Effet de l'activité physique et du régime diététique sur une population de grands obèses à court et à long terme

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La tesi è dedicata a loro…………………….ciò che ho di più caro al mondo.

GRAZIE

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Liste abréviation

AEE : activity energy expenditure
BAT : brown adipose tissue
BIA : bioimpendance analysis
BMI : body mass index
BW : body weight
BWR : body weight reduction
CHD : coronary heart disease
CG : center of gravity
CKCE : closed kinetic chain exercises
CMJ : counter movement jump
CP : chest press
CPR : constant pulse rate
CVD : cardiovascular disease
DLW : doubly labelled water
DBP : diastolic blood pressure
DEXA : Dual energy X-ray absorptiometry
EE : energy expenditure
EI : energy intake
EPOC : excess post-exercise oxygen consumption
FC : fréquence cardiaque
FCex : fréquence cardiaque d'exercice
FCmax : fréquence cardiaque maximale
FDA : food and drug administration
FFM : fat free mass
FM : fat mass
FPSS : Framingham point scoring system
GB : gastric bypass
GDP : gross domestic product
GNP : gross national product
GP : general pratitioners
HBDs : hypoenergetic balanced diets
HDL : high density lipoprotein
HDL-C : high density lipoprotein cholesterol
HR : heart rate
HRs : hazard ratios
HRQL : health related quality of life
HRT : hormone replacement therapy
IP : indice de performance
kcal : kilocalorie
LAGB : laparoscopy gastric bypass
LCD : low calorie diets
LP : leg press
LTPA : leisure time physical activity
PA : physical activity
PAL : physical activity level
PAR : physical activity ratio
PI : performance idex
PIL : prodotto interno lordo
RCM : réduction de la masse corporelle
REE : resting energy expenditure

1RM : one maximal repetition
RMR : resting metabolic rate
RPE : rating of perceived exertion
SBP : systolic blood pressure
SES : socio-economic status
SSBs : sugar-sweetened beverages
Tc : time contact
TEE : total energy expenditure
TEM : thermic effect of a meal
Tf : time fly
VBG : vertical banded gastroplasty
VLCD : very low calorie diets
VLED : very low energy diets
VT : vertical tractrion
$\dot{V}O_2ex$: exercise oxygen consumption
$\dot{V}O_2max$: maximal oxygen consumption
W : absolute power
Wmax : maximum anaerobic power output
Wspec : specific power

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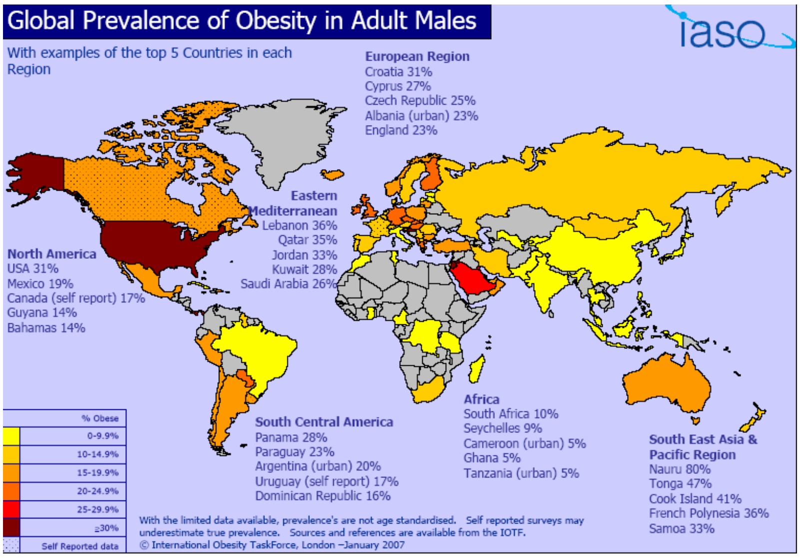
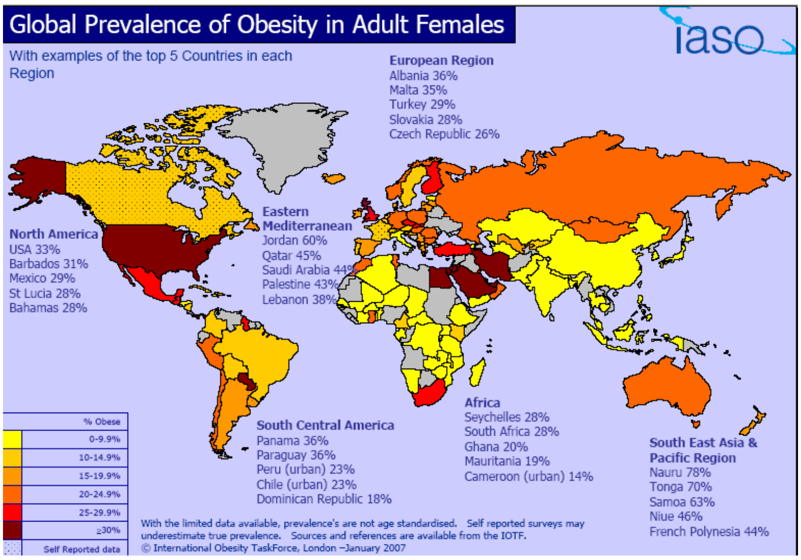
1 Introduction

