.e., exercise stereotypes) on the outcome variable (i.e., physical activity level). This was followed by the assessment of the moderation of the treatment effect of the independent variable on the mediator (i.e., perceived physical fatigue). Lastly, the moderation effect of the mediator on the outcome variable, as well as the moderation of the residual treatment effect (i.e., the direct effect of the independent variable controlling for the mediator) of the independent variable on the outcome variable, were assessed.

Results

Results are presented in three parts. First, we present descriptive analyses. Second, we describe the results from the stepwise regression analysis. Third, we present the structural equation modeling analyses by looking at the results of the three hypothesized models.

Descriptive analyses

Descriptive statistics, means and standard deviations; alpha coefficients, and bivariate correlations for all study variables are presented in Table 1.

Regression analysis

A four-step hierarchical regression analysis identified the predictors of PA level as the dependent variable. In the first step, previous PA level (PPA) and age (AGE) ($\beta = .33$, $p < .001$; $\beta = -.03$, $p = \text{NS}$) significantly predicted PA level, $R^2 = .11$. In the second step, when exercise stereotypes dimensions were added, exercise benefits (BEN, $\beta = .15$, $p < .01$), exercise risks ($\beta = -.08$, $p = \text{NS}$) and lack of capacity for exercise ($\beta = -.19$, $p < .001$) significantly predicted PA level, $R^2 = .18$ ($\Delta R^2 = .07$). Perceived physical fatigue was entered in the third step and significantly predicted PA level, $R^2 = .20$ ($\Delta R^2 = .02$). In the

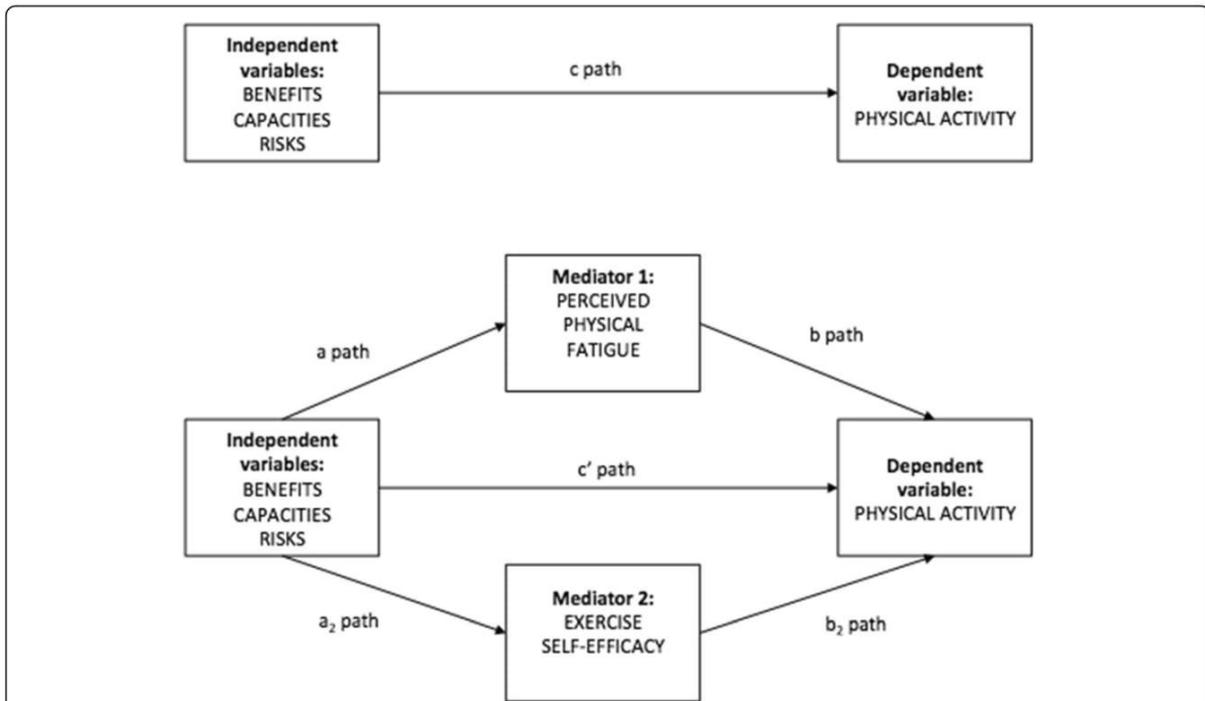


Fig. 1 Descriptive parallel mediation model with indirect and direct pathways of exercise stereotypes dimensions on physical activity with perceived physical fatigue and exercise self-efficacy as mediators. Notes: $N = 305$; Benefits: exercise benefits stereotypes (IV); Capacities: lack of capacity for exercise stereotypes (IV); Risks: exercise risks stereotypes (IV); Exercise self-efficacy (mediator); Perceived fatigue (mediator); Physical activity (DV); a path: relationship between the independent variables and each mediator; b path: relationship between each mediator and the dependent variable; c path: relationship between the independent variables and the dependent variable (direct pathway); c' path: relationship between the independent variables and the dependent variable controlling for the mediators (indirect pathway)

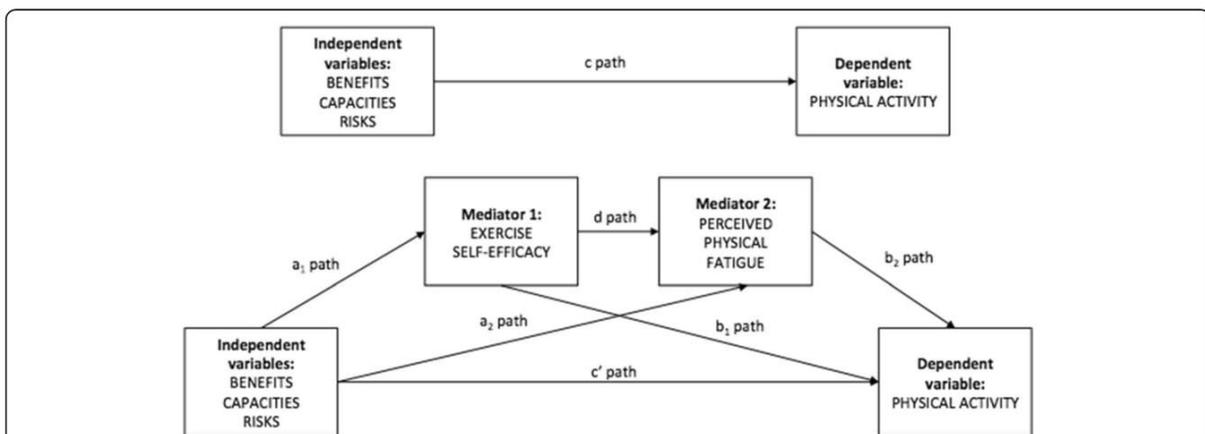
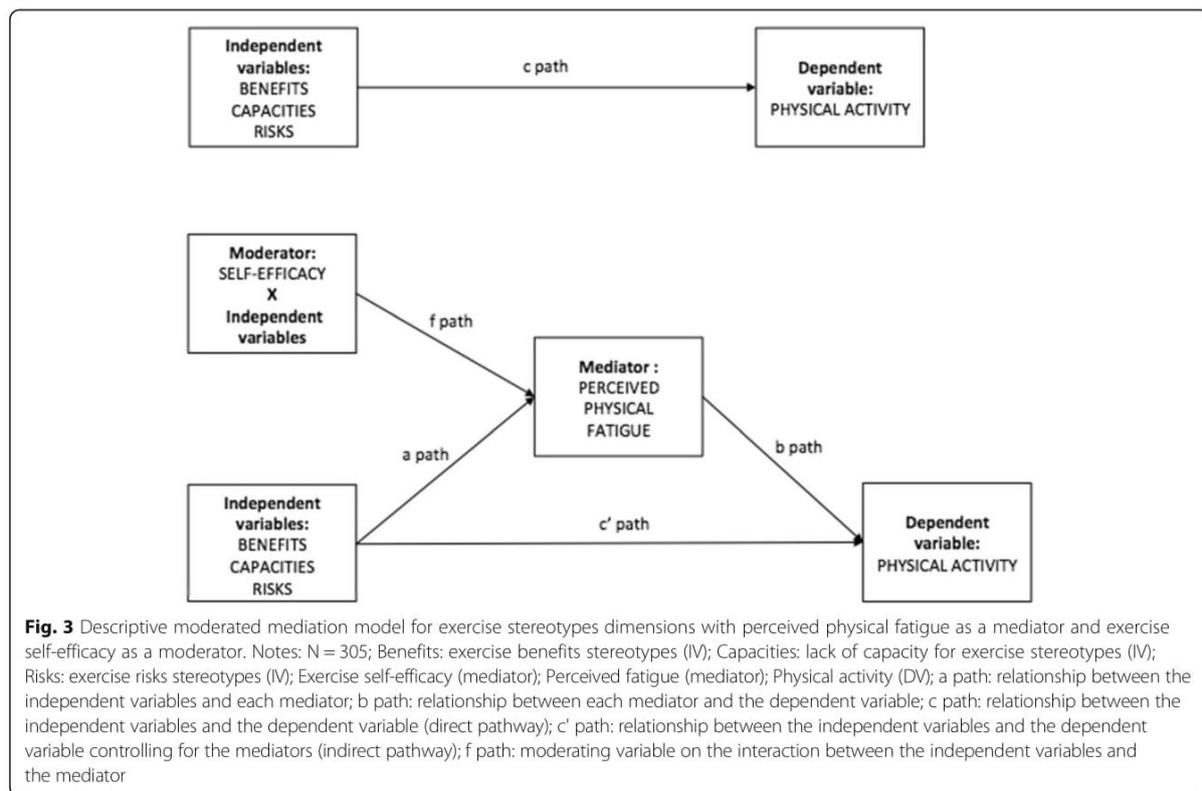


Fig. 2 Descriptive serial mediation model with indirect and direct pathways of exercise stereotypes dimensions on physical activity with exercise self-efficacy and perceived physical fatigue as a mediators. Notes: $N = 305$; Benefits: exercise benefits stereotypes (IV); Capacities: lack of capacity for exercise stereotypes (IV); Risks: exercise risks stereotypes (IV); Exercise self-efficacy (mediator); Perceived fatigue (mediator); Physical activity (DV); a path: relationship between the independent variables and each mediator; b path: relationship between each mediator and the dependent variable; c path: relationship between the independent variables and the dependent variable (direct pathway); c' path: relationship between the independent variables and the dependent variable controlling for the mediators (indirect pathway); d path: influence of mediator 1 on mediator 2



last step, exercise self-efficacy was added and significantly increased variance by 45% revealing the strongest prediction of PA level ($\Delta R^2 = .09$), $F_{change}(7, 305) = 35.77, p < 0.001$. The four steps of the hierarchical regression determining the predictors of PA level are illustrated in Table 2.

Main analyses: model fit

Three hypothetical models were assessed in order to examine the role of exercise self-efficacy and perceived physical fatigue in the relationship between exercise stereotypes and PA.

Parallel mediation model

The parallel model placing perceived physical fatigue and exercise self-efficacy on the same level (Fig. 1) and controlling for PA level before HIV infection as well as age did not provide a good model fit: $\chi^2(8) = 36.076, p < .001, CFI = .918, TLI = .712, NFI = .902, RMSEA = .108$ (90% confidence interval [CI] [.073, .144]).

Serial mediation model

The serial mediation model in which the first mediator was exercise self-efficacy and the second was perceived

Table 1 Means, Standard Deviations, Coefficient Alphas and Bivariate Correlations between exercise stereotypes dimensions, self-efficacy, perceived physical fatigue and physical activity in people living with HIV, France, 2017

	BEN	RIS	LCE	SE	FAT	PA	M	SD	α
BEN	1						4.60	1.14	.78
RIS	-.01	1					1.90	1.11	.79
LCE	-.034	.27**	1				3.07	1.28	.84
SE	.40**	-.18**	-.29**	1			4.84	1.37	.95
FAT	-.17**	.26**	.54**	-.44**	1		3.21	1.54	.86
PA	.23**	-.13*	-.20**	.46**	-.27**	1	19.7	5.17	-

Notes: N = 305, FAT Perceived physical fatigue, BEN Exercise benefits stereotypes, RIS Exercise risks stereotypes, LCE Lack of capacity for exercise stereotypes, SE Self-efficacy, PA level of physical activity, M Mean, SD Standard deviation, α Cronbach's alphas
* $p < .05$, ** $p < .01$, *** $p < .001$

Table 2 Stepwise regression analyses: Psychosocial predictors of physical activity in people living with HIV, France 2017

Steps	Predictors	F	df	R ²	ΔR ²	β	t
1	PPA	17.89***	2	.11		.33***	5.98
	AGE					-.03	-.46
2		9.17***	5	.18	.07		
	PPA					.32***	5.89
	AGE					.002	.04
	BEN					.15**	2.89
	RIS					-.08	-1.44
3		6.31**	6	.20	.02		
	PAA					.30***	5.71
	AGE					.01	.17
	BEN					.13*	2.46
	RIS					-.06	-1.23
	LCE					-.12	-1.82
4		35.77***	7	.29	.09		
	FAT					-.16*	-2.51
	PPA					.28***	5.50
	AGE					-.01	-.90
	BEN					.02	.36
	RIS					-.03	-.63
	LCE					-.08	-1.41
	SE					.35***	5.98

Notes. N = 305, BEN exercise benefits stereotypes, RIS exercise risks stereotypes, LCE lack of capacity for exercise stereotypes, SE exercise self-efficacy, FAT perceived physical fatigue, F Fisher-Snedecor distribution, df degrees of freedom, R² standardized variance, ΔR² delta R-squared or the change in R-squared between two equations, β beta weight values, t t-statistic values *p < .05. **p < .01, ***p < .001

physical fatigue, controlling for PA level before HIV infection and age, provided a good fit to the data: $\chi^2(7) = 8.59$, $p = .283$, CFI = .995, TLI = .981, NFI = .977, RMSEA = .027 (90% confidence interval [CI] [.000, .079]) (see Fig. 4).

After controlling for covariates (age, previous level of PA), mediation analyses for the serial model revealed that the indirect effects of exercise stereotypes on PA were significant. No significant direct effects of exercise stereotypes on PA were observed (see Table 3). Specifically, exercise self-efficacy and perceived physical fatigue fully mediated the relationship between the different stereotypes (exercise benefits, exercise risks and lack of capacity for exercise) and PA accounting for 19% of variance in PA level.

Moderated mediation model

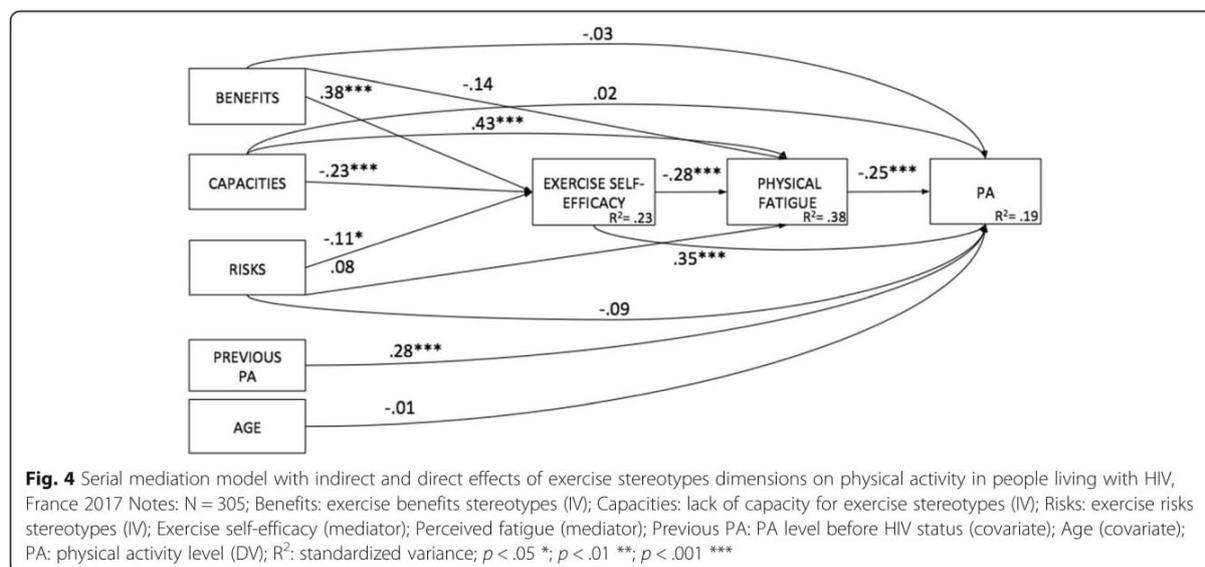
The third model examined whether the mediation of the exercise stereotypes – PA relationship by perceived

physical fatigue was moderated by self-efficacy. A good fit was revealed, with the moderator: $\chi^2(3) = 3.265$, $p = .353$, CFI = .999, TLI = .988, NFI = .993, RMSEA = .017 (90% confidence interval [CI] [.000, .100]) (see Fig. 5).

We then followed the steps outlined by Muller et al. [35] to test for mediated moderation effect. To this purpose, parameters for three regression equations were estimated to assess: (a) the overall treatment effect of exercise stereotypes on PA level as moderated by exercise self-efficacy, (b) the treatment effect of exercise stereotypes on perceived physical fatigue as the mediator moderated by exercise self-efficacy and (c) the mediator’s (partial) effect on the outcome variable PA and the residual effect of the treatment (exercise stereotypes) on PA, controlling for the mediator (perceived physical fatigue) moderated by exercise self-efficacy (see Table 4). The first equation (a) revealed significant direct effects of exercise benefits on PA and of exercise self-efficacy on PA. The second equation (b) revealed a significant effect of lack of capacity for exercise stereotype on perceived physical fatigue that was moderated by exercise self-efficacy ($b = -.06$, $p < .01$). The third equation (c) showed that the partial effect of perceived physical fatigue on PA was not significant but a significant interaction effect between self-efficacy and lack of capacity stereotype on PA was observed ($b = .02$, $p < .05$). This model predicted 27% of variance in PA (see Fig. 2).

Simple slope analyses were then run following suggestions from Dawson [36] that plotting the effects allows to observe their size and precise nature making interpretation easier [36]. With the simple slopes we can know the direction of the relationship for high and low levels of the moderating variable [37]. In our analysis, we looked at the specific relationship between exercise stereotypes and level of PA at different levels of exercise self-efficacy. We wanted to know if, for example, for PLHIV with high exercise self-efficacy there is evidence that their exercise beliefs (stereotypes) would be beneficial for their level of PA by running simple slope tests as suggested by Cohen et al. [38]. Of course, we took into consideration that we have positive and negative exercise stereotypes and that high levels of exercise self-efficacy will interact differently with these stereotypes in the sense that high exercise self-efficacy would reduce the impact of negative exercise stereotypes whilst enhancing that of positive exercise stereotypes.

Simple slope tests were run on the significant interaction effect of exercise stereotypes related to lack of capacity for exercise ($p = .022$) on PA level as the outcome, showing that lack of capacity for exercise varies as a function of exercise self-efficacy as the moderator (see Fig. 6). At low levels of self-efficacy (slope = $-.804$, $t = -2.54$, $p < .01$) lack of capacity for exercise stereotypes



was significantly negatively related to PA level. This suggests that the more participants endorsed stereotypes related to the lack of capacity for exercise, the less they were physically active. For high levels of self-efficacy (slope = .222, *t* = 1,56, *p* < .05), lack of capacity for exercise stereotypes was significantly positively related to PA level. Here, participants showed that lower levels of endorsement of stereotypes related to a lack of capacity for exercise corresponded to higher levels of PA.

Discussion

This study examined the relationship between positive and negative exercise stereotypes and PA as a health behavior, focusing on the underlying psychological mechanisms among PLHIV. Different competing models were tested in order to examine the role of exercise self-efficacy and perceived physical fatigue in the relationship between exercise stereotypes and PA. As a brief overview, the serial mediation model (with exercise self-efficacy and perceived physical fatigue as mediators), and the moderated mediation model (with exercise self-

efficacy as a moderator of exercise stereotypes and perceived physical fatigue a mediator) showed good fits. The moderated mediation model explained the most variance in PA (R² = .27) with indirect links for exercise benefits and risks remaining significant. Lack of capacity for exercise was moderated by exercise self-efficacy for both high and low levels with significant effects on PA.

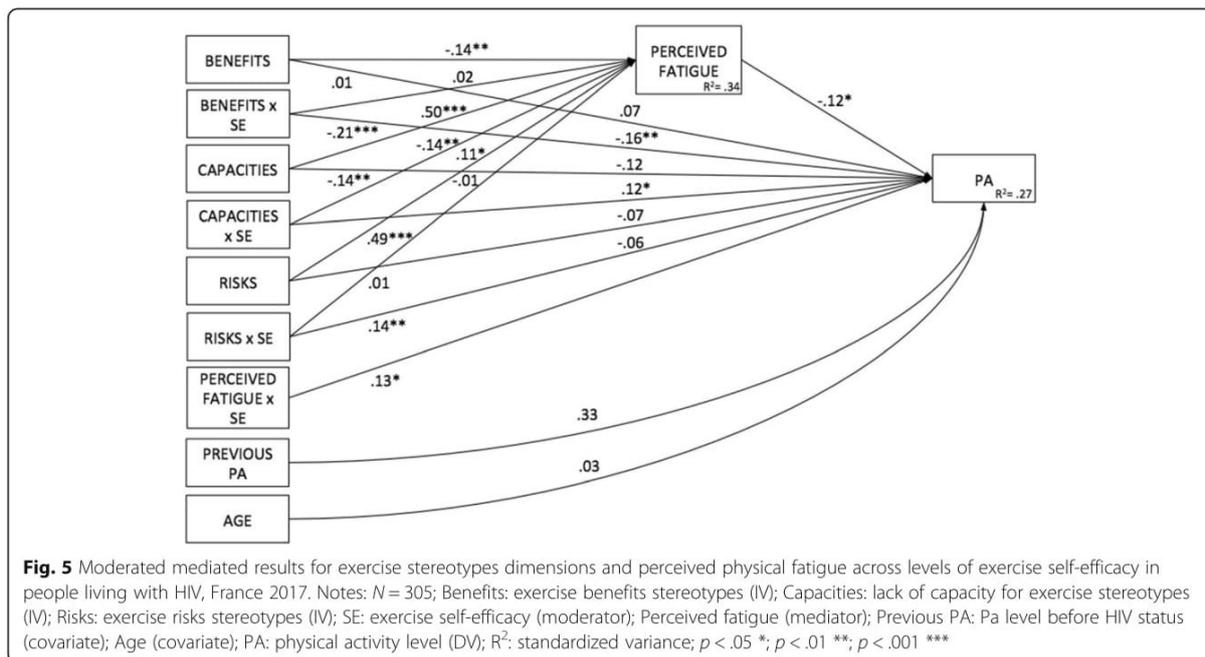
The serial mediation was run to observe the plausible causal chain in which the constructs function. This model was contingent to Levy and Bavishi’s [39] research, which showed that the C-reactive protein, a marker of increasing stress-related inflammation, played a mediating role in the relationship between self-perceptions and longevity. This suggests additional mediators between self-perceptions and observed health outcomes. Inflammation is a stress marker and inducing stereotypes causes stress (see [40]), which can be related to fatigue and be an indicator of the ego depletion mechanism [15]. The different exercise stereotypes (exercise benefits, exercise risks and lack of capacity for exercise) were indirectly

Table 3 Total, direct and indirect effects of exercise stereotypes dimensions as independent variables and exercise self-efficacy and perceived physical fatigue as mediators on physical activity in people living with HIV, France 2017

	Mediators	IV → mediator (s)	Mediator(s) → DV	Total effect	Direct effect	Indirect effect	95% CI
BEN → PA	SE-FAT	.38***/-.05	.001**/-.16	.16**	.13	.02**	[.006 to .061]
RIS → PA	SE-FAT	-.11/-.08	.001**/-.16	-.08	-.06	-.02*	[-.051 to -.002]
LCE → PA	SE-FAT	-.23/.44	.001**/-.16	-.19**	-.12*	-.08*	[-.154 to -.018]

Notes. N = 305, IV independent variable, DV dependent variable, BEN exercise benefits stereotypes, RIS exercise risks stereotypes, LCE lack of capacity for exercise stereotypes, SE exercise self-efficacy, FAT perceived physical fatigue, 95% CI lower and upper bound of bias-corrected 95% confidence interval with 5000 bootstrap samples

p* < .05. *p* < .01, ****p* < .001



associated to PA through exercise self-efficacy and perceived physical fatigue. Specifically, the higher the positive exercise stereotypes, the higher the exercise self-efficacy, the lower the perceived physical fatigue and the higher the level of PA, with the contrary being observed for negative exercise stereotypes. The overall model explained 19% of variance in PA level. This serial mediation of exercise self-efficacy and perceived physical fatigue confirmed the role of multiple mediators in the relationship between stereotypes and health outcomes such as PA. Our findings would extend the existing literature by showing that, beyond stress-related inflammation, perceived physical fatigue could be another valuable candidate in the relationship between self-perceptions and health outcomes.

The moderated mediation model placed self-efficacy as a moderator of exercise stereotypes in the causal

chain: exercise stereotypes > perceived physical fatigue > PA level. This model was tested as previous studies have shown that people with higher self-perceptions in the physical domain have not internalized the stereotypes or have distanced themselves from their group and are thereby less sensitive to the stereotypes [30, 41, 42].

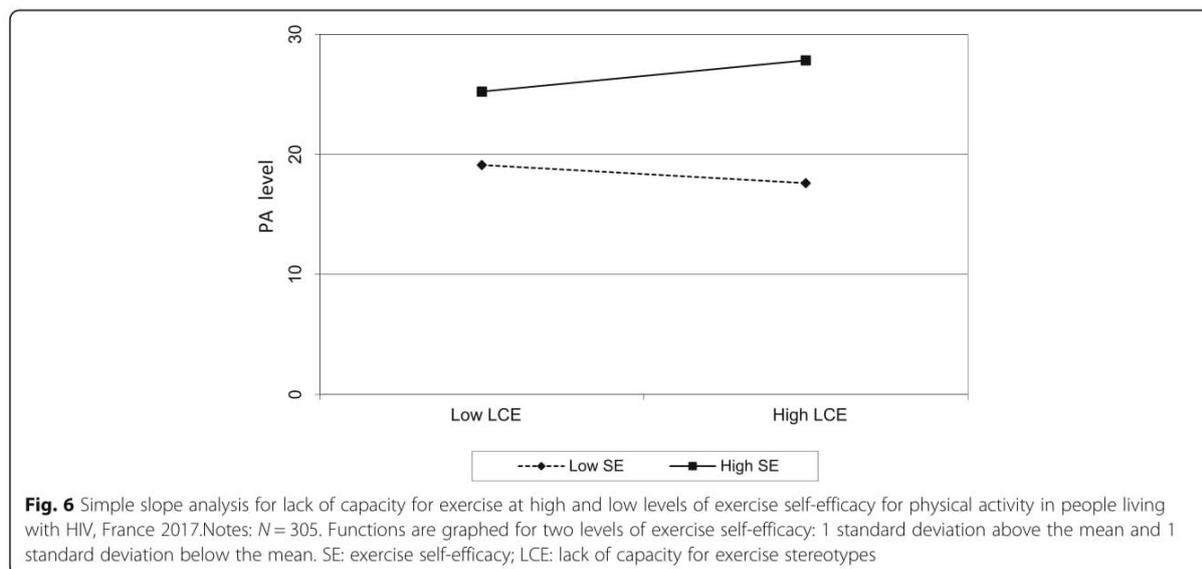
Results showed that indirect association between negative exercise stereotypes in terms of lack of capacity for exercise and PA via fatigue was fully moderated by exercise self-efficacy, explaining 27% of variance in PA level. For PLHIV with low levels of exercise self-efficacy, high negative exercise stereotypes are risk factors that increase their perceived physical fatigue, which in turn decreases their level of PA. In contrast, this negative chain is reduced in PLHIV with high levels of exercise self-efficacy. The moderated mediation model results are in

Table 4 Total, direct and indirect effects of exercise stereotypes dimensions as independent variables, perceived physical fatigue as mediator and exercise self-efficacy as a moderator on physical activity in people living with HIV, France 2017

	Mediators	IV → mediator(s)	Mediator(s) → DV	Total effect	Direct effect	Indirect effect	95% CI
BEN → PA	FAT	.07**	-.12	.09*	.07	.02*	[.002 to .040]
BENxSE→PA	FAT	-.16	-.12	-.16**	-.16**	-.003	[-.017 to .004]
RIS → PA	FAT	.001*	-.12	-.09	-.07	-.01*	[-.036 to -.001]
RISxSE→PA	FAT	-.06	-.12	-.06	-.06	.001	[-.009 to .018]
LCE → PA	FAT	.001**	-.12	-.17**	-.11	-.06	[-.116 to -.007]
LCExSE→PA	FAT	-.06**	-.12	.14*	.12	.02*	[.002 to .037]

Notes. $N = 305$, IV independent variable, DV dependent variable, BEN exercise benefits stereotypes, RIS exercise risks stereotypes, LCE lack of capacity for exercise stereotypes, SE exercise self-efficacy, FAT perceived physical fatigue, 95% CI lower and upper bound of bias-corrected 95% confidence interval with 5000 bootstrap samples

* $p < .05$. ** $p < .01$, *** $p < .001$



line with previous studies that have evidenced that stereotypes can influence health outcomes through an ego depletion mechanism as operationalized through perceived fatigue in self-control task performance [15] and subjective vitality in the physical activity domain [12]. Furthermore, our results enrich this literature by showing that exercise self-efficacy could act as a moderator in this mechanism.

The parallel model that was tested revealed a near but non reliable fit, suggesting that a dual pathway, considering internalization [3] and ego depletion [12] side by side, does not best describe the mediating role of self-efficacy and perceived physical fatigue in the relationship between exercise stereotypes and PA level. However, the near fit for this model encourages the importance of each of these mechanisms and calls for further investigation as to how these mechanisms interact.

The two viable models provide support for multiple pathways of influence of positive and negative exercise stereotypes in PLHIV (i.e., internalization and ego depletion), while suggesting their differential effects on PA level. The parallel and serial mediation models are contingent with recent research (see [12]) providing support for the role of both internalization and ego depletion mechanisms in the relationship between exercise stereotypes and health outcomes such as PA. Moreover, results suggest that exercise self-efficacy would play a complex role in the relationship between exercise stereotypes and physical activity, playing either a mediating role or a moderating role. However, the higher explained variance of the moderated model ($R^2 = .27$) suggests retaining the role of self-efficacy as moderator.

Limitations and future directions for research and intervention

This study points out some limitations. The data being of correlational nature, inferences can not be made about causal relationships between exercise stereotypes, mediators (perceived physical fatigue and self-efficacy), moderators (self-efficacy) and patients self-reported level of PA. Also, temporal causality cannot be inferred as the relationship between perceived physical fatigue and self-efficacy as regards to PA level could be recursive with a lower level of PA causing higher perceived physical fatigue or less self-efficacy which, in turn, discourages PA participation. Furthermore, the sample in this study presents specific sociodemographic characteristics in terms of gender, socioeconomic status and types and frequency of PA, thus limiting the generalization of the results. Moreover, although the moderated mediation model explains a higher variance in PA, further research is still needed to clearly establish the role of exercise self-efficacy as a mediator or as a moderator.

Despite these limitations, this study allows for several important implications in public health. First, as HIV is increasingly considered a chronic illness for people who have access to combined antiretroviral therapy, PLHIV are living longer and are faced with the health-related consequences of HIV [43–45]. Exercise presents itself as a self-management strategy that can limit disability, including mental, cognitive, physical and emotional symptoms, and enhance quality of life [46]. Hereby, the better understanding of the role of psychological barriers related to exercise stereotypes provided by the present findings, is of great interest to promoting a physically active lifestyle among PLHIV. Second, and more specifically, the fact that

positive exercise stereotypes are positively related to PA via exercise self-efficacy and perceived physical fatigue encourages the promotion of the benefits of PA among people living with HIV and health professionals through different communication strategies. Furthermore, exercise self-efficacy as a moderator of stereotypes related to lack of capacity for exercise points to the interest of positive individual PA experiences that nurture self-efficacy, through for example adapted physical activity offers and interventions [27]. Such perspectives however call for additional research based on the experimental manipulation of exercise self-efficacy and its effects on stereotype endorsement and health outcomes, and also call for longitudinal research to observe the effects of manipulated self-efficacy over time.

Conclusion

The moderated mediation model emphasizes that exercise stereotypes in people living with HIV might influence their PA through the ego depletion mechanisms as indexed by perceived physical fatigue, and be tempered by exercise self-efficacy. However, the relatively low explained variance for PA calls for further research, namely in order to investigate other variables in the relationship between exercise stereotypes and PA. Furthermore, it is of interest to consider the double status of exercise self-efficacy (moderator and mediator) in the relationship between exercise stereotypes and PA, as these roles enrich existing literature in the mechanisms at play [12] and encourage complementary experimental investigations.

Abbreviations

BEN: Exercise benefits; CFI: Comparative fit index; CI: Confidence interval; FAT: Perceived physical fatigue; HIV: Human immunodeficiency virus; LCE: Lack of capacity for exercise; NFI: Normed fit index; PA: Physical activity; PLHIV: People living with HIV; PPA: Previous physical activity; RIS: Exercise risks; RMSEA: Root mean square error of approximation; SE: Exercise self-efficacy; TL: Tucker-Lewis index

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Ethics approval

All procedures performed in this study involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent: Signed informed consent was obtained from all individual participants included in the study.

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Availability of data and materials

The dataset supporting the conclusions of this article is included within the article and its additional file.

Authors' contributions

LG oversaw collection of the experimental data, performed the statistical analysis, interpreted the results, and wrote the manuscript; AC contributed to the statistical analysis, interpretation of the results, and writing of the manuscript. JD provided knowledge related to HIV/AIDS, and collaborated on the general project to obtain funding; ER, CP, MD and IR contributed to the collection of data, provided specific knowledge related to HIV/AIDS, and collaborated on the general project to obtain funding; LS contributed to the data collection, interpretation of the results, and collaborated on the general project to obtain funding; SSC contributed to the development of the scale, and collaborated on the general project to obtain funding; FdAL was responsible for the scientific project and oversaw funding obtainment, oversaw the collection of data, contributed to the interpretation of the results, and helped write the manuscript. All authors have read and approved the final version of the manuscript and agree with the order of presentation of the authors.

Consent for publication

Participants were informed that all data collected would remain anonymous. That data would be treated statistically only and remain confidential.

Competing interests

On behalf of all authors, the corresponding author states that there are no competing interests.

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Summary of Study 3

Using the validated HIV Exercise Stereotypes Scale, this research sought to explore the plausible mechanisms at play in the relationship between HIV exercise stereotypes and PA level in PLHIV. Emile et al. (2014) reported that exercise stereotypes were related to PA level in older adults through perceived physical self-worth, giving credit to the internalisation mechanism (Levy, 2009). A further study by Emile et al. (2015) showed a direct relationship between exercise stereotypes and subjective vitality independently of older adults' perceived physical self-worth. Negative exercise stereotypes negatively predicted subjective vitality, suggesting the implication of the ego depletion mechanism (Muraven et al., 2000). In line with this literature, our study explored the internalisation mechanism indexed by self-efficacy as a situational measure of self-perceptions and the ego depletion account indexed by perceived physical fatigue (Hagger et al., 2010).

The moderated mediation model, in which the mediating role of perceived physical fatigue was moderated by self-efficacy, explained the highest variance in PA, thus providing support and enriching the ego depletion mechanism. This study was however limited by its correlational design and subjective measure of fatigue.

The fourth study of this doctoral work sought to overcome some of these limitations and looked to characterise the prevalent fatigue in PLHIV through an integrative approach taking into account both perceived fatigue and performance fatigability (Kluger et al., 2013), to date, never explored in this population. Moreover, as recent research (Webel et al., 2016a) advanced that perceived fatigue is lower in active PLHIV as compared to less active PLHIV, we also considered the level of PA of PLHIV.

Study 4

Characterising perceived fatigue and performance fatigability in active and less active people living with HIV

(Gray Laura, Lebesque Loïc, Durand Jacques, Rosenthal Eric, Pradier
Christian, d'Arripe-Longueville & Colson S. Serge.
Manuscript in preparation)

Introduction

In France, there are 6000 new HIV infections on average per year with 150000 people living with HIV (PLHIV). Though treatment can prolong the life expectancy and quality of life of those infected (Johnson et al., 2013; Lima et al., 2007), these treatments are costly. In addition, treatments can cause side effects and accentuate some of the HIV symptoms including fatigue. Studies focusing on the symptoms of HIV describe fatigue as one of the most prevalent symptoms with prevalence rates ranging from 37% to 88% (Phillips et al., 2004). Fatigue contributes greatly to physical limitations and disability making it essential to evaluate and treat (Ferrando et al., 1998). One of the biggest challenges faced by HIV/AIDS health-care professional is to characterize fatigue (Adinolfi, 2001) in order to lessen its impact on patients' quality of life. .

In light of the literature, PLHIVs' fatigue essentially reflects a multidimensional subjective complaint defined as a feeling of exhaustion or a lack of energy (Krupp, Alvarez, LaRocca, & Scheinberg, 1988; Lee, Lentz, Taylor, Mitchell, & Woods, 1994). To date, no biological factor appears to be a recurrent determining factor of fatigue in HIV infection (Barroso & Voss, 2013). Co-infection, like hepatitis C, could also participate to the fatigue symptom in PLHIV (Braitstein et al., 2010). Antiretroviral-based HIV treatments are also considered as factors that may influence perceived fatigue (Carr, Miller, Law, & Cooper, 2000; Gérard et al., 2000; Lars Hagberg Gunilla Lidin Janson, 2009). Psychological factors have been investigated and a strong correlation between depressed mood in PLHIV and fatigue was established (Barroso et al., 2003; Barroso & Lynn, 2002; Breitbart, McDonald, Rosenfeld, Monkman, & Passik, 1998; Henderson et al., 2005; Millikin, Rourke, Halman, & Power, 2003; Phillips et al., 2004; Voss, 2005). In advanced stages of the disease, fatigue is a symptom that is associated with depression but is not only a symptom of it (Ferrando et al., 1998). A study by Rabkin, Wagner, and Rabkin (1999) showed that even if depressed mood is

reduced, fatigue remains. Based on these studies, it is clearly recognized that multiple factors influence fatigue of PLHIV (Voss, Dodd, Portillo, & Holzemer, 2006). In this multidimensional approach, fatigue has only been evaluated using self-reported measures (i.e., questionnaires) that quantify perceived fatigue: Barroso & Voss, 2013; Voss et al., 2006) and reflect the so-called chronic fatigue. Surprisingly, other approaches using maximal muscular force loss, to quantify performance fatigability after a task or physical exercise has, to our knowledge, never been investigated in PLHIV.

In the scientific literature, fatigue induced by a task or physical exercise is defined as "a decrease in the ability of the muscle to develop strength or power induced by exercise, and reversible with recovery" (Bachasson, Guinot, et al., 2013a). Many studies have used this approach to characterize fatigue of different populations of individuals and under multiple experimental conditions. However, fatigue encompass both the perceived fatigue and performance fatigability (Kluger, Krupp, & Enoka, 2013). It is well accepted that the origin of performance fatigability may depend on peripheral factors and / or central factors. In patients with chronic diseases, these peripheral and central factors may be influenced by the pathophysiology of the disease. For example, in patients with multiple sclerosis, a lack of voluntary activation influences performance fatigability and contributes to perceived fatigue symptoms (Sheean, 1997). In another pathological context, central fatigue plays a major role in endurance loss and cancer-related fatigue (Yavuzsen et al., 2009). Also, in fibromyalgia syndrome, muscle contractility deficit is an important factor for patients' functional limitations (Bachasson, Guinot, et al., 2013a). Therefore, the characterization of fatigue (i.e., both perceived fatigue and performance fatigability) is a crucial step in identifying the factors to be taken into account in the interpretation of fatigue in PLHIV.

Another important unresolved issue is the potential influence of performance fatigability on perceived fatigue. For example, Lou, Benice, Kearns, Sexton, and Nutt (2003)

observed that a decrease in motor performance (i.e., performance fatigability) was not significantly correlated with perceived fatigue. Nevertheless, several foundations suggest a possible link between performance fatigability and perceived fatigue (Twomey et al., 2017). Decreased fatigue resistance during acute exercise may result in greater functional impairment, fatigue accumulation and require greater recovery time. This accumulation of fatigue would act indirectly on the perceived fatigue modifying the homeostatic conditions of functional regulation. Thus, only an integrated approach would make it possible to understand all the dimensions of fatigue and to identify the different factors that explain perceived fatigue and performance fatigability.

For better quality of life and expected life expectancy increases, different interventional studies aimed at reducing the perceived fatigue of PLHIV by using, for example, supplementation of thyroid hormones (Derry, 1996), or therapy with androgens such as testosterone (Rabkin, Ferrando, Wagner, & Rabkin, 2000) ,or the practice of a regular PA. For example, Webel, Perazzo, Decker, Horvat-Davey, Sattar, et al., (2016a) showed that for every 150 minutes of moderate PA practiced, perceived fatigue decreased by 17%. Unfortunately, perceived fatigue is also one of the major reasons for the non-involvement of PLHIV in PA practice (Ferez & Thomas, 2012). This observation is not specific to PLHIV and has been reported in multiple sclerosis (Iriarte, Katsamakis, & De Castro, 2016), Parkinson's disease (Garber & Friedman, 2003) and some neuromuscular diseases (Kalkman, Schillings, Zwarts, van Engelen, & Bleijenberg, 2007). However, a recent study conducted in healthy young people, indicated that training status (i.e., trained vs. untrained) and by extrapolation, the amount of PA practiced, significantly influenced performance fatigability (Bachasson, Decorte, Wuyam, Millet, and Verges 2016). Hence, one can postulate that physically active PLHIV may experience less perceived fatigue and less performance fatigability than less physically active PLHIV.