1.1 Problem statement

1.1.1 The obesity epidemic

Current International Obesity Task Force (IOTF) estimates suggest that at least 1.1 billion adults are overweight around the world including 312 million who are obese (James, 2004). The task force's conservative estimates suggest that obesity levels will continue to rise in the early 21st century - with severe health consequences - unless urgent action is taken now.



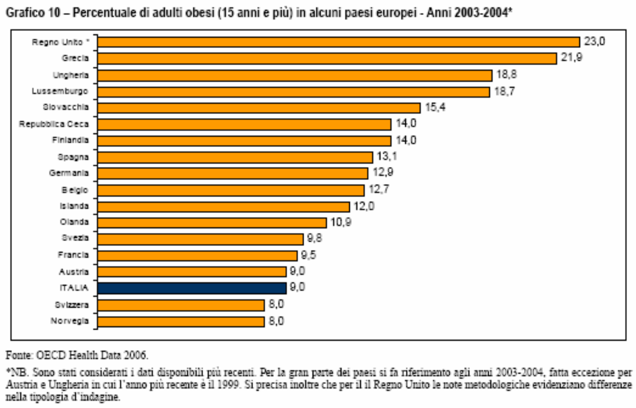


From: Sources and references are available from the IOTF.

Over the last few decades, overweight has been increasing in several developed, but also developing, countries, including the USA (Will, 1999; Flegal, 2002, 2004a; Freedman, 2002; Manson, 2003; Chopra, 2004; Olshansky, 2005), Canada (Katzmarzyk, 2002), the Pacific countries (WHO, 2003a), Australia, China and several Western European countries (Silventoinen, 2004), including Spain (Rodriguez Artalejo, 2002; Martinez, 2004), Great Britain (Rennie, 2005) and Denmark (Bendixen, 2004).

Estimates of self-reported overweight and obesity in Italy were derived from the National Multipurpose Surveys, conducted by the National Institute of Statistics (ISTAT, 2005) and from Gallus, 2006. Body Mass Index (BMI) was computed as the ratio between weight in kg and height in m^2. BMI was categorized in four levels, according to the standard classification by the World Health Organization (WHO, 2000; James, 2001): underweight (BMI <18,5 kg/m^2), normal range (BMI between 18,5 and 24,9 kg/m^2), overweight (BMI between 25,0 and 29,9 kg/m^2) and obese (BMI >30,0 kg/m^2).

Gallus's estimates of overweight and obese subjects are in broad agreement with the survey conducted in 2003 on more than 50000 Italian adults (ISTAT, 2005). The obesity levels in the adult population in Italy are not so alarming as those recorded in the United States, where more than 30% of the 15 year-old people and more is obese. Both reports confirm the findings from a survey including more than 15000 adults from the 15 countries of the former European Union (Martinez, 1999), showing that Italy, with France and Luxembourg, had the lowest prevalence of overweight or obese adults (37% as compared to an average of 41% for the European Union) (Martinez, 1999).