In this study, we seek to characterize perceived fatigue and performance fatigability in PLHIV based on their PA level. The main objective of our research is to study fatigue in a clinical research context (Kluger et al., 2013) based on two domains: perceived fatigue and performance fatigability induced by a fatiguing task. A second objective is to identify the role of PA on fatigue. Indeed, regular PA could reduce PLHIVs' perceived fatigue (Webel, Perazzo, Decker, Horvat-Davey, Sattar, et al., 2016a), but no research has examined the characteristics of perceived fatigue and performance fatigability in relation to the PA level of PLHIV.

Method

Participants

Seven PLHIV (6 men and 1 woman; Age = 55 ± 6 years, Height = 1.71 ± 0.07 cm, Body mass = 65.3 ± 10.5 kg, BMI = 22.3 ± 2.7 kg / m²) were recruited from the Archet 1 hospital of Nice and took part in this controlled, comparative monocentric study with no individual benefit for the patient. Participants read and signed written informed consent. In addition, to be included, PLHIV had to have a Physical Activity Score (SAP of Dijon; Robert et al., 2004) greater than or equal to 22 or less than or equal to 15. This questionnaire is composed of 9 items and has a maximum of 30 points. Based on the score, PLHIV were divided into two distinct groups: a group consisting of physically active individuals (i.e., SAP ≥ 22 ; APLHIV), and a group of individuals with low physical activity level (i.e., SAP ≤ 18 ; LPLHIV). This questionnaire was chosen as it has previously been used in PLHIV (Gray et al., 2018; 2016) and other populations with various pathologies (Falzon, Radel, Cantor, & d'Arripe-Longueville, 2015; Gremeaux et al., 2008). The main criteria for non-inclusion were PLHIV with a motor disability, with a contraindication to PA, suffering from co-morbidities, with a co-infection (hepatitis B or C), a contraindication to magnetic stimulation (hearing

apparatus or metal carriers), patients who have stopped ART treatment and / or medical follow-up recently and who have a progressive recovery of their infection. Participants were informed about the procedure, signed written informed consent and were free to leave the experiment at any time. The study was conducted in accordance with the Helsinki Declaration with the approval of the local Committee on Human Research (CPP Sud-Est; Clinical Study Number: NCT03124914).

Procedure

All included participants took part in one evaluation session. Upon arrival, participants were briefed and prepared for the neuromuscular fatigue protocol. Anthropometric and body measurements were taken and the participants filled-out the perceived fatigue questionnaire. After a period of familiarization, they completed the fatigue protocol with the neuromuscular assessments.

Anthropometric measures

Each participant was measured and weighed (i.e., Tanita BF 555 impedance balance) to determine body fat and lean mass. In addition, by measuring the circumference and the anterior skin fold of the right thigh, the quadriceps cross-sectional area (qCSA) was estimated by the following formula (Housh et al., 1995):

$$\text{qCSA} = (2,52 \times Cc) - (1,25 \times \text{ACF}) - 45,13$$

with qCSA = cross sectional area of the quadriceps (cm²), Cc = circumference of the middle of the thigh (cm) and ACF = anterior skin fold of the thigh (mm).

Perceived fatigue measures

The participants filled-out the EMIF-SEP questionnaire to assess their level of perceived fatigue. This questionnaire is the French version initially validated in patients with multiple sclerosis (Debouverie, Pittion-Vouyovitch, Louis, & Guillemin, 2007) of the Fatigue Impact Scale (FIS) developed and validated by Fisk et al. (1994) and widely used in PLHIV (Marcellin et al., 2007). This questionnaire includes 40 items to assess perceived fatigue and its impact on the cognitive (10 items), physical (10 items) and social (20 items) dimensions of the participants' daily life. Participants answered the different questions on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Knee extensor muscles' evaluation

The measurements were performed on the right lower limb under isometric conditions as previously described (Bachasson JEK 2013). The participant was placed on an isokinetic ergometer (Biodex® System 3, BIODEX Corporation, Shirley NY, USA). The positioning of the participants on the ergometer was standardized with a trunk / thigh angle of 130 ° and a knee / leg angle of 90 °. Belts positioned around the abdomen and the thorax secured the participants to minimize body movement. Participants crossed their arms on their chest with hands on their shoulders to avoid any interfering movement. The motor of the ergometer's axis was aligned with the knee joint's rotation axis. The lever-arm, attached to the motor's axis and parallel to the studied segment, was positioned two fingers above the external malleolus of the tested limb. Surface EMG signals (sEMG) of the right vastus lateralis (VL) were recorded according to SENIAM recommendations. Pairs of bipolar silver-chloride electrodes (10-mm diameter, Contrôle Graphique Medical, Brie-Comte-Robert, France) were positioned over the muscle belly of the muscle with a 25-mm interelectrode distance and the reference electrode was attached on the patella. Low impedance ($< 5 \text{ k}\Omega$) was obtained by

means of shaving and abrading the skin with emery paper and cleaning the skin with alcohol. sEMG signals were amplified (MP150 Biopac[®] Systems Inc., Holliston, MA, USA; CMRR = 110 db, Z input = 1000 M Ω , gain = 1000, A/D resolution = 16 bits), filtered with a bandwidth frequency ranging from 10 Hz to 500 Hz, and online digitized with a sampling frequency of 1000 Hz. Torque and sEMG were synchronized and stored on a portable computer for further off-line analysis.

Magnetic stimulation of the femoral nerve

Two magnetic stimulators (Magstim 200, Magstim Company Ltd, Whitland UK) connected by a dual stimulation module (BiStim Module, Magstim) were used to stimulate the femoral nerve using an eight-shaped coil (diameter 45mm, peak value of the magnetic field 2.5 T). The coil was positioned on the upper part of the femoral triangle laterally to the femoral artery. The optimal stimulation site was determined from a maximal unpotentiated twitch and a maximum electrophysiological response (M wave) of the VL muscle. The location of the coil was then marked on the skin to always stimulate the same area and was manually controlled by the same experienced investigator throughout the protocol. Single (1 Hz) and doublets (10 and 100 Hz) magnetic stimuli of 1-ms duration were delivered at maximum stimulator intensity (Bachasson, Millet, et al., 2013b; Gruet et al., 2016; Verges et al., 2009). The supramaximality of the stimulation was evaluated by stimulating the femoral nerve with an intensity ranging from 100% to 80% of the maximum intensity of the generator in 5% steps. Supramaximality was confirmed by the absence of reduction in the unpotentiated twitch and maximal M wave between the different stimulations, as previously observed (Verges et al., 2009; Gruet et al., 2016).

Knee extensor muscles fatigue protocol

Once the participant was familiarized, the neuromuscular test sequence and the fatigue protocol were performed according to the procedures reported earlier (Bachasson et al., 2016; Bachasson, Millet, et al., 2013b; Gruet et al., 2016; Verges et al., 2009) (see Figure 1). The participants started with a standardized warm-up on the ergometer. This included progressive submaximal isometric contractions of the knee extensor muscles performed intermittently for 4 minutes. This warm-up also allowed the subjects to become familiar to generate a specific torque with visual feedback. At the end of the warm-up, participants performed three maximal voluntary contractions (MVC) with 30 seconds of rest between each contraction (Gruet et al., 2016). Following these MVC allowing for muscular potentiation (Kufel, Pineda, & Mador, 2002), participants performed a sequence of neuromuscular tests including:

- A 5-s MVC during which a 1 ms double stimulation at 100 Hz followed by two double stimulations at 100 Hz and then 10 Hz (respectively Db_{100} and Db_{10}) delivered at rest after the MVC. These last two stimulations were 4-s apart respectively.
- 30-s after the first MVC, a second 5-s MVC was performed during which a single stimulation of 1Hz (Tw_s) was delivered followed by the same stimulation delivered at rest (Tw_p) after the MVC.

Once this sequence of neuromuscular tests was performed, the participant had to perform the fatigue protocol consisting of a progressive incremental test comprising several series of 10, 5 seconds on-5 seconds off intermittent voluntary contractions (Bachasson, Millet, et al., 2013b). The first set of 10 voluntary contractions was set at 10% of the previously determined MVC. The following series were performed with a 10% increase of the MVC for each series until the task failure determined by the inability to reach the target torque for two consecutive contractions. The participant could see the target torque exerted via a visual feedback on the screen of the computer throughout the experimental protocol. The

contraction and rest periods were punctuated by a rhythmic sound signal. At the end of each series of 10 contractions, at the time of exhaustion and after 10 minutes of recovery, the neuromuscular tests were performed identically to the pre-experimental measurements.

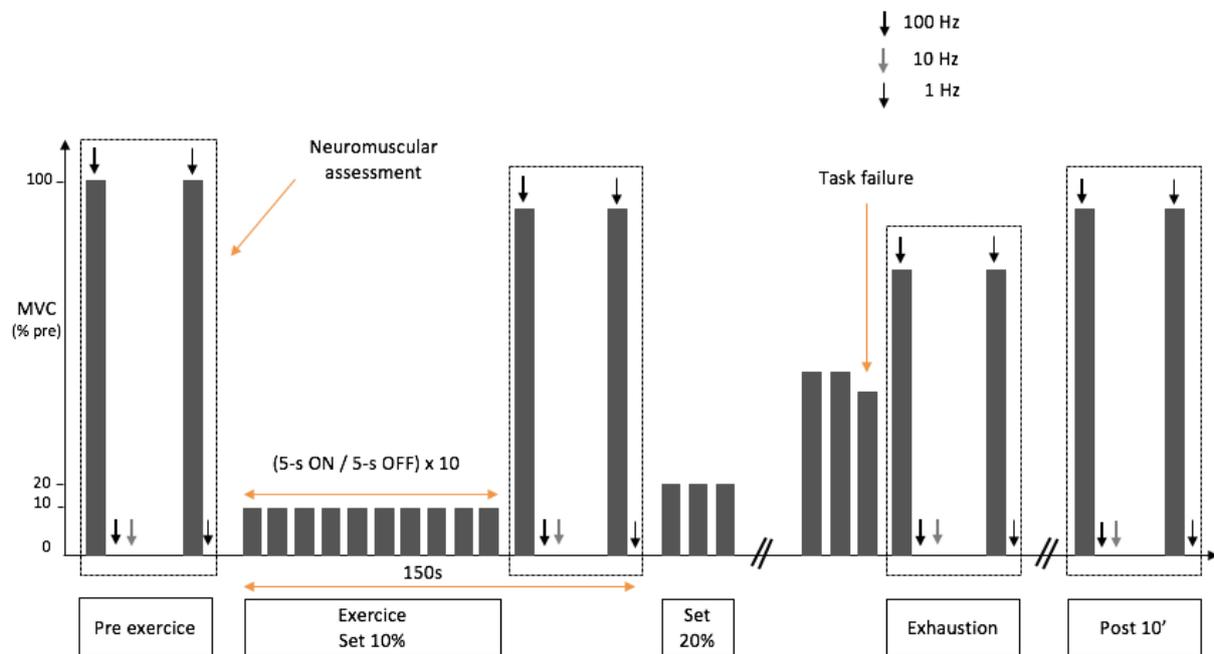


Figure 2. Neuromuscular fatigue test protocol.

Notes. MVC: maximal voluntary contraction; % pre: percentage of pre-test MVC; 100Hz: superimposed doublet and potentiated doublet; 10Hz: potentiated doublet; 1Hz superimposed and potentiated doublet; (5-s ON/5-s OFF) x 10: series of 10 sub-maximal contractions (5-s contraction/ 5-s rest); post 10': neuromuscular assessment after 10-minutes rest. Based on Bachason et al., (2013)

Data analysis

The peripheral responses to single magnetic stimulation were analyzed: amplitude and duration of T_{w_p} , amplitude and area of M_{max} . The following peripheral responses for doublets were analyzed: Db_{100} , Db_{10} , and the $Db_{10}: 100$ ratio. These parameters were also standardized with the previously estimated qCSA. The maximum voluntary activation level (VA) determined using interpolation twitch technique (Merton, 1954) was quantified according to Allen et al.'s (1995) formula:

$$VA (\%) = [1 - (\text{Amplitude } Db_{100s} / \text{Amplitude } Db_{100})] \times 100$$

When the stimulations were delivered before or after the maximum momentum plateau of the maximal voluntary contraction, a correction of the activation level calculation formula was applied (Strojnik & Komi, 1998):

$$AV (\%) = [1 - (\text{superimposed doublet} \times (M_{\text{stim}}/MVC)) / \text{potentiated doublet}] \times 100$$

with M_{stim} = voluntary momentum when the stimulation is applied.

The number of submaximal contractions was taken as the index of relative endurance while the total force-time output was taken as the index of absolute endurance. The changes in muscular responses obtained during spontaneous and evoked contractions between the initial evaluation (i.e., before the fatigue protocol) and at exhaustion were used as an index of fatigability. The changes in voluntary and evoked responses between exhaustion and recovery (i.e., post 10) were used as an index of recovery.

Statistical analysis

Statistical analysis was performed using Statistica® software for Microsoft Windows (StatSoft, version 8.0, Tulsa, OK, USA). The significance threshold was set at 5% ($p < 0.05$). The data was presented as the mean \pm standard deviation (SD). Before each analysis, the conditions of application of the various statistical tests were verified. A Mann-Whitney U test was performed to examine the differences between two groups (group factor) in pre-test, exhaustion and post 10. A non-parametric Friedman ANOVA was used to see the differences between several dependent variables during the fatigue protocol (time factor). A non-

parametric Wilcoxon test was performed on variables with a significant difference (time factor).

Results

The characteristics of active and less active PLHIV.

The PA scores of the inactive group of PLHIV was, as expected, significantly lower than the scores of the active PLHIV (see Table 1). No significant differences in the anthropometric measures (i.e., age, height, weight, IMC, qCSA) were observed between the two groups. Also, no significant differences were observed between the two groups as regards to their global perceived fatigue scores (global EMIF-SEP), the different sub-scales of the EMIF-SEP, and their pain and fatigue VAS (Table 1).

Table 1. Initial assessment based on reported PA level

	Less active	Active	P
<i>SAP</i>	12 ± 2	24 ± 2	< 0.05
<i>EMIF-SEP</i>			
Cognitive	2.70 ± 0.10	2.69 ± 1.49	0.51
Physical	3.43 ± 0.76	2.70 ± 1.48	0.51
Psycho-social	3.19 ± 0.67	2.64 ± 1.21	0.27
Global	3.11 ± 0.44	2.68 ± 1.39	0.82
<i>VAS</i>			
Initial fatigue	3.17 ± 3.81	1.60 ± 2.43	0.66
Initial pain	0.10 ± 0.17	0.15 ± 0.13	0.82

Notes. *SAP*: physical activity score ; *EMIF-SEP*: perceived fatigue questionnaire ; *VAS*: visual analogue scale

The neuromuscular function characteristics of the knee extensor muscles are shown in Table 2.

Table 2. Pre-test neuromuscular function in active and inactive PLHIV

	Inactive	Active	<i>p</i>
MVC (Nm)	104 ± 58	147 ± 26	0.27
qCSA (cm ²)	51.5 ± 10.1	65.2 ± 9.8	0.13
MVC/qCSA (Nm/cm ²)	1.6 ± 1.4	2.3 ± 0.4	0.82
<i>Evoked reponses</i>			
Simple potentiated stimulation			
Tw _p (Nm)	18.7 ± 9.3	30.5 ± 12.2	0.28
Tw _p /qCSA (Nm/cm ²)	0.36 ± 0.13	0.46 ± 0.12	0.51
Contraction time (ms)	62.3 ± 9.1	74.3 ± 28.3	0.83
Half relaxation time (ms)	97.0 ± 21.2	89.7 ± 13.3	0.56
M-wave amplitude (V)	1.34 ± 0.70	2.80 ± 0.44	< 0.05
Peak to peak M-wave duration (ms)	8.3 ± 0.3	9.0 ± 0.5	0.10
M-wave area (V.s)	0.011 ± 0.005	0.017 ± 0.004	0.28
Potentiated doublets			
Db ₁₀₀ (Nm)	11.3 ± 4.5	33.7 ± 13.6	< 0.05
Db ₁₀₀ /qCSA (Nm/cm ²)	0.22 ± 0.06	0.51 ± 0.17	< 0.05
Db ₁₀ (Nm)	7.4 ± 2.0	22.9 ± 15.1	< 0.05
Db ₁₀ /qCSA (Nm/cm ²)	0.15 ± 0.03	0.34 ± 0.18	< 0.05
Db _{10:100}	1.05 ± 0.56	0.73 ± 0.39	0.82
Central parameters			
VA (%)	72.7 ± 12.2	90.4 ± 4.6	< 0.05

Notes. MVC = maximal voluntary contraction ; qCSA = quadriceps cross sectional area ; Tw_p = single twitch at 1Hz ; Db₁₀₀ = doublet at 100Hz ; Db₁₀ = doublet at 10Hz ; VA = Voluntary Activation

No significant difference (*p* >0.05) between the 2 groups was observed for MVC (absolute values or values normalized by qCSA) and mechanical response induced by simple stimulations (Tw_p). On the other hand, the mechanical responses induced by double

stimulations (Db_{100} and Db_{10}) for both absolute values and values normalized by qCSA, were significantly higher in active compared to less active PLHIV ($p < 0.05$). Similarly, active PLHIV had a higher voluntary activation than less active PLHIV ($p < 0.05$). The M-wave amplitude of the VL muscle was significantly greater for the active group than for the inactive group ($p < 0.05$), whereas no difference was observed regarding the M-wave duration and area. Finally, although the root mean squared (RMS) values of the VL muscle were not different between the groups, the RMS / M ratio was significantly lower for the active PLHIV ($p < 0.05$).

Influence of the fatigue protocol

Endurance. The total number of submaximal contractions reached by active PLHIV (67 ± 9 , $p < 0.05$) was significantly higher than the inactive PLHIV (46 ± 7). The total force-time production of the active group (19993 ± 8130 Nm.s, $p < 0.05$) was significantly higher than the inactive group (7669 ± 5329 Nm.s) at exhaustion. After 40 contractions (i.e., level reached by all participants), total force-time production was not significantly different between groups ($p > 0.05$).

MVCs and evoked responses. For all participants, a significant effect of time on MVC was observed ($\chi^2(6) = 16.34$, $p < 0.01$). A significant difference was noted between the pre-test MVC values and the 30%, 40% and exhaustion levels ($p < 0.05$). The magnitude of the mechanical response T_{wp} was also affected by time ($\chi^2(5) = 11.09$, $p < 0.05$). Indeed, the pre-test values of 24.61 ± 11.63 Nm were significantly different from that at 40% (17.69 ± 14.71 Nm) and at exhaustion (15.92 ± 15.05 Nm). No significant differences were observed for the other variables.

Rate of perceived effort (RPE) and visual analogue scales. The subjective assessment of task difficulty (RPE) increased significantly between the 10% (1.08 ± 1.20), 20% (2.08 ± 2.09) and 30% (3.00 ± 2.74) increments for the 2 groups ($p < 0.05$ between each of the three levels). Similarly, the fatigue and pain VAS significantly increased between the beginning of the protocol and exhaustion ($p < 0.05$).

Post-test characteristics of active and inactive PLHIV and at 40% MVC.

When exhausted (post-tests), the mechanical responses T_{wp} and Db_{100} of the active group were significantly higher than those of the inactive (24.87 ± 18.05 Nm vs 6.97 ± 0.40 Nm and 23.48 ± 19.45 Nm vs 19.45 ± 4.15 Nm, respectively, $p < 0.05$). The M-wave amplitude and the RMS / M ratio of the VL muscle were significantly different between the groups ($p < 0.05$).

At the 40% MVC level, attained by all participants, similar results were observed for the same variables. Interestingly, the relative decrease percentage of T_{wp} in the active group was $16.8 \pm 22.5\%$, compared to $48.9 \pm 13.5\%$, with an effect size of 1.32 in the inactive group. Although no significant differences were observed for MVC values at 40% between the 2 groups, the relative MVC decrease percentage of active PLHIV was $12.2 \pm 5.6\%$ while that of inactive PLHIV was $22.5 \pm 12.2\%$. The effect size calculated on these differences was greater than 1, suggesting a large effect.

Recovery period

After 10 minutes of recovery, the MVC values were significantly different from the exhaustion values (105.26 ± 46.76 Nm vs. 93.65 Nm ± 39.29 , $p < 0.05$), even if the latter remained below the pre-test MVC values ($p < 0.05$). The T_{wp} values did not increase significantly compared to exhaustion and remained significantly lower than the pre-test values.

Discussion

With fatigue being the most prevalent symptom in PLHIV, the main aim of this study was to characterize the performance fatigability of active and less active PLHIV. The main findings show that: i) some neuromuscular factors of knee extensor muscles differ between both groups; ii) although the MVC decrease was not different at exhaustion between the two groups, a trend towards a lower MVC reduction was observed in the active PLHIV at the 40% level for similar absolute endurance among the groups; and iii) performance fatigability appears to be predominantly peripheral for both groups with inactive PLHIV revealing greater peripheral fatigue compared to active PLHIV.