From: Istituto nazionale di statistica, 2007.

Overall, 3,4% of the Italian adult population were underweight, 57,1% (Gallus, 2006) 52,6% (ISTAT, 2005) had a normal range of BMI, 31,3% (Gallus, 2006) 34,2% (ISTAT, 2005) were overweight, and 8,2% (Gallus, 2006) 9,8% (ISTAT, 2005) were obese.

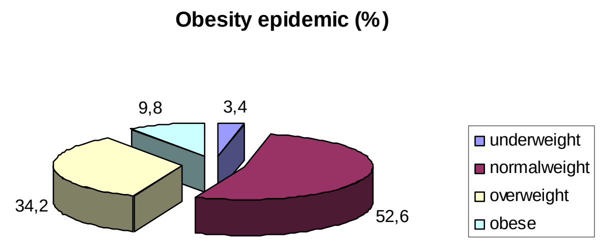


Fig. 1 Italian Obesity Epidemic

The two analyzed studies are not in agreement for obesity trend in the last years. ISTAT data underline that obesity is growing up: around 4 million and 700 thousand adult people are obese in Italy, with an increase of 9% in comparison with five years ago. The increase of obesity is due above all to the recorded raise in the masculine population, particularly in the 25-44 year-old young adults and among the elderly ones. On the contrary, Gallus study shows that in both sexes, overweight increased from 1983 to the early 1990s, and then leveled off. Prevalence of obesity remained around 8–9% across the last 20 years. The lack of unfavorable trends in overweight and obesity in Italy may, therefore, at least in part be attributed to the type of 'Mediterranean diet' (Trichopoulou, 2005), and to the absence of a systematic increase in portion size. The Wold Health Organization (WHO) Monica project, analyzing 10-year trends of total energy supply from several countries worldwide, showed that, in Italy, per capita total energy intake remained approximately stable between 1986 and 1994, whereas it increased by more than 200 kcal/capita/day in the USA and in several Western European countries (Harnack, 2000; Silventoinen, 2004).

Overweight was reported only by 14,1% (Gallus, 2006) 13,1% (ISTAT, 2005) of subjects aged 18–24 years (the highest values are reported for men). The highest proportions of overweight subjects were in the 45–74 year age group (45,1% Gallus, 2006, 46,1% ISTAT, 2005). The same trend is observed for obesity: younger people reach only 2,4% (Gallus, 2006) 2,1% (ISTAT, 2005), on the contrary obesity increases at higher values for older people (11,9% Gallus, 2006; 15,6% ISTAT, 2005).

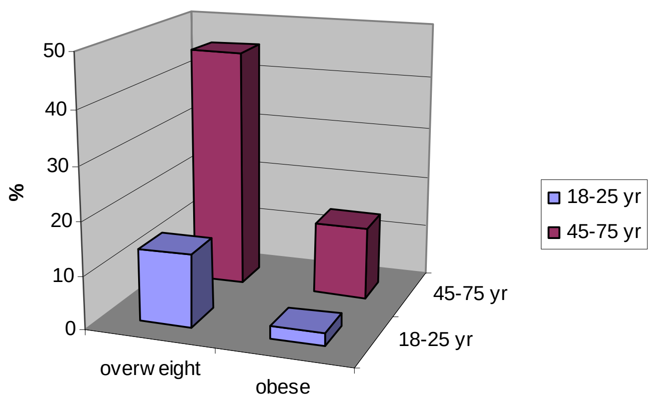


Fig. 2 Obesity increase with age

The excess of weight is more spread among men, but the differences of sex are more marked for overweight than obesity: 38,4% of men, 24,7% of women (Gallus, 2006) 42,5% of men and 26,6% of women (ISTAT, 2005). In agreement both studies show that, among women aged 18–24 years, underweight (15,1%) is a more common phenomenon than overweight and obesity.