Pre-test characteristics of active and inactive PLHIV

Although PLHIV included in each group had different PA scores, the perceived fatigue measures (i.e., EMIF-SEP, fatigue VAS) did not discriminate between the two groups of participants. This observation is also valid for the MVCs produced during the pre-tests where it was legitimate to expect a difference between the groups. Indeed, a significant difference in MVCs have been reported in the literature for healthy young participants with different training status (Bachasson et al., 2016). However, when effect sizes were calculated for the MVC values produced during the pre-test a moderate effect ($ES = 0.91$) was found between the two groups. This trend was confirmed by the differences observed between the groups on the absolute and relative mechanical response values induced by double stimulations (Db_{100} , Db_{10} , $Db_{100} / qCSA$ and $Db_{10} / qCSA$), the voluntary activation and the M-wave amplitude of the VL muscle. These observations give support to the possibility of favorable neuromuscular adaptations (e.g., greater muscle mass, motor unit recruitment and motoneuron excitability) induced by regular PA in active PLHIV and reinforce the importance of encouraging PLHIV to have physically active lifestyle.

Performance fatigability of the knee extensor muscles

The fatigue protocol chosen for this study has been widely used in the literature (Bachasson et al., 2016; Bachasson, Millet, et al., 2013b; Gruet et al., 2016) in healthy individuals and in patients with different conditions. The observed MVC decrease percentages and the number of contractions reached before exhaustion are in agreement with the data from these studies. In addition, the increase in RPE and fatigue and pain VAS values confirm that intermittent submaximal isometric contractions increased perceived effort and perceived fatigue at the end of the protocol, despite no differences between the groups being observed. However, although the MVC decrease was not significantly different at exhaustion between groups, active PLHIV had a lower tendency to decrease than inactive PLHIV at the end of the 40% MVC level for equivalent absolute endurance between the groups ($12.2 \pm 5.6\%$ vs. $22.5 \pm 12, 2\%$, $ES = 1.02$). Therefore, we could suggest that inactive PLHIVs' performance fatigability was greater than that of active PLHIV.

The decrease in MVC values at exhaustion could mainly be attributed to mechanisms of peripheral origin as the Tw_p values were significantly reduced while the voluntary activation levels and the RMS / M values were not significantly modified. This reduction of the Tw_p suggests an alteration of the excitation-contraction coupling. This alteration could in part be related to a decrease in membrane excitability since a decrease in the amplitude of the resting V wave of the VL muscle was also observed. These results were not found in healthy individuals (Bachasson et al., 2016; Bachasson, Millet, et al., 2013b) or patients with cystic fibrosis (Gruet et al., 2016). The decrease in membrane excitability observed in this study indicated that this alteration would mainly be related to physical inactivity. Indeed, an effect size calculation performed between the groups concerning the relative decrease of the M-wave at exhaustion and at 40% of the MVC value had a moderate effect on these values ($ES = 0.81$ and 0.79 , respectively) indicating that the decrease was greater for inactive PLHIV.

Inactive people would therefore tend to develop more peripheral fatigue than active people (Bachasson et al., 2016).

No difference in the level of voluntary activation was observed between pre-test and exhaustion values or between groups of PLHIV. Along with the absence of RMS / M ratio modifications of the VL muscle, it would seem that no central nervous mechanisms could explain the decrease of MVC value, either at exhaustion or at 40% of MVC. Indeed, this protocol of intermittent sub-maximal isometric contractions is recognized to induce little fatigue of central origin (-5% at exhaustion; Bachasson, Millet, et al., 2013b).

Performance fatigability and perceived fatigue

The absence of a significant difference in the perceived fatigue subscales EMIF-SEP) between the groups does not corroborate the results found by Weibel et al. (2016a) showing that regular PA resulted in less perceived fatigue. This result could be partly explained by the small sample size, which does not make it possible to distinguish differences statistically. However, a significant positive correlation ($r = 0.64$) between the EMIF-SEP physical fatigue subscale scores and the pre-test VAS fatigue scores was observed for all patients. PLHIV with the highest EMIF-SEP scores (measuring relatively general characteristics) were also those who reported high VAS fatigue scores (measuring situational psychological states).

During the fatigue protocol, one could expect to observe differences in the RPE values according to previous research showing that people with good physical fitness had lower perceived effort scores for a given task, compared to people in poorer physical condition (Travlos & Marisi, 2016). Again, the small number of patients in each group limits our interpretation even though the calculated effect size between the RPE values of the two groups between the 10% and 40% levels indicated a large effect on these values ($ES = 1.11$).

Limitations and perspectives

The major limitation of this study lies in its low number of patients included due to the recruitment difficulties encountered. Thus, the possibilities of interpretation and discussion are limited. The use of magnetic stimulation, although better endured by patients than electrical stimulation, remains a limited tool. Indeed, not being able to exceed 100% of the maximum power of the generator, certain stimulations are not always delivered under supramaximal conditions throughout the fatigue protocol due to the loss of excitability of the motoneurons. The use of accelerometer data to objectify the level of PA is also a way to overcome the subjectivity of the PA score using the SAP. It has been recommended as a tool to quantify the PA of patients with cystic fibrosis (Savi et al., 2013). Equipping patients with accelerometers as recommended by Migueles et al. (2017) would attest patients actual PA level.

Conclusion

In conclusion, despite its limitations, this study offers promising perspectives in understanding the mechanisms underlying perceived fatigue and fatigability in PLHIV based on their PA level in line with the integrative approach by Kluger et al. (2013). These results also encourage experimental and interventional studies that would examine the effect of PA on the pluridimensions of fatigue.

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Summary of Study 4

Fatigue is by far the most prevalent symptom in PLHIV, with prevalence rates of up to 88% (e.g., Henderson et al., 2005; Jong et al., 2010; Phillips et al., 2004; Webel et al., 2016a). To date, fatigue has only been studied as a subjective complaint in PLHIV. The main goal of this study was to characterise the prevalent fatigue in PLHIV through an integrative approach, taking into account both perceived fatigue and performance fatigability (Kluger et al., 2013), all the while considering the PA level of PLHIV (Webel et al., 2016a).

A progressive intermittent isometric sub-maximal contraction task was used to evaluate performance fatigability in active and less active PLHIV based on neuromuscular fatigue protocols reported in the literature (e.g., Bachasson, Decorte, Wuyam, Millet, & Verges, 2016; Gruet et al., 2016). The main results revealed that some neuromuscular characteristics differed between active and less active PLHIV, including M-wave amplitude and potentiated doublets. A less significant downward trend in MVC decrease at 40% for similar absolute endurance in less active PLHIV was also observed, even though the MVC decrease was not significant at exhaustion between the two groups. Lastly, performance fatigability appeared to be predominately related to peripheral factors in both groups with greater influence of these peripheral factors reported in less active PLHIV as compared to active PLHIV.

This study offers valuable perspectives in understanding the mechanisms at play in the relationship between perceived fatigue, performance fatigability and PA level in PLHIV. Measuring fatigue through a neuromuscular approach is a promising avenue for an objective measure of the most prevalent symptom in PLHIV. The next two studies examine how the psychological context (namely stereotype activation and self-efficacy) might influence performance in fatiguing tasks. In line with the role of lack of capacity for exercise stereotypes evidenced in Study 3 (Gray et al., 2018), we took a specific interest in the influence of the nonexerciser stereotype threat.

Study 5

Does self-efficacy modulate the effect of stereotype threat on performance on a fatiguing task in less active people living with HIV?

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Manuscript in preparation)

Abstract

Based on stereotype threat theory (Steele & Aronson, 1995), we looked to elucidate the effect of the emerging nonexerciser stereotype on performance in a group of less active PLHIV. Furthermore, based on the findings of a study by Gray et al., (2018) showing that self-efficacy could moderate the relationship between negative exercise stereotypes and PA level we sought to observe the modulating role of self-efficacy between stereotype activation and performance.

Eighteen PLHIV were recruited to participate in two experimental sessions in which both a stereotypical context and self-efficacy were manipulated. Participants repeated a 15-s MVC fatiguing handgrip task proceeded and followed by 5-s MVCs measuring pre- and post-exercise fatigue four times (Control 1; Control 2; Stereotypical; High self-efficacy or Low-self-efficacy).

Results revealed a significant performance decrease on the average force output during the 15-s handgrip fatiguing task when the nonexerciser stereotype was induced. Performance increased again after a high self-efficacy manipulation. For the pre- post-exercise 5-s MVCs a significant condition effect was observed across both sessions.

Our results revealed a classical detrimental stereotype threat effect on performance during a handgrip task when the nonexerciser stereotype was activated among less active PLHIV. When a high self-efficacy feedback was given, participants' performance increased significantly compared to the stereotypical condition indicating that self-efficacy can moderate the deteriorating effect of a negative exercise stereotype on task performance in less active PLHIV.

Key words: Self-efficacy; Nonexerciser stereotype; Stereotype threat; Handgrip task;

HIV

Introduction

The stereotype threat theory posits that a threat is present in certain situations where there are known stereotypes in performance (Steele, 1997). The outcome of this threat results in underperformance on stereotype relevant tasks (Steele & Aronson, 1995). Participants find themselves in a predicament as their performance could confirm a negative societal stereotype as self-characteristic (Steele, 1997). Furthermore, the effects of stereotype threat are considered to be moderated by stereotype relevance in the test setting (Steele, 1997), domain identification (Steele, 1997; Steele et al., 2002) and test difficulty (Steele & Aronson, 1995; Steele et al., 2002). Stereotype threat has been studied to a great extent in the cognitive domain (Spencer, Steele, & Quinn, 1999; Steele & Aronson, 1995). Fewer studies focused on physical competence and motor skills (Chalabaev, Sarrazin, Stone, & Cury, 2008a; Hively & El-Alayli, 2014; Stone, Lynch, Sjomeling, & Darley, 1999). Most of these studies revealed the effect of sex stereotypes on performance outcomes (Beilock, Jellison, Rydell, McConnell, & Carr, 2006; Chalabaev et al., 2013; Chalabaev, Stone, Sarrazin, & Croizet, 2008b; Hermann & Vollmeyer, 2016; Hively & El-Alayli, 2014). For example, Chalabaev, et al. (2008a) showed that in a soccer dribbling task, overall evaluated speed on the drill, was significantly slower for females under stereotype threat than for those without threat. This line of research suggests that sex-stereotype threat is salient in the sensorimotor domain, warranting further questioning concerning the influence of different stereotypes on performance outcomes.

A new nonexerciser stereotype has emerged in the literature (Martin Ginis & Leary, 2006). The nonexerciser stereotype probably having its roots in “healthism” (Martin Ginis & Leary, 2006) defined as health-promoting activities with a moral obligation and considering those who do not practice such behaviors to be weak, deviant and without virtue (Crawford, 1980; White, Young, & Gillett, 1995). Nonexercisers are thus perceived, by both exercising

and non-exercising people, as less healthy, less energetic, unfit, less strong and weaker (Lindwall & Martin Ginis, 2010; Martin Ginis & Leary, 2006; Martin, Sinden, & Fleming, 2000; Rodgers, Hall, Wilson, & Berry, 2009). Studies observing the possible effects of this exercise stereotype have focused mainly on impression formation {Lindwall:2010be, MartinGinis:2006da, Rodgers:2009bt} but have not, to our knowledge, manipulated the exercise stereotype in its negative or positive forms. Recent research has taken a specific interest in exercise related stereotypes in vulnerable populations such as the elderly (Emile, Chalabaev, Stephan, Corrion, & d'Arripe-Longueville, 2014), cancer patients (Falzon et al., 2014) and people living with HIV (Gray et al., 2016) looking at the associations between exercise stereotype endorsement and PA and revealing associations between negative exercise stereotypes and PA. Based on this research, we looked towards the stereotype threat model to observe the manipulated effects of this nonexerciser stereotype in PLHIV.

Stereotypes are of a pervasive nature and are difficult to change. Recent research looked towards ways of challenging and overcoming stereotype threat. Among these ways, providing counter-stereotypes or stereotype inconsistent information at encoding (Radvansky, Lynchard, & Hippel, 2008), using coping models (Dijksterhuis et al., 1998), or avatars (Ratan & Sah, 2015), have been shown to be effective to reduce stereotype threat in different tasks. Further studies have focused on the role of individual's perception of their ability in a task. This line of research looked at priming the implicit theory of ability (Burnette, Pollack, & Hoyt, 2010; Emile et al., 2017; Froehlich, Martiny, Deaux, Goetz, & Mok, 2016; Good, Aronson, & Inzlicht, 2003). For instance, in a verbal intelligence test, higher entity theory (i.e., perceiving abilities as stable and unchangeable) endorsement predicted stereotype threat effects for Turkish-origin students, and stereotype lift effects for German students (Froehlich et al., 2016). In addition, Emile et al. (2017) revealed that stereotype-inconsistent information could improve physical performance on a handgrip task for older people who hold

incremental beliefs (i.e., seeing abilities as changeable). Furthermore Wang, Zhou, Tan, and Zhang (2017) suggested that incremental theorists may be more willing to re-appropriate stigma through reframing and self-labeling. In the same vein, affirming personal values can buffer against individual self-threats and group-relevant identity threats as evidenced by an improvement in women's performance in competitive environments where they were negatively stereotyped (Kinias & Sim, 2016).

These studies suggest that perceived control and competence may be key mechanisms in ways of overcoming stereotype threat. Beyond the actual skills or abilities individuals possess, self-efficacy is the "belief in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura, 1997), suggesting developing task self-efficacy would be a manner of reducing the effects of stereotype threat. It is self-efficacy that determines whether a given behavior will be initiated, how much effort will be expended, and how long the effort will be sustained in the face of obstacles and aversive experiences (Bandura, 1997). Several studies have proposed that specific self-efficacy would be one of the psychological mediators of stereotype threat (see Pennington, Heim, Levy, & Larkin, 2016 for a review). When focusing on the role of manipulated self-efficacy, Hansen and Wänke (2009), for example, showed that self-efficacy could be influenced by stereotype-activation as participants primed with professors were more confident as regards to their intellectual performance than participants primed with secretaries. Moreover, studies have also shown that self-efficacy mediated the role between stereotype-activation and behavior with higher self-efficacy beliefs resulting in better performance (Hansen & Wänke, 2009; Wang et al., 2017).

In the physical activity domain, a recent correlational study by Gray et al. (2018) focused on the role of self-efficacy and perceived physical fatigue in the relationship between exercise stereotypes and PA participation in PLHIV. The results showed that exercise self-

efficacy moderated the mediating role of perceived physical fatigue in the relationship between exercise stereotypes and PA level. Specifically, self-efficacy moderated the role of exercise stereotypes related to lack of capacity: high levels of self-efficacy reduced the perception of lack of capacity for exercise, perceived physical fatigue was lower and in turn PA level was higher whereas low self-efficacy increased lack of capacity for exercise which increased perceived physical fatigue and reduced the level of PA.

These results provide support to the theory of self-account (Wheeler et al., 2007) in which self-concept is considered a moderating variable between stereotype activation and behavior. In line with this literature, the present research looked to examine the effects of stereotype threat on handgrip performance in less active PLHIV and the modulating effect of self-efficacy. We hypothesized that stereotype threat would have a detrimental effect on performance fatigability resulting in lower force development over the 15-s handgrip task. Concerning self-efficacy, we emitted the hypothesis that, when in the HSE condition, participants would benefit from a performance increase compared to the stereotypical condition and that in the LSE condition, participants would experience a further decrease in performance compared to the stereotypical condition.

Method

Participants and design

Eighteen non-exercising middle aged ($M=53.68$; $SD=5.12$) men ($N=7$) and women ($N=11$) living with HIV were took part in the experimental procedure consisting of two visits separated by at least one week. All participants were under antiretroviral therapy for at least 5 years and reported having stable viral loads. Each participant was assigned to both of the following randomized sessions: high self-efficacy (HSE) and low self-efficacy (LSE) related to handgrip performance. Before recruitment, participants were asked to fill out a physical

activity questionnaire (Physical Activity Score of Dijon, SAP). Participants were included in the study if their SAP score was equal to or lower than 20/30 suggesting that they were non-exercising PLHIV. Of over 40 participants screened in two associations, 18 participants met the inclusion criteria and accepted to take part in the study. The study was conducted according to the Declaration of Helsinki and participants were informed and signed a written consent form prior to the study. Prior to the first visit, participants were encouraged to wear an actigraph accelerometer to count the number of steps taken during four days including two week days and two week-end days to ensure that they were non-exercisers (i.e., less physically active). Participants were asked not to take part in any form of physical exercise the day before the scheduled experimental procedure to ensure no experimental bias.

Procedure

At the first visit, participants were familiarized with maximal voluntary contractions with the instruction to “squeeze as hard and as fast as possible to maximum force”. This familiarization also served as a warm-up procedure. Once they felt accustomed with handgrip strength production the experimental procedure started. At the second visit, participants only performed submaximal contractions for warm-up purposes.

During each visit, participants were asked to perform an identical neuromuscular sequence four times (e.g., T0, T1, T2 and T3; Figure 1). A sequence comprised a 5-s maximal voluntary contraction (MVC), followed by a 15-s fatiguing MVC immediately followed by another 5-s MVC. Whatever the contraction, participants had to “squeeze the handgrip as hard and as fast as possible to maximum force and to maintain it until they hear the experimenter say stop”. During all measures, participants were not verbally encouraged and no visual feedback was provided. Participants were given a 5-minute rest period between each sequence.

Participants received the stereotype threat context information during the 5-minute resting period between T1 and T2. The following study information was given: “From this moment forward we are going to focus on your handgrip strength performance. We are interested in the differences between people who exercise regularly (considered as active) and people who do not exercise regularly (considered as less active). For this, you are going to perform a long MVC once again. We are going to observe strength parameters and indicators of fatigue that show, according to scientific literature, that there are notable differences in performance between regularly active people and less active people. Indeed, in such task, less active people are more fatigued and have lower performance than active people”.

Following this sequence under stereotype threat context information (T2), participants performed a last sequence (T3) with performance feedback based on exercise self-efficacy provided during rest between T2 and T3. In the high self-efficacy (HSE) condition participants were congratulated and informed that their performance placed them in the top 10th percentile for handgrip strength and endurance, based on normative values for individuals of similar age and gender (Hutchinson et al., 2008). Conversely, in the low self-efficacy (LSE) condition participants were told that their performance was in the bottom 10th percentile for similar age and gender. HSE and LSE conditions were randomly presented across participants.

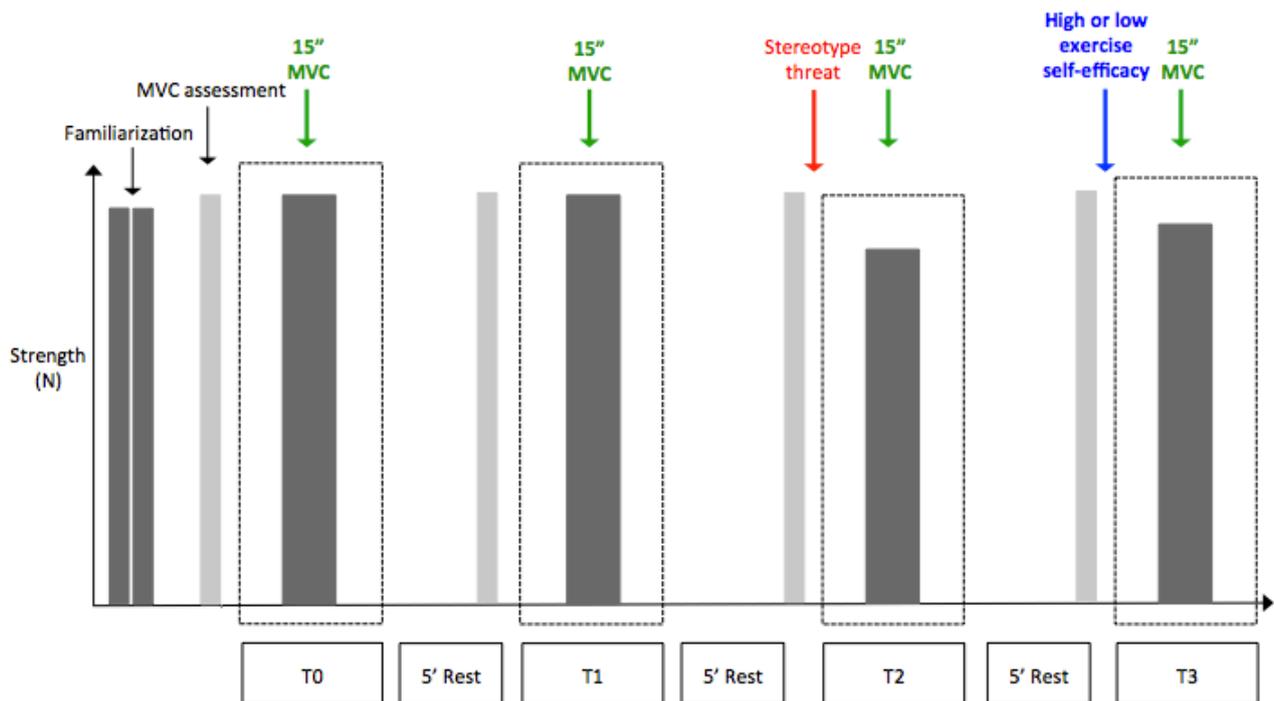


Figure 1: Study protocol

Materials

Handgrip strength was measured using the MicroFET 4 dynamometer (Hoggan Health Industries, West Jordan, UT) and data was stored on a computer through wireless connection. Participants were seated with the shoulder of their dominant writing hand adducted and neutrally rotated with the elbow flexed at 90° and the forearm and wrist in neutral position in accordance with the standardized position recommended by the American Society of Hand Therapists (Fess & Moran, 1981). Hand dominance was determined by asking each participant if she/he was right- or left-handed.

Measures

Identification to physical activity domain. Before the experiment, two items based on Chalabaev et al. (2013) were assessed on a 7-point scale to ensure that participants considered

athletic ability important. A mean score of four or higher characterized exercise domain identified participants.

Handgrip Performance. Measures of performance include instantaneous force (peak MVC), the mean force for the 500-ms MVC calculated from 50-ms to 350-ms, the average force of the 15-s fatiguing MVC. Global fatigue was measured using the difference between 5-s MVCs pre and post 15-s fatiguing MVC measures.

Stereotype manipulation check. For manipulation check participants were presented four items: “According to me, in the physical activity domain, the performance level of people who do not exercise is...”; “According to me, the physical activity domain, the performance of people who exercise is ...”; “According to me, in the physical activity domain, the fatigue of people who do not exercise is...”; “According to me, in the physical activity domain, the fatigue of people who exercise is...”. They were asked to rate their answer on a 7-point Likert scale (1= “much weaker/lower”; 7= “much better/higher”).

HIV Exercise Stereotype Scale (HIVESS) scores. Participants completed the HIVESS developed and validated by Gray et al. (2016) to measure the endorsement of exercise stereotypes in PLHIV. Participants rated 5 items related to exercise benefits (e.g., “Practicing a physical activity improves the morale of HIV-infected patients”, 4 items measuring exercise risks (e.g., “Practicing a physical activity should be avoided by HIV-infected patients because it causes injuries”) and 5 items related to the lack of capacity for exercise (e.g., “HIV-infected patients do not have enough physical resources to practice a physical activity”) on a 6-point Likert scale ranging from (1= “Do not agree at all” to 7= “Totally agree”).

Statistics

The statistical analysis was run on all four conditions in the two sessions. Data normality was confirmed using a Kolmogorov Smirnov analysis. One group (non-exercising

PLHIV) \times 4 conditions (control 1 vs. control 2 vs. stereotypical vs. SE) \times session (HSE or LSE) \times 2 time measurements (pre- and post-exercise) repeated measures ANOVAs on all factors compared the absolute MVC values to explore the effect of stereotypical and high or low self-efficacy information on pre- and post-exercise MVCs. One group (non-exercising PLHIV) \times 4 conditions (control 1 vs. control 2 vs. stereotypical vs. SE) \times session (HSE or LSE) repeated measures ANOVAs on condition and session were conducted to explore the effects of stereotypical and high or low self-efficacy information on performance of the 15-s fatiguing MVCs. Newman-Keuls post-hoc tests were used to assess for differences among pairs of means when appropriate. Effect sizes were computed from partial eta² (η^2) and the significance level was set at $p < 0.05$. Association between two variables were quantified using Pearson's product-moment correlation coefficient.

Results

Stereotype manipulation check. The stereotype manipulation showed good adherence of all the participants with rates for the performance of people who do not exercise being lower (2.12 ± 0.59) compared to high scores for the performance of people who do exercise (6.37 ± 0.52). Similarly, fatigue was considered higher in regard to people who do not exercise (6.03 ± 0.42) as compared to people who exercise (1.87 ± 0.47). These results suggest that all participants understood the stereotype context induced.

HIVESS scores. Participants revealed high scores for exercise benefits (5.11 ± 0.56). Exercise risks were rated much lower (1.65 ± 0.47) with lack of capacity for exercise being moderately rated (2.99 ± 0.62).

Handgrip Performance. For MVC values no significant overall interaction (i.e., conditions \times session \times time) was revealed ($F(3,51) = 0.313$; $p = .816$; $\eta^2 = .02$). However, a significant conditions \times session interaction effect was observed ($F(3,51) = 17.24$; $p < .001$; $\eta^2 =$

.50). Post-hoc comparisons of pooled pre and post MVC values indicated that control 1 and control 2 conditions did not significantly differ within each session ($p > 0.05$) nor between sessions ($p > 0.05$). Stereotypical MVC values were depressed in comparison to control values in both sessions (session HSE: $0.01 < p < 0.001$; Figure 1; session LSE: $p < 0.001$; Figure 2). Finally, HSE MVC values re-increased compared to the stereotypical MVC values ($p < .001$; Figure 1) whereas no significant difference was observed between stereotypical and LSE MVC values ($p = 0.18$; Figure 2). In addition, a significant main time effect was noted ($F(1,17) = 54.04$; $p < .001$; $\eta^2 = .76$) with post-exercise MVCs values lower than pre-exercise whatever the condition and session considered. This observation indicated that our 15-s fatiguing exercise was effective to induce fatigue as attested by the MVCs values depression. MVC values were systematically reduced between 22.33 ± 10.57 to 29.42 ± 12.12 % across conditions of both sessions (see Figures 1 and 2).

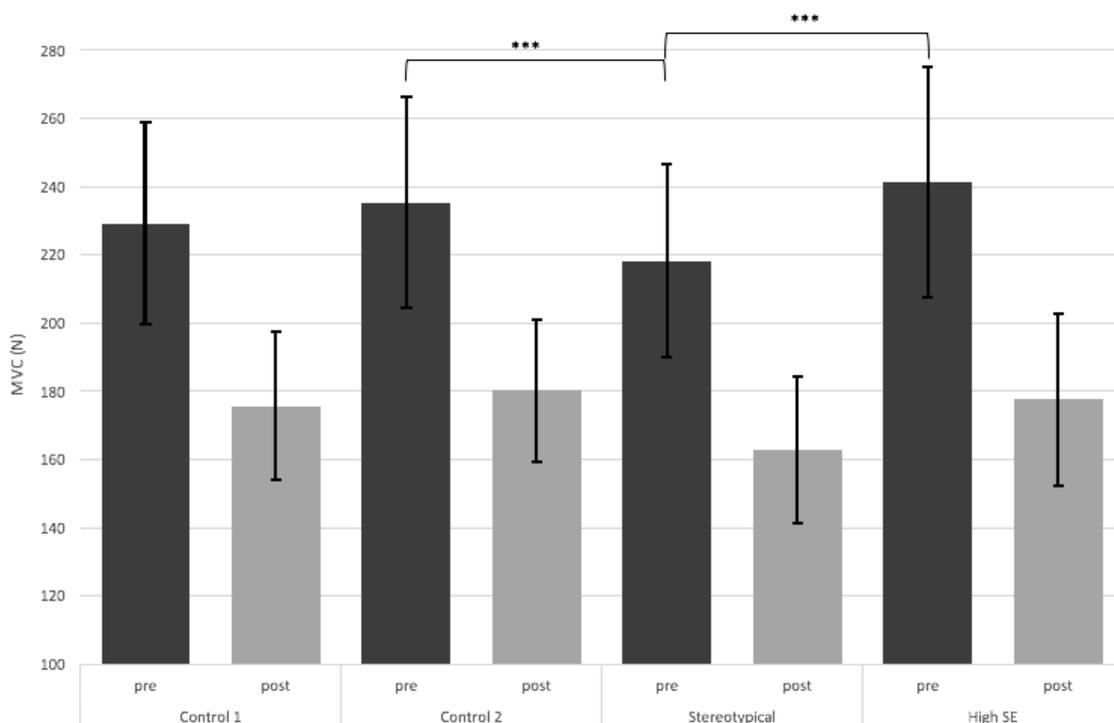


Figure 1: Pre- and post-exercise 5-s MVC values for all conditions in the HSE session.

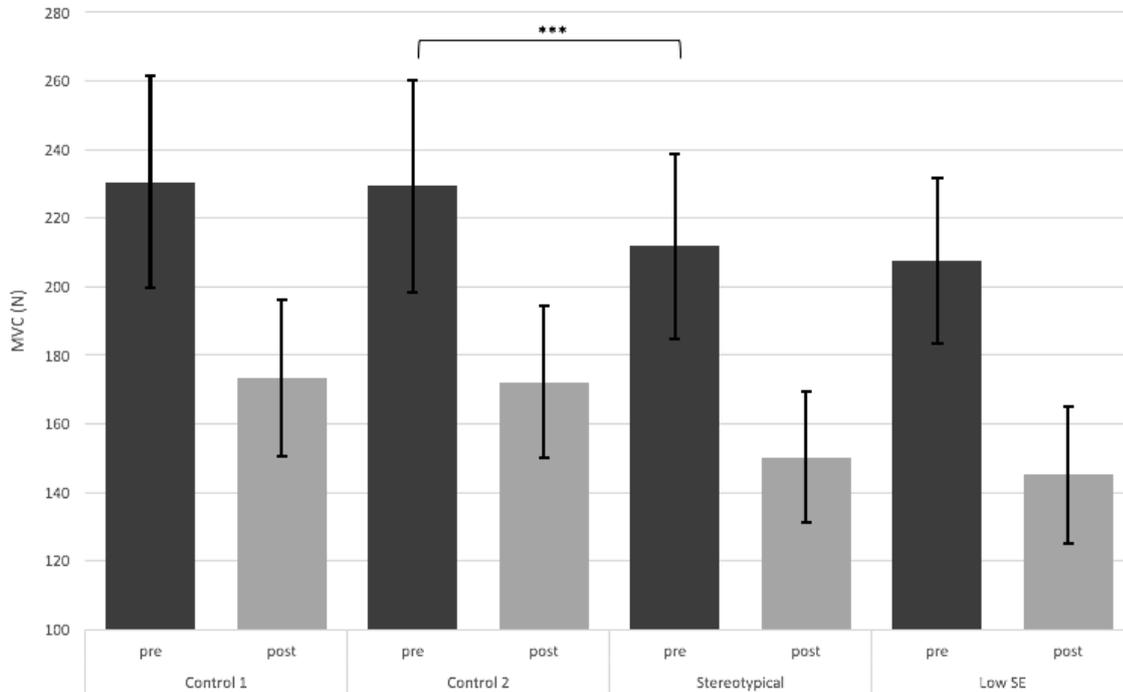


Figure 2: Pre- and post-exercise 5-s MVC values for all conditions in the LSE session.

The 15-s fatiguing MVC performances revealed a significant condition \times session interaction effect: $F(3.51) = 17.74$; $p < .001$; $\eta^2 = .51$. In both sessions, performances across control conditions (i.e., 1 and 2) did not differ. The stereotypical performance was characterized by lower average force output during the 15-s MVC (session HSE: $0.01 < p < 0.001$; Figure 3; session LSE: $p < 0.001$; Figure 4). Furthermore, a significant re-increase in average force output was noted in the HSE session ($+12.69 \pm 11.60\%$; $p < 0.001$; Figure 3) compared to the stereotypical condition (181.05 ± 42.87) whereas, no significant difference ($p = 0.08$) was observed between the stereotypical (176.95 ± 53.56 N) and the LSE (169.70 ± 51.46 N) conditions (Figure 4).

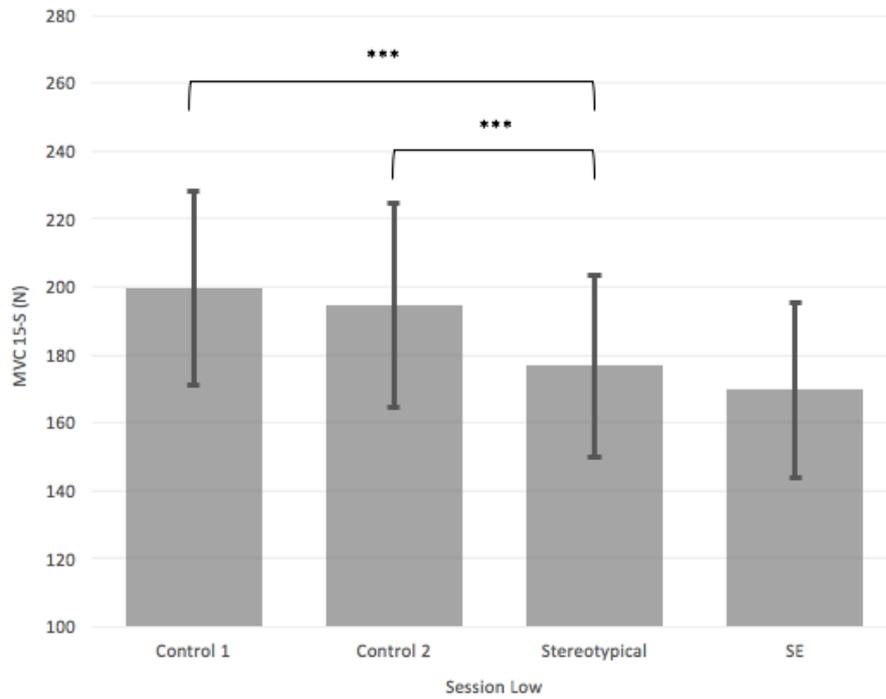


Figure 3: 15-s MVC values expressed in mean force development for all conditions in the LSE session. *Notes:* SE: self-efficacy; *** $p < .001$

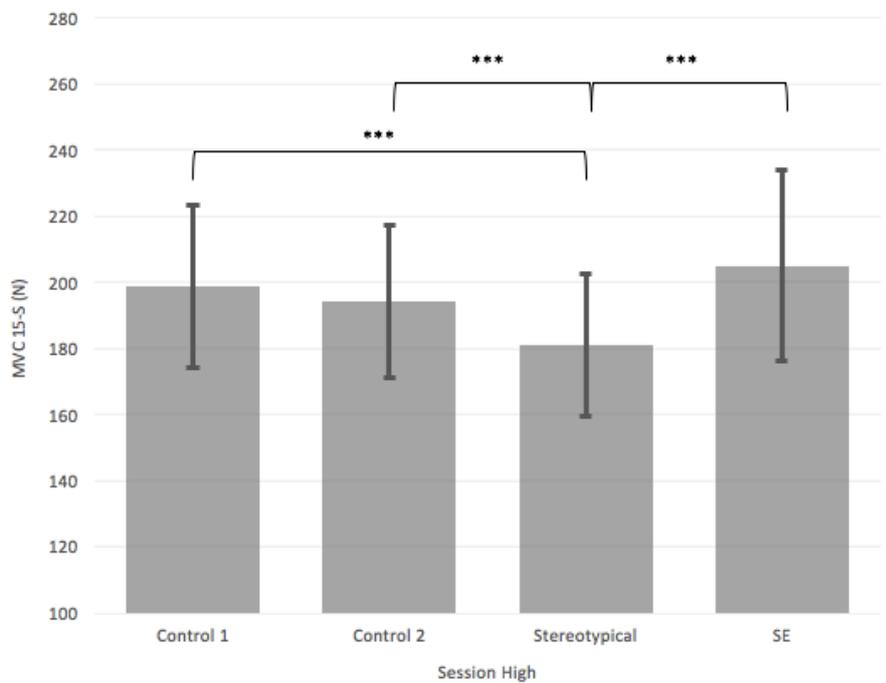


Figure 4: 15-s MVC values expressed in mean force development for all conditions in the HSE session. *Notes:* SE: self-efficacy; *** $p < .001$

Discussion

The purpose of this study was to elucidate the effect of the nonexerciser stereotype on performance in a group of less active PLHIV and to consider self-efficacy as a possible moderator of this stereotypical context. In line with our hypotheses, our results revealed a significant negative effect of the nonexerciser stereotype on less active PLHIVs' handgrip task performance (i.e., both the pre- and post-exercise MVC values as well as the 15-s fatiguing MVC). Furthermore, self-efficacy was shown to moderate the effect of the nonexerciser stereotype with performances increasing after a high self-efficacy feedback.

In regard to the negative effect of the nonexerciser stereotype on fatiguing task performance in less active PLHIV, the classical stereotype threat effect was evidenced (Steele, 1997, 1998). Less active PLHIV underperformed when confronted with a negative stereotype related to their level of PA. Thus, the nonexerciser stereotype would affect PLHIV's performance in the PA domain in line with the stereotype threat literature focusing mainly on the sex-stereotype (e.g., Chalabaev et al., 2008; Hively et al., 2014; Stone & McWhinnie, 2008). Interestingly, our result also revealed that not only the fatiguing task was affected by the nonexerciser stereotype activation; indeed, the pre- post-exercise fatigue measured by 5-s MVCs increased in the stereotypical conditions as compared to the control conditions. These results are consistent with studies among older adults in which stereotype threat had a detrimental effect on handgrip performance on different measures including grip persistence (i.e. the time grip was maintained) and grip strength (i.e. the force produced) (Swift, Lamont, & Abrams, 2012). Swift et al. (2012) used social comparison as a means to activate stereotype threat in older adults and age comparison led to decreased strength performance and persistence in handgrip tasks. Chiviacosky et al. (2018) found similar detrimental effects of negative stereotype context induced via social comparison on a balance task but with delayed onset, suggesting that motor learning was affected.

With the nonexerciser stereotype negatively affecting performance in a fatiguing task in less active PLHIV, the need to explore possible strategies to overcome stereotype threat takes all its meaning. Self-efficacy through downward and upward social comparison was the strategy employed in this study to moderate the negative effects of stereotype threat on handgrip performance. Our results revealed a significant re-increase in performance (i.e., both the pre- and post-exercise MVC values as well as the 15-s fatiguing MVC) after a downward social comparison. These results provide support to previous research in several ways. First, they are consistent with earlier findings revealing a positive effect of high self-efficacy feedback on perceived and sustained effort in a handgrip task (Hutchinson, Sherman, & Martinovic, 2008). They are also in line with the Stephan, Chalabaev, Kotter-Grühn, and Jaconelli (2013) study in which, social comparison was manipulated in older adults. Their results revealed that, compared to their same-age peers felt younger. Hence, their performance on handgrip strength was increased. Finally, they provide support to the theory of self-account (Wheeler et al., 2007) in which self-concept is considered a moderating variable between stereotype activation and behavior. Interestingly, these results complement the results of our correlational study (Gray et al., 2018) through a causal approach.

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Summary of Study 5

This study had two main objectives. Firstly, we sought to observe the effects of stereotype threat on a fatiguing task in less active PLHIV, and secondly, we examined the possible modulating role of exercise self-efficacy between stereotype activation and performance fatigability. The main results revealed a significant condition effect on performance on the fatiguing task. Indeed, our less active PLHIV were significantly less performant in the stereotypical condition as compared to the control condition. Furthermore, a moderating role of self-efficacy was evidenced: participants' performance was significantly increased in the high self-efficacy condition as compared to the stereotypical condition.

These results provide support to previous research in a number of ways. First, they are consistent with earlier findings, revealing a positive effect of high self-efficacy feedback on handgrip endurance (Hutchinson, Sherman, & Martinovic, 2008). Our results are also in line with the Stephan, Chalabaev, Kotter-Grühn, and Jaconelli (2013) study in which, through manipulated social comparison, results revealed that older adults receiving positive performance feedback compared to their same-age peers felt younger and their performance on handgrip strength was increased. Finally, they provide support to the theory of self-account (Wheeler, DeMarree, & Petty, 2007) in which self-concept is considered a moderating variable between stereotype activation and behavior. Interestingly, these results complement the results of our correlational study (Gray et al., 2018) through a causal approach.

The nonexerciser stereotype has, to our knowledge, not been the object of experimental studies to, with the exception of the present study in less active PLHIV. The objective of the next study of this thesis was to observe the effect of the nonexerciser stereotype on a fatiguing task in healthy exercising and non-exercising young adults with the aim to broaden the stereotype threat literature in the physical activity domain.

Study 6

Performance on a fatiguing task among exercisers and nonexercisers: effects of the nonexerciser stereotype

(Laura Gray, Maxime Deshayes, Serge S. Colson, Fabienne d'Arripe-Longueville, & Corentin Clément-Guillotin. Manuscript under review)

Abstract

Perceptions of active and inactive people are conveyed by society and a nonexerciser stereotype has emerged (Martin Ginis & Leary, 2006). Past research has focused of information formation with nonexercisers perceived, by both exercising and non-exercising people, as less healthy, less energetic, unfit, less strong and weaker (Rodgers et al., 2009). We know, however, that stereotype threat can contribute to the underperformance of individuals belonging to a range of negatively stereotyped groups and in a number of domains. Furthermore, fatigue is an important indicator of performance. The present study sought to observe the effect of the nonexerciser stereotype on performance in a fatiguing task consisting of executing intermittent contractions at 40% of their maximal voluntary strength until exhaustion, comparing 13 young male nonexercisers and 13 young male exercisers. We observed that, contrary to classic stereotype threat effects, nonexercisers under stereotype threat improved their performance as revealed by increased time to exhaustion (i.e., higher number of submaximal contractions performed) on the fatiguing task. Exercisers also increased their performance when under stereotype threat, in line with the stereotype lift effect. Valuable results were observed for rate of perceived effort (RPE) as a mechanism through which performance on a fatiguing task may be affected. This study is encouraging, in that it revealed that nonexercisers' performance on a prolonged fatiguing task was not decreased by the negative nonexerciser stereotype but rather that to some degree stereotype threat could be beneficial to performance.

Key words: Stereotype threat, Physical activity, Performance, Fatigue, Rate of perceived exertion.

Introduction

With the benefits of exercise upon health being vastly and increasingly studied over the past decades (e.g., Fletcher et al., 1992; Garber et al., 2011; Mothes et al., 2017), we currently live in a society where exercise promotion for health is at a peak. Studies are increasingly specific with the kind of exercise that might be beneficial for various pathologies and populations (e.g., Buffart et al., 2017; Grace, Chan, Giallauria, Graham, & Smart, 2017; O'Brien, Tynan, Nixon, & Glazier, 2017), but the quintessence remains unchanged: exercise has many health benefits and we should all adopt a healthy level of physical activity (PA) (e.g., Conn, Hafdahl, & Mehr, 2011). Thus, perceptions of active and inactive people defined by their level of PA, are conveyed by society and a nonexerciser stereotype has emerged (Martin Ginis & Leary, 2006), with nonexercisers perceived, by both exercising and non-exercising people, as less healthy, less energetic, unfit, less strong and weaker (Rodgers, Hall, Wilson, & Berry, 2009). The present research investigated the effect of this nonexerciser stereotype during a fatiguing task.

Martin Ginis and Leary (2006) suggest that the nonexerciser stereotype probably has its roots in “healthism” defined as health-promoting activities with a moral obligation and considering those who do not practice such behaviors to be weak, deviant and without virtue. As these studies evidence, the nonexerciser stereotype have, up to now, mainly been studied on impression formation (Lindwall & Martin Ginis, 2006; Martin Ginis & Leary, 2006; Martin, Sinden, & Fleming, 2000) with nonexercisers receiving lower ratings than exercisers on all dimensions (i.e., kind/unkind; lacks confidence/confident; physically sickly/healthy; fit/unfit; etc.) and nonexercisers being perceived as less healthy, less energetic, slightly fatter, less motivated, less concerned about their health, less strong, less busy, less committed, less happy, less concerned about their appearance, weaker and less disciplined than exercisers (Rodgers et al., 2009).

In their study, Rodgers et al., (2009) informed their participants that they would be rating exercisers and nonexercisers. Participants were thus given the opportunity to manipulate their answers to support their self-image. Though this is a form of stereotype-activation through priming with words related to two different groups, to our knowledge, the nonexerciser stereotype has not been manipulated thus far in research. One of the mechanisms to manipulate a negative stereotype is stereotype threat. Stereotype threat occurs when an individual is in a position to potentially confirm a negative stereotype that downgrades the ability of his or her own social group. The stereotype threat model was introduced by Steele (1997) as a threat present in certain situations giving birth to “a threat in the air”. This “threat in the air” is characterized by the presence of known stereotypes in performance. Stereotype threat can contribute to the underperformance of individuals belonging to a range of negatively stereotyped groups and in a number of domains. For example, stereotype threat has been vastly studied in the cognitive domain and extensively on math and scientific tasks (e.g., Inzlicht & Ben-Zeev, 2000; Spencer, Steele, & Quinn, 1999). Here stereotype threat seems to effect working memory which in turn influences affect, motivation and/or physiological factors such as stress (Schmader, Johns, & Forbes, 2008).

Fewer studies, however, focused on the sensorimotor domain (e.g., Chalabaev, Sarrazin, Stone, & Cury, 2008a; Hively & El-Alayli, 2014; Stone, Lynch, Sjomeling, & Darley, 1999). Chalabaev et al., (2008a) showed that in a soccer dribbling task, overall evaluated speed on the drill was significantly slower for females under stereotype threat than those without threat. The majority of these studies demonstrated the effects of sex stereotypes on performance (e.g., Hively & El-Alayli, 2014) revealing the salience of this sex stereotype in the sensorimotor domain, warranting further questioning concerning the influence of various stereotypes. The mechanisms of stereotype threat in the sensorimotor domain have only scarcely been explored (e.g., anxiety; Stone et al., 1999) but none emerged as

meaningful mediators. Furthermore, (Beilock, Jellison, Rydell, McConnell, & Carr, 2006) showed that performance alteration in the sensorimotor domain, contrary to the cognitive domain, was not mediated by working memory. It is suggested, that although stereotype threat may damage working memory for demanding tasks by reducing the resources available for execution, it may impair proceduralized skills by prompting too much attention to execution processes that function in a relatively automatic manner outside of conscious control. The pressure caused by the stereotype leads the individual to focus on task specific components demanding separate activation and execution of each component and increasing the opportunities for error. It is this breakdown of the integrated control system that may result in performance decline.

The effects of stereotypes on performance are not always negative. For example, Chalabaev et al., (2013) showed that maximal strength, an indicator of performance, was not influenced by stereotype threat in female participants. However, after a similar task performed in an elderly population, Emile et al., (2017) suggested that stereotypical information positively modified motor performance due to central adaptations. The task used in these studies (i.e., maximal strength performance) was of short duration and delineating the underlying mechanisms that could explain the outcomes with such task is challenging. Considering that, fatigue is a limiting factor for performance (Amann & Dempsey, 2008), a task performed until exhaustion such as a fatiguing exercises allows testing the hypothesis of central fatigue adaptations and observe the possible effect of stereotype threat. Consequently, in the present study, neuromuscular function will be evaluated to assess the origins (i.e., central vs peripheral) of the induced fatigue. Within stereotype threat studies, motivational factors were also considered to play a role on fatiguing tasks. For example, self-competence was measured and revealed higher scores within the stereotype threat condition (Chalabaev et al., 2008). Heidrich and Chiviawosky (2015) further suggested that modified self-efficacy

could influence participants perceived competence. Specifically, higher self-efficacy resulted in improved performance in experimental protocols (e.g., Hansen & Wänke, 2009; Wang, Zhou, Tan, & Zhang, 2017). Hence, in this study, we will observe whether self-efficacy is modified under stereotype threat.

Beyond the effects of stereotype threat on the performance of the ingroup, outgroup performance is influenced. For example, Chalabaev, Stone, Sarrazin, and Croizet (2008b) revealed that men's performance was improved when a negative stereotype about women was induced. This assumption was introduced by Walton and Cohen's (2003) meta-analysis as the 'stereotype lift effect', defined as an increase in performance that occurs when downwards comparisons are made with a stereotyped outgroup. Indeed, the stereotype lift effect would explain the improved performance in the outgroup (e.g., men) observed in the sensorimotor domain (e.g., Chalabaev et al., 2013; Chalabaev, Stone, Sarrazin, & Croizet, 2008b).

In the sensorimotor domain, research has mainly focused on sex stereotypes. We seek to broaden this literature by observing the effects of a new stereotype, the nonexerciser stereotype. Indeed, no studies have, to our knowledge, evaluated the effect of the negative exerciser stereotype. Furthermore, as fatigue is a limiting factor to performance, the aim of this study was to examine the effects of a negative nonexerciser stereotype on performance during a fatiguing task in both exercisers and nonexercisers. Based on stereotype threat literature (e.g., Hively & El-Alayli, 2014), we hypothesized that the nonexerciser stereotype would negatively impact nonexercisers' performance. Furthermore we suggested an improvement in performance in exercisers due to stereotype lift (e.g., Walton & Cohen, 2003).

Method

Participants and design

Sample size calculated in G-power rendered a total sample size of 26 participants with an effect size of 0.08 (Chalabaev et al., 2013) and power of 0.90 for a within subject analysis. 13 exercising ($M_{age}= 22.1$, $SD= 3.5$; $M_{mets/min}= 5381.2$, $SD= 4385.4$) and 13 non-exercising ($M_{age}= 23.1$, $SD= 3$; $M_{mets/min}= 613.2$, $SD= 163.7$) male participants were recruited to take part in a within subject protocol based on their reported physical activity level for which they were asked if they followed the World Health Organization (WHO) recommendations for physical activity including at least 150 minutes of moderate-intensity aerobic PA per week and two muscle-strengthening activities twice a week. Their PA level was also calculated using the Global Physical Activity Questionnaire (GPAQ). Participants took part in the experimental procedure including three visits separated by at least 24h and performed at the same time of day. The first session allowed participants to be familiarized with the protocol. The second and third sessions were the same experimental conditions and included the stereotype manipulation (i.e., stereotypical and nullified conditions). Participants took part in all three sessions with the stereotypical and nullified conditions being randomized. All participants signed a written informed consent form and were fully debriefed after the experimental procedure was completed. At recruitment, participants were asked not to take part in any form of physical activity the day before the scheduled experimental procedure to ensure no experimental bias.

Materials

Torque. The maximal voluntary isometric torque of the knee extensor muscles was measured using a dynamometric chair with a 140° hip angle and 90° knee angle, the axis of the dynamometer being aligned with the anatomical knee axis. The participant's right ankle

was connected to the calibrated load cell (Model SM 2000N; Interface, Scottsdale, AZ, USA) by a non-deformable metallic rod using a noncompliant strap to determine evoked, as well as voluntary knee extensor muscles' force.

Electrical stimulation. To elicit evoked knee extensor muscles' twitch torques a self-adhesive electrode (cathode) was placed on the femoral triangle to stimulate the femoral nerve. An anode (5 x 10cm) was positioned on the inferior portion of the *gluteus maximus*. Electrical stimuli were delivered with a constant-current, variable-voltage stimulator (Digitimer® Ltd., DS7, Hertfordshire, UK).

Experimental procedure

Fatiguing protocol. At the beginning of experimental sessions, supramaximality, referring to the optimal intensity for stimulation, was determined. Single evoked force stimulations were delivered with 1000 μ s duration with maximal voltage of 400V in increments of 10mA. When there was no further increase in twitch torque amplitude, despite greater stimulus intensity, maximal spatial recruitment of motor units was considered reached. The current intensity was then increased by a further 20% to ensure stimuli were supramaximal, and this intensity was recorded.

Warm-up. After supramaximality determination, participants warmed-up based on standardized ergonomic warm-up protocols including 10 5-s intermittent submaximal knee extensor contractions during 4 min (10 x 5-s contraction and 25-s rest) followed by three maximal isometric contractions (MVC) with 30s rest between each MVC (Gruet et al., 2016).

Pre-exercise assessments. Participants performed a series of five 3-s MVCs to establish their maximum torque with a minute of rest separating each contraction. The last three MVCs were accompanied by muscle stimulation. A 100Hz doublet twitch was delivered at about 1.5s onto the contraction to coincide with maximal torque, and 2s after the MVC to

provide a resting potentiated doublet twitch torque followed by a single twitch 3s later. All data were recorded using an electromyograph (PowerLab 16/35-ML138; ADInstruments, Bella Vista, Australia) and processed using Matlab (Matlab 7.12, MathWorks, Natick, MA). Participants were also asked to record their level of PA and their identification to the physical activity and exercise domain before each session.

Fatiguing exercise. Each participant practiced attaining target percentage of 40% of the peak torque of previously measured MVCs for submaximal contractions. Participants practiced by repeating three 3s-on, 2s-off submaximal contractions. A three-minute resting period was given during which participants received task instructions. After the warm-up and task information were given, the fatiguing task was initiated. Participants performed intermittent isometric contractions (3s-on, 2s-off) at 40% of MVC for as long as possible. Every minute, participants were asked to rate perceived exertion (RPE) on the Borg scale as well as rating a self-efficacy item. At the end of each minute, participants were instructed to produce a MVC, before returning to targeted contractions. Target torque was presented on a screen with visual feedback of dynamometer torque with the same verbal instruction from the experimenter. Task failure was determined when participants were unable to attain the target torque for three consecutive contractions. Participants were informed of each miss and following the third missed contraction were asked to perform a final MVC. This final MVC, at exhaustion, was accompanied by stimulations. This intermittent fatiguing neuromuscular task was used by Burnley, Vanhatalo, and Jones (2012) based on Bigland-Ritchie, Furbush, and Woods (1986) and revealed high levels of central fatigue (see Figure 1). It was of importance that we chose a protocol inducing central fatigue to ensure visibility of a possible effect of stereotype threat.

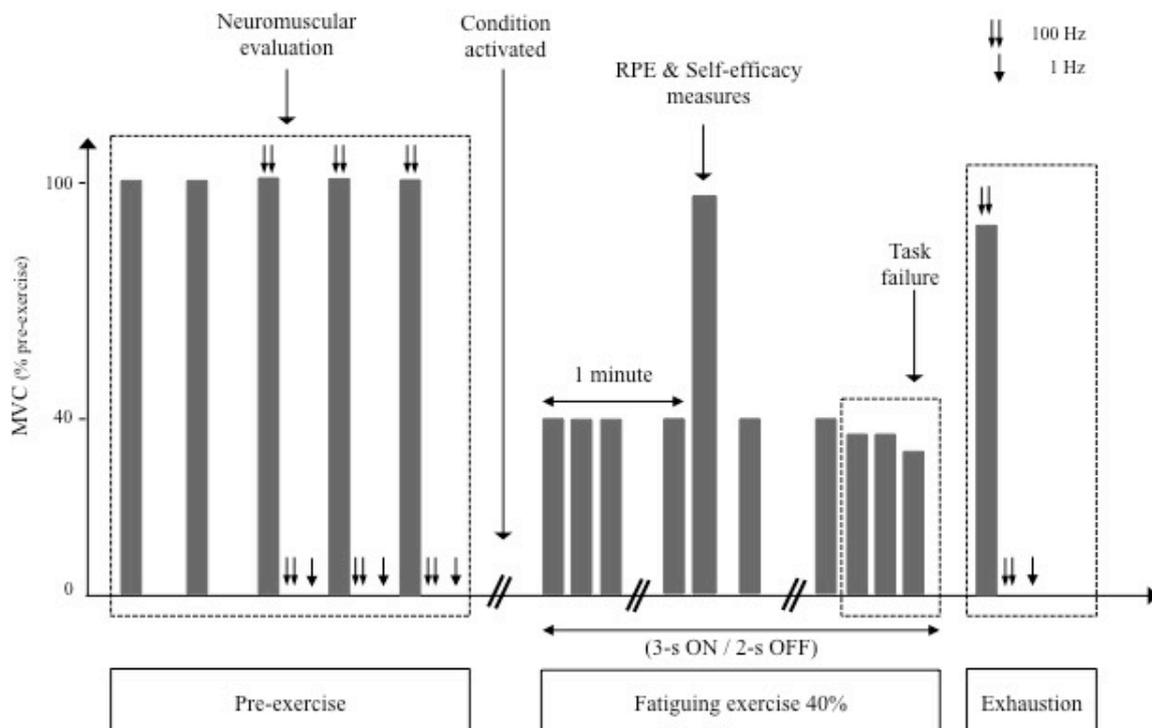


Figure 1. Schematic representation of the experimental protocol

Notes. MVC: maximal voluntary contraction; RPE: rate of perceived exertion

Stereotype manipulation. In the stereotypical condition, participants received the same instruction to which the stereotype activation was added. The participants were told the following: “From this moment on we are going to measure the neuromuscular adaptations during performance. We take an interest in the differences between people who exercise (considered as active) and people who do not exercise (considered as inactive). For this, we are going to perform the intermittent contraction task. We are going to observe physiological parameters that are health indicators and that, according to the literature, have shown that there is a difference in performance between active and inactive people; indeed, inactive

people are less healthy and have weaker performances than active people on this type of task”.

For the nullified condition the following context was told to participants: “From this moment on we are going to measure the neuromuscular adaptations during performance. We take an interest in the differences between people who exercise (considered as active) and people who do not exercise (considered as inactive). For this, we are going to perform the intermittent contraction task. We are going to observe cognitive and mental parameters that, according to the literature, have shown that there is no difference in performance between active and inactive people on this type of task”.

Manipulation check. Using two questions we checked to which degree participants agreed to experimental information given in all conditions. Participants responded on a 7-point Likert scale ranging from 1 (“totally disagree”) to 7 (“completely agree”).

Measures and data analysis

Performance. Measures of performance included time to task failure and global fatigue. As previously stipulated, task failure was considered to have occurred when three consecutive contractions failed to reach target percentage. The first of these contractions was used to indicate time to task failure. Global fatigue was measured using the difference of MVCs values between pre-exercise and exhaustion. Both MVC absolute values and Δ MVC (percentage change from pre-exercise to exhaustion) were considered for the analysis.

Central fatigue. Central fatigue was calculated as the reduction in voluntary activation (VA) from pre-exercise to exhaustion (Δ VA). VA was quantified by the twitch interpolation technique (Merton, 1954) and was calculated using the following formula:

$$VA (\%) = 1 - (\text{superimposed doublet} / \text{resting potentiated doublet}) \times 100.$$

Peripheral fatigue. Knee extensors peripheral fatigue was quantified as the difference in both the resting potentiated evoked torques (i.e., single and doublet) from pre-exercise to exhaustion. Absolute values of evoked torques as well as their respective change from pre-exercise to exhaustion were analyzed.

Perceived exertion. The Rating of Perceived Exertion (RPE; Borg, 2009; Borg & Linderholm, 1970) was used as a measure of whole-body rating of perceived exertion during exercise. The RPE is a 15-point scale ranging from 6 to 20, with anchors ranging from *very, very light* to *very, very hard*. Participants rated their perceived exertion each minute during the protocol. The RPE slope was calculated and normalized by time to exhaustion.

Self-efficacy. Based on Welch, Hulley, and Beauchamp (2010), we developed an item to assess self-efficacy perceptions during the fatiguing exercise. This item was built following the guidelines for developing self-efficacy scales (Bandura, 2005; McAuley, Bane, & Mihalko, 1995). Before starting the fatiguing exercise and every minute during exercise, participants were asked to indicate their degree of confidence in their ability to reach target force during the next minute. Participants responded on a scale ranging from 0% (*cannot do at all*) to 100% (*certain can do*).

PA level. Participants reported their physical activity level at the beginning of each session. They were asked if they followed the World Health Organization (WHO) recommendations for physical activity including at least 150 minutes of moderate-intensity aerobic PA per week and two muscle-strengthening activities twice a week. Participants then completed the Global Physical Activity Questionnaire (GPAQ). PA level was calculated using the WHO guidelines for the GPAQ scale and the average energy expenditure was reported in mets/min for data analysis.

Statistics

The statistical analysis was run on the experimental conditions and did not include the familiarization session. The Shapiro-Wilk was used to confirm the normality of the data. Two groups (exercisers vs. nonexercisers) \times 2 conditions (nullified vs. stereotypical) \times 2 time measurements (pre-exercise and exhaustion) ANOVAs with repeated measures on condition and time compared the absolute MVC, VA, and resting potentiated twitches. A 2 group (exercisers vs. nonexercisers) \times 2 conditions (nullified vs. stereotypical) repeated measures ANOVAs were conducted on performance, defined as time to task failure, PA level, MVC decrease (Δ MVC), VA decrease (Δ VA), resting potentiated twitches decreases, RPE slope and self-efficacy. Bonferroni post-hoc tests were used to assess for differences among pairs of means when appropriate. Effect size was computed from partial eta² values (η^2) and the significance level was set at $p < 0.05$. Associations between two variables were quantified using Pearson's product-moment correlation coefficient.

Results

Participants' characteristics

Independently of the stereotype condition (i.e., nullified and stereotypical), results revealed a significant condition main effect for the level of PA, $F(1, 24) = 9.95, p = .004 \eta^2 = .29$. The reported level of physical activity confirmed that exercisers were more physically active (according to the above WHO recommendations) as compared to nonexercisers. PA level main effect ($F(1, 24) = 19.04, p < .001 \eta^2 = .44$) was significant.

Along with a higher PA level, MVC ($F(1,24) = 13.04, p < .01 \eta^2 = .35$), single ($F(1,24) = 10.84, p < .01 \eta^2 = .31$) and doublet ($F(1,24) = 9.51, p < .01 \eta^2 = .28$) evoked twitches were greater for the exercisers compared to the nonexercisers, whereas VA ($F(1,24) = 0.53, p = .82$) did not differ according to participants PA level.

Global fatigue

As expected, the protocol led to knee extensor muscles fatigue. A significant condition \times time interaction was observed $F(1, 24) = 8.18, p = .009, \eta^2 = .25$ for MVCs. Whatever the group considered, MVCs significantly decreased after both conditions ($p < .001$) and MVCs values of the nullified condition were significantly lower ($p < .05$) compared to the stereotypical condition after exhaustion. Significant main time effects were found for VA $F(1, 24) = 102.69, p < .001, \eta^2 = .81$, as well as for single ($F(1, 24) = 263.08, p < .001, \eta^2 = .92$) and doublet ($F(1, 24) = 145.12, p < .001, \eta^2 = .86$) evoked torques displaying lower values after exhaustion compared to pre-exercise whatever the condition considered (i.e., nullified and stereotypical).

Influence of PA level and stereotypical conditions

Means and standard deviations for all studied variables are presented in Table 1. No significant interaction effects were observed for any of the study variables.

Table 1. Means (\pm standard deviations) for the different dependent variables

<i>PA level & Variables</i>	<i>Nullified condition</i>	<i>Stereotypical condition</i>
Exercisers		
Time to task failure (s)	571.85 \pm 340.59	655.38 \pm 374.84
MVC (N)	600.89 \pm 121.20	605.46 \pm 147.52
Δ MVC (%)	44.89 \pm 14.60	39.23 \pm 13.75
Δ VA (%)	9.68 \pm 10.46	10.85 \pm 13.65
Δ resting potentiated twitch (%)	52.50 \pm 14.73	53.48 \pm 15.57
RPE	13.2 \pm 1.17	13.1 \pm 1.53
RPE increase speed	2.2 \pm 0.91	2.0 \pm 0.79
Self-efficacy (%)	62.2 \pm 10.49	59.7 \pm 11.44
Nonexercisers		
Time to task failure (s)	731.23 \pm 220.01	788.31 \pm 219.05
MVC (N)	455.07 \pm 78.52	440.97 \pm 96.39
Δ MVC (%)	44.21 \pm 13.53	37.23 \pm 16.04
Δ VA (%)	16.87 \pm 7.29	16.33 \pm 12.09
Δ resting potentiated twitch (%)	55.69 \pm 14.49	51.89 \pm 12.67
RPE	14.7 \pm 1.16	15.0 \pm 1.43
RPE increase speed	1.7 \pm 0.93	1.5 \pm 0.96
Self-efficacy (%)	54.2 \pm 6.29	55.8 \pm 8.54

Notes. PA: physical activity; MVC: maximal voluntary contraction; VA: voluntary activation; RPE: rate of perceived exertion.

Performance. While no significant group effect (i.e., exercisers and nonexercisers) $F(1, 24) = 0.03, p = 0.87$ was observed, a significant condition main effect (i.e., nullified and stereotypical) was shown, $F(1, 24) = 40.42, p < .001, \eta^2 = .63$ (see Figure 2). Whatever the group considered, time to exhaustion was longer in the stereotypical condition (721.85 ± 308.33 s) than in the nullified condition (651.54 ± 292.44 s).

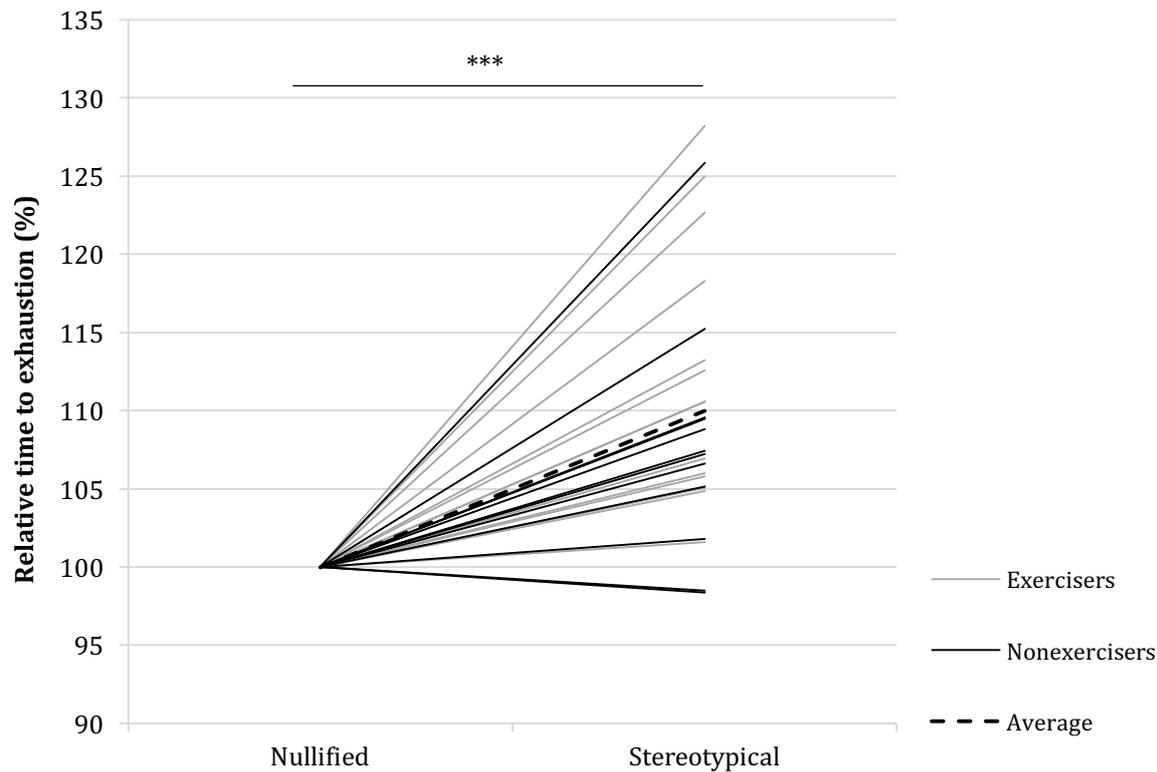


Figure 2. Performance as indicated by relative time to exhaustion comparing the nullified and stereotypical conditions among exercisers and nonexercisers.

Notes. *** $p < .001$ for test of difference for time to task failure in the different conditions.

MVCs. A significant condition main effect $F(1, 24) = 7.05, p < .05, \eta^2 = .23$ was observed for the MVCs decreases. After the nullified condition, the MVCs decreases were greater than the stereotypical condition.

RPE. Although no significant group effect $F(1, 24) = 1.76, p = 0.20$ was noted, a significant condition main effect appeared for the RPE slope, $F(1, 24) = 6.88, p = .015, \eta^2 = .23$. The rate of RPE increase was greater in the nullified condition as compared to the stereotypical condition. We took a closer look at the RPE increase to determine at what point in the task the slopes differed between the nullified and stereotypical conditions. We divided the task time in four representing 25%, 50%, 75% and 100% of the time to task failure. A significant condition \times time interaction was observed $F(3,72) = 5.18, p = .003, \eta^2 = .18$. Specifically, in the stereotypical condition all participants (i.e., exercisers and nonexercisers)

had a lower RPE at 50% (14.5 ± 2.18 ; $p < .001$) and at 75% (17.15 ± 1.74 ; $p = .028$) of time to task failure as compared to the nullified condition (50%: 15.5 ± 1.63 ; 75%: 17.77 ± 1.31). No differences were observed at 25% and 100%. Finally, whatever the condition considered, a significant negative correlation fitted with a linear function was found between RPE slope and time to exhaustion ($r = 0.72$, $p < .001$; Figure 3).

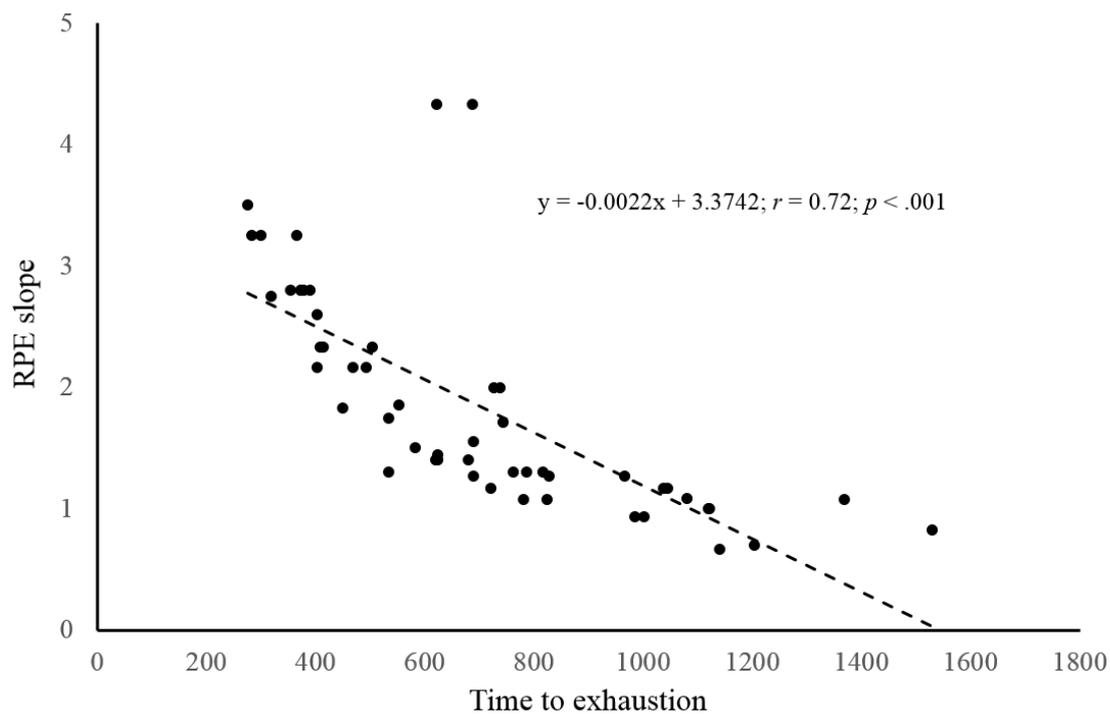


Figure 3. Individual data of the RPE slope plotted against time to exhaustion for both the exercisers and nonexercisers among the nullified and stereotypical conditions ($n = 52$).

VA. No significant differences for group ($F(1, 24) = 0.83$, $p = .37$), nor condition ($F(1, 24) = 0.26$, $p = .61$) was observed.

Knee extensor peripheral fatigue. No significant effects in resting potentiated twitch torques were observed for single twitch (group, $F(1, 24) = 0.03$, $p = .87$ and condition, $F(1, 24) = 0.25$, $p = .62$) and for the doublet (group, $F(1, 24) = 0.01$, $p = .92$, condition, $F(1, 24) = 0.15$, $p = .70$).

Self-efficacy. No significant effects of group ($F(1, 24) = 2.92, p = .10$), nor condition ($F(1, 24) = 0.14, p = .71$) on self-efficacy were revealed.

Discussion

The aim of this study was to observe the effects of the emerging nonexerciser stereotype among exercisers and nonexercisers on performance during a fatiguing task. We hypothesized that, nonexercisers' performance would decrease due to a stereotype threat effect and that the activation of the nonexerciser stereotype would increase performance due to stereotype lift among exercisers.

Results revealed that both exercisers and nonexercisers improved their performance on the fatiguing task when the negative nonexerciser stereotype was induced. Considering the nonexercisers' increase in performance under stereotype threat, our results are not consistent with classic stereotype threat literature that revealed a decrease in performance (e.g., Hively & El-Alayli, 2014). Other studies have shown that simple tasks do not lead to any change in performance (Chalabaev et al., 2013). As previous stereotype threat research has mainly been conducted on short and technical tasks, such as, golf putting (Stone et al., 1999), soccer dribbling (Chalabaev, Sarrazin, Stone, & Cury, 2008a) or basketball shooting (Hively & El-Alayli, 2014), which are short duration and/or precision tasks rather than fatiguing tasks; it is plausible that during tasks performed until exhaustion, such as the present study, participants are more engaged in the task, prompting performance improvement. Further research is needed for a more in-depth assessment of this hypothesis by testing the effect of the nonexerciser stereotype on similar fatiguing tasks but with variations and measures of the energy expenditure (low vs. high).

Beyond the nature of the task, an explanation could be the level of participants' identification. Indeed, it is of importance to note that both the exercisers and nonexercisers

were considered highly identified with the physical activity and exercise domain. Research has revealed that the level of identification could moderate the effects of stereotype threat (Nguyen & Ryan, 2008). In their meta-analysis, Nguyen and Ryan (2008) noted that, in math, moderately identified women were more affected than highly identified women. Further research showed that math-identification positively predicted threatened participants' math performance in a manner that high math-identification boosts threatened women's performance (Saunders, 2016). Though our results do not reveal higher performance levels among nonexercisers as compared to the non-threatened exercisers, based on this literature, we could suggest that when the level of identification was high, threatened participants benefited from the lift effect, thus increasing their performance. Indeed, in their meta-analysis, Walton and Cohen (2003) noted that there was a trend for studies that preselected subjects based on high identification levels to show higher lift effects. Further research is needed to test and observe if a high level of identification could boost or hinder performance.

Another plausible explanation could be the salience of the nonexerciser stereotype in the physical activity and exercise domain. Research has shown the salience of the sex-stereotype in the sensorimotor domain (e.g., Hively & El-Alayli, 2014) but the nonexerciser stereotype being an emerging stereotype has not been tested before and is possibly less salient than the sex-stereotype. Thus, its threatening or boosting status may have less impact. In light of our results it is of interest to note that there is not a greater increase in performance in the outgroup (exercisers) as compared with the threatened group (nonexercisers) hereby suggesting the less salient status of the nonexerciser stereotype. Indeed, in their study, Rodgers et al., (2009) revealed that positive 'exercising' stereotypes showed higher endorsement than negative 'non-exercising' stereotypes, emphasizing the importance of using positive characteristics of becoming an exerciser rather than negative characteristics of not exercising in exercise information interventions. In particular, nonexercisers would be more

open to arguments emphasizing the advantages of becoming an exerciser rather than arguments highlighting the dangers of remaining physically inactive. With this in mind, it is feasible that nonexercisers felt less concerned by the negative exerciser information and therefore their performance was not negatively influenced.

A final explanation for the absence of stereotype threat could be stereotype reactance, defined as an engagement in behaviors that are contrary to those prescribed by the stereotype. The stereotype reactance theory (Kray, Thompson, & Galinsky, 2001) affirms that reactance occurs when people perceive limitations to their ability to perform, in this case when the negative exercise stereotype was linked to performance on a physical fatiguing task in the ingroup (i.e. nonexercisers). The nature of the stereotype activation is suggested to differentiate a threat or reactance behavior (Kray et al., 2001). Indeed, when a negative ingroup stereotype is explicitly linked to performance on a task, people become aware of the stereotype and may try to defeat it. Our results revealed an increase in performance in nonexercisers (i.e. ingroup) when under threat, as compared to the nullified condition. Our findings are in line with stereotype lift research, as the nature of stereotype activation, explicit vs. implicit, is not thought to moderate stereotype lift (Walton & Cohen, 2003). Not only did nonexercisers not endure a performance decrease when under threat, but they also avoided being doubly stereotyped as their performance increased to a similar level as exercisers. This calls for future research to investigate the effects of explicit negative stereotype activation on performance in the sensorimotor domain.

Considering the mechanisms involved, RPE was assessed and plays a role in performance under stereotype threat. The significant condition effect observed for RPE, with a slower time to maximal RPE in the stereotypical condition, suggested that, under threat, exercisers and nonexercisers persisted in the task, as their subjective difficulty of the effort was lower. With the RPE increasing at a slower rate, this could be a valid reason for increased

performance, demonstrated by the negative correlation between RPE slope and performance. Similar observations were previously shown in the literature (Crewe et al., 2008). Through a more in depth approach dividing the task into periods of time (i.e. 25%, 50%, 75% and 100% of time to task failure), we observed a significant difference in RPE between the stereotypical and nullified conditions at both 50% and 75% of time to task failure. No significant differences were found at 25% and 100% of time to task failure since these two measurement points correspond to the beginning and the end (i.e., fatiguing task performed to exhaustion) of the task. This supports our explanation that stereotype threat would not have the same effect on fatiguing tasks as on more precision or short duration tasks. The fatigue literature supported the hypothesis that RPE may be influenced by psychological and environmental factors, such as, mental fatigue (Brownsberger, Edwards, Crowther, & Cottrell, 2013), sleep deprivation (Martin, 1981) or music and video (e.g., Chow & Etnier, 2017). For example, when participants were presented with music and video simultaneously, they perceived a significantly lower RPE when compared to a control condition (Chow & Etnier, 2017). However, the majority of these studies did not observe any modification of performance (e.g., Chow & Etnier, 2017). In other words, participants perceived the task as less difficult, but did not improve their performance. In the present research, in addition to the observed effect on RPE, an increase in performance was also observed. Further research is needed to analyze more deeply the effect of the nonexerciser stereotype on the perception of effort.

With regard to self-efficacy, we did not observe any differences between the stereotypical and nullified conditions. Self-efficacy was measured during the task, as it was suggested by previous research that a diminution of self-competence under stereotype threat (e.g., Chalabaev, Stone, Sarrazin, & Croizet, 2008b) would be due to a decrease in self-efficacy. Furthermore, increased performance could be due to higher self-efficacy (e.g., Hansen & Wänke, 2009). However, this was not verified because no significant differences

were observed in self-efficacy levels between exercisers and nonexercisers under stereotype threat, as compared to the nullified condition. Research suggests that self-efficacy can impact motivation and performance (e.g., Bandura, 1986; Maddux, 1993). Our study observed task specific self-efficacy, in line with Chung, Ehrhart, Holcombe Ehrhart, Hattrup, and Solamon (2010) but contrary to their findings, the effect of a negative stereotype does not seem to be consistently mediated by self-efficacy (e.g., Mayer & Hanges, 2003). Another explanation could be the manner in which self-efficacy was assessed in our protocol. Indeed, self-efficacy was assessed during the fatiguing task with participants indicating a percentage of felt capacity to continue the task during the next minute. Due to the task being an intermittent protocol, participants were asked to verbally assess their self-efficacy on a visual analogue scale. This could have limited participants' responses as they most likely had their last response in mind when asked again to rate their self-efficacy. Future studies should consider asking participants to mark a visual analogue scale, which will be measured and erased between measures in order to avoid participants answering according to previous responses.

Considering the physiological mechanisms, this intermittent fatiguing task was chosen as it calls for significant energy expenditure as it is performed to exhaustion, which is novel in stereotype threat research and seems to produce different results to short and technical tasks. Also, as previously shown (Burnley et al., 2012), the task chosen induced central fatigue considered to be the fatigue indices most likely to be affected by stereotype threat. The fatiguing task did induce central fatigue (determined by voluntary activation) and peripheral fatigue (characterized by the amplitude of the resting potentiated twitch) in our study. However, no significant differences in central or peripheral fatigue were observed between exercisers and nonexercisers in the stereotypical and nullified conditions despite the increase in performance in both groups under stereotype threat. Though central fatigue was observed in both conditions it is plausible that VA at pre-exercise was not high enough to detect an

effect of stereotype threat. Burnley et al., (2012) obtained VA levels of at least $87\% \pm 4\%$ whereas our participants' VA only averaged at $82\% \pm 7\%$. Also, half of the participants were nonexercisers and consequently could have lowered the overall level of VA, although no significant differences were observed between groups. The last reason could be the absence of encouragement. We decided to exclude encouragements so as to not interfere with the stereotype. However, it is well known that verbal encouragement enhanced the peak strength during an MVC. For example, McNair, Depledge, Brett Kelly, and Stanley (1996) observed that during a handgrip task, participants' maximal strength was higher when verbal encouragement was given, as compared to no encouragement. In future studies, more familiarization is needed to have less bias during MVCs.

Limitations and future directions

One limit to this study is that the nonexerciser stereotype is still an emerging stereotype (Martin et al., 2000) and may thus be less salient in the sensorimotor domain. Indeed, for a stereotype to take effect it is not necessary for it to be internalized, however, it needs to be known. Though we checked the stereotype manipulation, future research should ensure stereotype adherence prior to its activation as regards to emerging stereotypes, such as, the nonexerciser stereotype. Another limit is that, though the fatiguing task used demanded high energy expenditure, it does not closely relate to daily activities and it could be of interest to observe the effect of stereotype threat on other types of tasks that can be found in daily activities, such as, cycling or running. Our study provided results as to the effects of the nonexerciser stereotype on performance revealing a performance boost among exercisers and nonexercisers. Interestingly, the exercisers (outgroup) did not outperform the nonexercisers (ingroup) as classically observed in stereotype lift. This is a novel finding and could suggest that the detrimental effects of the nonexerciser stereotype are limited, as the ingroup are able

to perform to the same level as the outgroup rather than being doubly disadvantaged by the stereotype threat (Chalabaev et al., 2008).

Conclusion

This study is encouraging in that it revealed that nonexercisers' performance on a prolonged fatiguing task was not decreased by the negative nonexerciser stereotype but rather presented a similar performance increase effect as exercisers.

Our findings showed that the impact of negative nonexerciser stereotypes were not detrimental to performance contrary to classic stereotype threat effects. Nonexercisers engaged in behaviors contrary to those prescribed by the stereotype threat. Thus, their performance was not impaired, and they even revealed similar levels of improvement to exercisers. These findings are of interest as they suggest that young exercising and non-exercising men are not threatened by their physical activity status and may even benefit from a performance increase on fatiguing tasks. Furthermore, in our study, RPE stands out as a valid mechanism through which stereotype threat could take effect on performance on fatiguing tasks performed to exhaustion demanding higher participant engagement as a slower rate of RPE increase could allow participants to remain focused on the task for a longer time. These results call for further research using the nonexerciser stereotype to observe whether these beneficial effects on performance can occur among different populations and using different tasks.

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Summary of Study 6

The purpose of this study was to observe the effect of the emerging nonexerciser stereotype on the performance on a fatiguing task in exercising and non-exercising, healthy young adults. 13 active and 13 inactive healthy young men were recruited to complete an intermittent sub-maximal isometric contraction task at 40% of their maximal voluntary contraction force until exhaustion. The main results revealed that contrary to the classical stereotype threat effect (e.g., Hively & El-Alayli, 2014), no detrimental effect of the nonexerciser stereotype was observed on performance during a fatiguing task in the threatened group (i.e. inactive). Results also showed an increase in performance among the non-threatened group (i.e. active), congruent with the stereotype lift postulate (Walton & Cohen, 2003).

Among the plausible mechanisms behind this performance increase in the threatened individuals, the rate of perceived effort revealed valuable data. Indeed, slower rates of increase in measure of perceived exertion when under threat suggested that participants in this condition persisted in the task as their subjective difficulty of the effort was lower (Eston, Faulkner, St Clair Gibson, Noakes, & Parfitt, 2007). This result was not consolidated with higher self-efficacy as we expected based on previous work (e.g., Hutchinson et al., 2008). This result presents a promising avenue for future research as RPE stood out as a valid mechanism through which stereotype threat could take effect on performance on fatiguing tasks performed to exhaustion, demanding higher participant engagement.

GENERAL DISCUSSION

With PLHIV still being subject to stigma, prejudice and even discrimination, and fatigue being a common and distressing symptom in this population, and a barrier to PA participation, the general purpose of this doctoral work was to better understand the relationships between exercise stereotypes, fatigue and PA level in PLHIV, and to identify the mechanisms at play. Based on contemporary theories of stereotypes applied to health behaviours (e.g., Stereotype Embodiment Theory, Levy, 2009; Stereotype Threat Theory, Steele & Aronson, 1995) and an integrative approach of fatigue (Kluger et al., 2013), this doctoral work postulated that exercise stereotypes endorsement or activation would play a role in the PA level of PLHIV and in their performance in fatiguing tasks.

The first part of this thesis consisted of identifying the barriers to and facilitators of PA and exercise in PLHIV with the main objective being to identify the stereotype content related to exercise and regular PA in PLHIV. Once identified, a psychometric tool was developed to allow positive and negative exercise stereotypes to be assessed in PLHIV or in the general population. The second part of this thesis consisted of identifying different psychological mechanisms at play in the relationship between exercise stereotypes and PA level in PLHIV, including the role of self-efficacy and perceived fatigue. Because fatigue in PLHIV is known to be multidimensional (Barroso, 1999; Barroso & Lynn, 2002; Barroso et al., 2003; Barroso & Voss, 2006), we then sought to characterise fatigue in PLHIV from a perceived and performance fatigability perspective, based on Kluger et al. (2013) integrative approach. Finally, we looked to observe the effects of stereotype context on performance fatigability, taking into account the active mechanisms identified. Overall, using different designs and statistical analyses, six studies including a total of 943 participants were carried out in search of answers to the various questions of this doctoral work.

What is the stereotype content related to exercise and regular PA in PLHIV?

The literature has recently been greatly enriched with studies identifying barriers to and facilitators of PA in PLHIV. This line of research identified exercise risks with the fear of sustaining an injury as a main barrier (Li et al., 2017; Montoya et al., 2015; Simonik et al., 2016; Vader et al., 2017), while improved physical function appeared as a major benefit and facilitator to PA in PLHIV (e.g., Montoya et al., 2015; Vader et al., 2017; Vancampfort et al., 2017). Social support was also a recurring facilitator to PA engagement (Ley, Barrio, & Leach, 2015; Roos et al., 2015; Simonik et al., 2016; Vader et al., 2017). These studies were generally based on perceptions of an exercise intervention program (i.e., Ley, Barrio, & Leach, 2015; Li et al., 2017; Montoya et al., 2015; Roos et al., 2015) or were focused on readiness to exercise (Simonik et al., 2016). They were not designed to describe barriers to and facilitators of PA in daily-life. In contrast, our qualitative study intended to grasp the multiple factors influencing exercise and PA levels in PLHIV in their natural environment. Furthermore, this study aimed to identifying exercise stereotypes underlying the barriers to and facilitators of PA in this population. With different socio-environmental, psychological and physiological barriers to and facilitators of PA emerging from our research, we specifically identified positive shared beliefs related to: (a) the benefits of PA, including well-being and physical fitness, (b) the perceived risks of exercise including fear of injury, and (c) the physical self-perceptions including lack of capacity for exercise and perceived physical appearance. These results suggested that both positive and negative stereotypes might exist in PLHIV, and that their internalisation might play a role in PLHIV PA level.

To examine this hypothesis, we needed to develop a valid psychometric tool to measure positive and negative exercise stereotypes in PLHIV. In the literature, scales have been developed and validated to measure HIV-related stigma including the HIV Stigma Scale (Berger, Ferrans, & Lashley, 2001; Bunn, Solomon, Miller, & Forehand, 2007) and the

Internalised AIDS-related Stigma Scale (Kalichman et al., 2005). These scales focused on HIV-related stigma, with items associated with personalised or enacted stigma, disclosure concerns, negative self-image and concern with public attitudes toward people with HIV (Berger, Estwing Ferrans, & Lashely, 2001; Bunn, Solomon, Miller, & Forehand, 2007), as well as self-defacing beliefs and negative perceptions of PLHIV (Kalichman et al., 2009). Our goal was to develop an HIV stereotype scale specifically measuring beliefs towards exercise and PA. Thus the *HIV Exercise Stereotype Scale* was developed, based on the findings of our qualitative research and existing literature in different vulnerable populations, including cancer patients (Falzon et al., 2014) and older adults (Chalabaev et al., 2013). The scale was validated following Vallerand's (1989) procedure. The HIVESS consisted of 14 items that were subdivided into three categories of exercise beliefs related to: (a) exercise benefits, (b) exercise risks, and (c) lack of capacity for exercise. The HIVESS adds to the HIV-related literature in that it allows access to specific stereotypes linked to exercise and PA which in turn can help elucidate the underlying mechanisms for lower levels of PA in PLHIV, while being a useful tool in clinical practice.

What are the mechanisms at play in the relationship between exercise stereotypes and PA level in PLHIV? What is the role of perceived fatigue?

With a valid tool to assess exercise stereotypes in PLHIV, we sought to identify the psychological mechanisms underlying the relationship between exercise stereotypes and PA level in this population. Using the HIVESS among men and women living with HIV, our third study allowed us to explore the plausible role of stereotype internalisation and ego depletion in the relationship between HIV exercise stereotypes and PA level. We hypothesised that internalisation, as indexed by self-efficacy, would play a role alongside ego depletion, indexed by perceived fatigue, in line with research by Emile et al. (2015). The model in which

self-efficacy was a moderator of the relationship between exercise stereotypes and PA level, as mediated by perceived fatigue, provided the highest explained variance of PA. These findings suggest that self-efficacy would temper the mediating role of perceived fatigue in the relationship between negative exercise stereotypes and PA level, with high levels of self-efficacy reducing perceived fatigue and increasing PA level, and inversely, for low levels of self-efficacy. This study provides support to the ego depletion mechanism and suggests that self-efficacy could moderate this mechanism.

These relationships are limited for interpretation as they are based on subjective measures and as they are examined through a correlational design. To overcome some of these limitations, the following study sought to characterise the prevalent fatigue in PLHIV through the integrative approach suggested by Kluger et al. (2013), taking into account both perceived fatigue and performance fatigability. As recent research has suggested that perceived fatigue is lower in active PLHIV as compared to less active PLHIV (Webel et al., 2016a), we also took into account the level of PA of our participants in this fourth study. The main results revealed a trend for higher pre-test MVC values in active PLHIV compared to less active PLHIV. This would suggest that, in line with research among healthy trained and less trained adults (Bachasson et al., 2016), PLHIV who are regularly active would benefit from favourable neuromuscular adaptations. This result is supported by the literature in which physically active cystic fibrosis patients showed no significant differences in muscle endurance and fatigability compared to healthy adults, suggesting that the effects of PA are relevant in chronic illnesses.

Furthermore, the decrease in exhaustion MVC values was not significantly different between active and less active PLHIV, but active PLHIV revealed a lower downward trend at the end of the 40% MVC level for absolute endurance as compared to the less active PLHIV. This lower tendency in MVC value decrease could indicate that performance fatigability is

greater in less active PLHIV in contrast to active PLHIV. Lastly, performance fatigability appeared to be largely of peripheral origin for both active and less active PLHIV with higher levels of peripheral fatigue observed in less active PLHIV. These results are innovative and essential in HIV-related fatigue research and add a valuable variable to the existing multidimensional model of fatigue in PLHIV (Voss et al., 2006, based on Barroso and colleagues work: Barroso, 1999; 2001; Barroso & Lynn, 2002). By measuring both perceived fatigue and performance fatigability we took a step forward in allowing for the unified taxonomy of fatigue (Kluger et al., 2013) to be supported in the specific context of HIV.

As the previous studies were correlational or descriptive, they did not allow elucidating the role of stereotypes on performance fatigability. Based on stereotype threat theory, stereotype context has been shown to impact performance in different contexts including the cognitive domain (e.g., Inzlicht & Ben-Zeev, 2000; Spencer et al., 1999; Steele, 1997; Steele & Aronson, 1995) and, more recently, the physical activity domain (e.g., Beilock et al., 2006; Chalabaev et al., 2008; Chalabaev et al., 2013a; Hively & El-Alayli, 2014). The objective of the last part of this doctoral work was to examine a potential causal relationship between stereotype activation and performance in fatiguing tasks in different populations, with a specific focus on the nonexerciser stereotype.

How does stereotype threat influence performance on fatiguing tasks in PLHIV and healthy adults? The role of the nonexerciser stereotype.

Research related to stereotype threat effects in the physical activity domain has mainly focused on the sex-stereotype. Yet, with the perceptions of active and less active people being largely conveyed by society, a new stereotype has emerged in the literature, the exerciser stereotype or nonexerciser stereotype in its negative form (Lindwall & Martin Ginis, 2006; Martin Ginis et al., 2003; Rodgers et al., 2009). In line with the specific role of lack of

capacity for exercise stereotypes evidenced in Study 3 (Gray et al., 2018), it was of interest to us to observe whether or not the nonexerciser stereotype would impact motor performance. In our fifth study we specifically hypothesised that activating the negative nonexerciser stereotype in less active PLHIV would have a detrimental effect on performance on the 15-s MVC handgrip task. Furthermore, we hypothesised that manipulating task-relevant self-efficacy would temper the effect of the nonexerciser stereotype. These hypotheses emerged from the findings of Study 3 and Study 4, suggesting that self-efficacy would moderate the relationships between stereotype endorsement and PA as mediated by perceived fatigue, and that fatigability would vary according to PA. They were also based on existing literature showing that the self may play an important role between stereotype activation and subsequent behavior (Wang, Zhou, Tan, & Zhang, 2017; Wheeler, DeMarree, & Petty, 2014; Wyer, Neilens, Perfect, & Mazzoni, 2011). Our results evidenced that providing *high* self-efficacy performance feedback positively moderated the detrimental effect of the negative nonexerciser stereotype on the mean force output during the 15-s MVC handgrip fatiguing task. These results provide support to the theory of active-self-account (Wheeler et al., 2007) in which self-concept is considered a moderating variable between stereotype activation and behavior. They also enrich the findings of our correlational study (Gray et al., 2018) by providing some experimental support to the moderating role of self-efficacy and extending the perceived fatigue construct to performance in fatiguing tasks. Such findings have also important practical implications in terms of fostering self-efficacy in PA promotion interventions in PLHIV.

With vulnerable populations facing stigma, it would seem reasoned to question whether the stereotypes in these vulnerable populations would impact healthy individuals in the same manner. Moreover, the effects of stereotype threat have, in some studies, not been congruent with the classical detrimental effect. Indeed some research reported no effect on task

performance (Chalabaev, Brisswalter, et al., 2013a) or even an increase in performance (Huber et al., 2015) of the threatened groups. In line with these studies, we hypothesised that active participants would benefit from a performance increase due to the theory of stereotype lift (Chalabaev et al., 2013a; Walton & Cohen, 2003) and that less active participants, consistent with the classical stereotype threat literature, would suffer a performance decrease when confronted with a negative stereotype about their less active condition. Our results validated the hypothesis related to performance improvement in active healthy young adults, giving support to the stereotype lift theory. However, our less active healthy young adults also performed better when under threat. This result was contrary to classical stereotype threat effects and our results found in less active PLHIV. A possible explanation was provided by slower rates of increase in measure of perceived exertion when under threat, suggesting that participants in this condition persisted in the task as their subjective difficulty of the effort was lower (Eston, Faulkner, St Clair, Noakes, & Parfitt, 2007). The results from our fifth and sixth studies broadened the stereotype threat literature by examining a new stereotype, the nonexerciser stereotype, while suggesting different effects in different populations with different explanatory mechanisms.

Limitations and perspectives

Although we tried to base our studies theoretically and methodologically with the maximum of rigor, this doctoral work suffers from a number of limitations related to each adopted design. Our findings also invite us to explore several avenues of research.

The first study of this thesis was based on semi-directive interviews and a qualitative approach. This approach provided a global descriptive and comprehensive view of perceived barriers to and facilitators of PA in PLHIV, without however, revealing explanatory mechanisms, nor allowing a generalisation of the results. Indeed, beyond its qualitative

paradigm, this study included a limited number of participants and focused on French PLHIV. The barriers to and facilitators of PA revealed in our study however, corroborated recent studies focusing on PLHIV in different countries including Canada (e.g., Li et al., 2017), South Africa (Roos et al., 2015) and the United States of America (e.g., Montoya et al., 2015), while highlighting the potential role of stereotypes related to PA and HIV. Based on the results from our qualitative study and the existing literature, in our second study we developed and validated a tool to assess the exercise stereotypes in PLHIV. The HIVESS would allow controlling some of the limitations related to qualitative research by adopting a quantitative approach in Study 3. This questionnaire however could gain external validity from applications in other correlational, longitudinal or interventional studies. Furthermore, the HIVESS was validated in French and thus can be used by francophone participants only. It would therefore be of interest to translate and validate the HIVESS into English to enhance its international visibility and encourage cross-cultural studies.

In studies 3, 4, 5 and 6, main limitations include the use of self-reported measures, yet it is important to consider that the answers obtained when using self-reported measures are susceptible to social desirability bias, underlined by the desire for participants to favourably present themselves according to social norms (Fisher, 1993). Future research looking at the possible relationships between exercise stereotypes and PA level should therefore also include objective measures of PA level such as accelerometer data (Migueles et al., 2017). Sample size was another limit, specifically in Study 4, for which we plan to analyse more data to allow for more powerful statistical analysis to be run and draw significant conclusions. Studies 5 and 6 addressed the limitations related to the interpretation of the correlational design used in Study 3 through an experimental approach activating stereotype contexts and manipulating self-efficacy. These causal inferences offer valuable perspectives for exercise promotion and interventions in both PLHIV and healthy young adults. The nonexerciser

stereotype however, is an emerging stereotype and has only been experimentally manipulated in our studies, thus far. Therefore, further studies should focus on examining the effects of the nonexerciser stereotype activation on different psychosocial and behavioural outcomes.

The interpretations of these results are also limited to middle-aged, less active PLHIV who are members of HIV/AIDS associations. Expanding the experimental protocol to active PLHIV as well as other chronic conditions would allow our results to gain salience. Moreover, the nonexerciser stereotype activation seems to not have the same influence on less active young adults' performance fatigability as on less active PLHIV. There are some plausible explanations for this discrepancy. Firstly, in Study 6, our participants were significantly younger than our sample of less active PLHIV in Study 5. Future research should perhaps focus on studying the effects of the nonexerciser stereotype in middle-aged, healthy adults to overcome this study bias. Secondly, the participants in our sixth study were all highly identified to the PA domain, and literature has suggested that less identified individuals may not experience the same stereotype effects as highly identified individuals (Nguyen & Ryan, 2008). The results of this study suggested a valuable explanation for performance increase when under threat in relation to perceived exertion and effort tolerance, thus encouraging to consider these constructs in future stereotype threat studies. Finally, recent literature has suggested the mere effort account, suggesting that the potential for evaluation motivates participants to want to perform well which, in turn, potentiates the prepotent or most likely response to the task (Harkins, 2006; Huber et al., 2015; Jamieson & Harkins, 2007) to be a plausible explanation for performance increase in threatened groups. It would be of interest to study the nonexerciser stereotype from this perspective in future work.

GENERAL CONCLUSION

Despite its limitations, this doctoral work contributes to the literature on several fronts. First this thesis allowed broadening the HIV-related literature on barriers to and facilitators of PA by highlighting the role of positive and negative stereotypes related to exercise and HIV, and developing a related valid psychometric tool. Second, some mechanisms of the relationship between these exercise stereotypes and PA level in PLHIV, or their performance in fatiguing tasks, were evidenced through correlational and causal designs. Specifically, perceived fatigue appeared as a mediator of the relationship between exercise stereotypes and PA, while self-efficacy acted as a moderator, thus enriching the ego depletion mechanism interpretation of stereotypes in the literature.

Furthermore, high self-efficacy performance feedback positively influenced performance fatigability in less active PLHIV under stereotype threat. These findings usefully expand the stereotype threat literature related to the PA domain, while offering promising research related to the theory of active-self account. Moreover, by considering performance fatigability as a dimension of fatigue in PLHIV that may vary according to PA level, our results also allow to enrich the multidimensional model of fatigue in the HIV literature (e.g., Barroso et al., 2003). More generally, our results raise some interesting questions for contemporary models of fatigue in chronic diseases (Gruet, 2018).

Finally, taking into account the detrimental impact of negative exercise stereotypes as well as the positive effect of self-efficacy performance feedback presents an encouraging avenue for future research in PA promotion and the development of exercise interventions in PLHIV.

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Résumé

L'activité physique (AP) aurait de nombreux effets bénéfiques chez les personnes vivant avec le VIH (PVVIH), notamment sur la fatigue, l'un des principaux symptômes et effets secondaires des traitements dans cette population. Néanmoins, les PVVIH restent insuffisamment actives au regard des recommandations. En s'appuyant sur des théories contemporaines des stéréotypes (e.g., *Stereotype Embodiment Theory*, Levy, 2009; *Stereotype Threat Theory*, Steele & Aronson, 1995) et sur une approche intégrative de la fatigue (Kluger et al., 2013), ce travail doctoral a postulé que l'endossement ou l'activation de stéréotypes liés à l'exercice influenceraient le niveau d'AP des PVVIH ainsi que leur performance lors de tâches fatigantes. La première partie de cette thèse a identifié le contenu des stéréotypes liés à l'AP et au VIH à travers une approche qualitative (Etude 1) et a permis le développement et la validation d'une échelle spécifique (Etude 2). La deuxième partie avait pour objectif d'identifier les mécanismes en jeu dans la relation entre stéréotypes liés à l'exercice, fatigue et AP. Les résultats montrent que les stéréotypes liés à l'exercice pourraient influencer l'AP par le biais du mécanisme d'*ego depletion*, indexé par la fatigue perçue et, être modérés par l'auto-efficacité (Etude 3). La fatigue perçue et la fatigabilité dépendraient également du niveau d'AP des PVVIH, les PVVIH les plus actives étant caractérisées par une fatigue perçue et une fatigabilité moindres (Etude 4). Enfin, basée sur la menace du stéréotype, la dernière partie de ce travail doctoral a indiqué que la menace du *nonexerciser stereotype* pouvait affecter la fatigabilité des PVVIH moins actives (Etude 5), mais pas celle d'adultes sains (Etude 6). De plus, l'auto-efficacité a modéré l'effet de menace du *nonexerciser stereotype* chez les PVVIH moins actives (Etude 5). Ces résultats enrichissent la littérature relative aux stéréotypes dans le domaine de l'AP tout en soulevant de nouvelles questions importantes pour le développement des modèles actuels de la fatigue dans des pathologies chroniques.

Mots Clés : *VIH ; Activité physique ; Fatigue perçue ; Fatigabilité ; Stéréotypes ; Auto-efficacité.*

Abstract

Physical activity (PA) has been reported to have many beneficial effects among people living with HIV (PLHIV), especially on fatigue, which is one of the main prevalent symptom and possible side effects of treatments in this population. Nevertheless, PLHIV remain insufficiently active according to PA recommendations. Based on contemporary theories of stereotypes applied to health behaviours (e.g., *Stereotype Embodiment Theory*, Levy, 2009; *Stereotype Threat Theory*, Steele & Aronson, 1995) and an integrative approach of fatigue (Kluger et al., 2013), this doctoral work postulated that exercise stereotypes endorsement or activation would play a role in the PA level of PLHIV and in their performance in fatiguing tasks. The first part of this dissertation identified the content of stereotypes related to PA and HIV through a qualitative approach (Study 1) and conducted the development and validation of a specific scale (Study 2). The second part aimed at identifying the mechanisms at play in the relationship between exercise stereotypes, fatigue and PA. Results showed that exercise stereotypes might influence PA through ego depletion mechanisms, as indexed by perceived fatigue and, be tempered by exercise self-efficacy (Study 3). Perceived fatigue and performance fatigability might also depend on the PA level of PLHIV, the more physically active PLHIV being characterised by lower perceived fatigue and performance fatigability (Study 4). Finally, based on stereotype threat theory, the last part of this doctoral work indicated that the nonexerciser stereotype threat could affect performance fatigability in less active PLHIV (Study 5) but not in healthy adults (Study 6). Furthermore, self-efficacy tempered the effect of the nonexerciser stereotype in less active PLHIV (Study 5). These results enrich the literature on stereotypes in the PA domain while raising interesting questions for contemporary models of fatigue in chronic diseases.

Key words: *HIV; Physical activity; Perceived fatigue; Performance fatigability; Stereotypes; Self-efficacy.*