The percent prevalence of overweight and obesity is 32,3% (Gallus, 2006) 31,85% (ISTAT, 2005) and 5,50% (Gallus, 2006) 9% (ISTAT, 2005) in northern respectively, 44,3% (Gallus, 2006) 33,5% (ISTAT,

2005) and 10,2% (Gallus, 2006) 9,0% (ISTAT, 2005) in central respectively, and 47,0% (Gallus, 2006) 38,7% (ISTAT, 2005) and 10,9% (Gallus, 2006) 11,6% (ISTAT, 2005) in southern Italy respectively. These underline the highest values of overweight and obesity in southern Italy and on the islands. The figure below graphs ISTAT values of overweight on the top and obesity on the bottom in Italy.

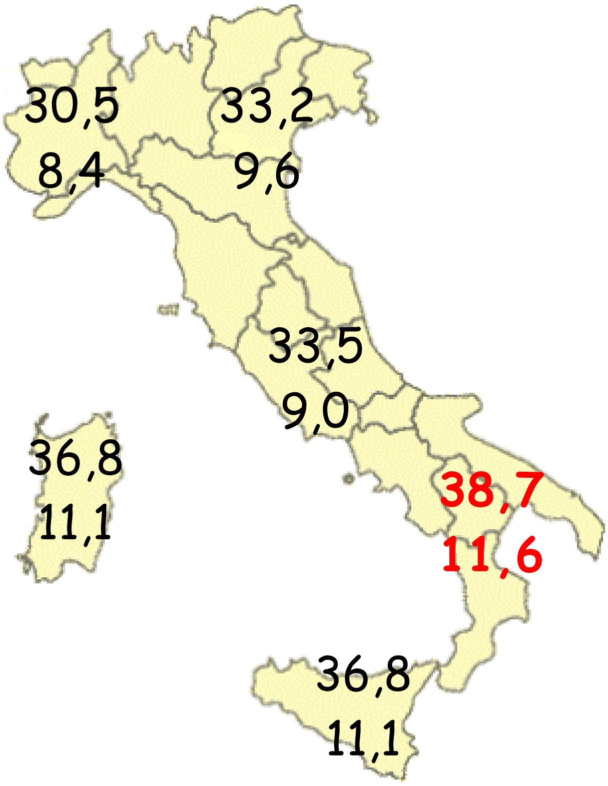


Fig. 3 Obesity differences among Italian regions

1.1.2 Economic costs of obesity

Obesity imposes an economic burden on society through increased medical costs to treat the diseases associated with it (direct costs: hospital stay, nursing home, medications, physician visits), lost productivity due to absenteeism and premature death (indirect costs: wages lost by people unable to work because of disease and also the forgone wages resulting from premature mortality) and missed opportunities, psychological problems and poorer quality of life (intangible costs) (Colditz, 1999). An estimate of the direct costs can be obtained through cost-of-illness studies. A compilation of direct cost studies worldwide reveals that health expenditure per inhabitant attributable to obesity ranges between US$ 13 (United Kingdom, 1998) and US$ 285 (United States, 1998).

Table 1. Estimated economic costs of obesity according to available studies

Country (study)	Year of estimate	BMI criterion	Cost			
			Type	Per capita (US$ at PPP[a])	Share of total current expenditure on health (%)	Share of GDP[b] (%)
In the WHO European Region						
Belgium *(22)*	1999	≥30	Direct	69	3	–
France (range) *(26)*	1992	≥30	Direct	71–148	0.6–1.3	–
France *(27)*	1992	≥27	Direct	202	1.8	0.9
Germany (range) *(28)*	2001	≥30	Direct	17–35	1.2–2.6	0.1–0.3
			Indirect	17–38	–	
Netherlands *(29,30)*	1993	≥30	Direct	32	1.7	–
Sweden *(31)*	2003	≥30	Direct	45	1.8	0.7
			Indirect	157	–	
Switzerland *(28)*	2001	≥25	Direct + indirect	186	–	0.6
United Kingdom (England, range) *(32)*	2002	≥30	Direct	NA[c]	2.3–2.6	–
EU (15 countries) *(25)*	2002	≥30	Direct + indirect	NA	NA	0.3
Outside the WHO European Region						
Australia (range) *(33)*	1995–1996	≥30	Direct	28–51	1.7–3.2	–
Canada *(34)*	1997	≥27	Direct	49	2.4	–
Canada *(35)*	2001	≥30	Direct	41	1.6	0.4
			Indirect	70	–	
Japan *(36)*	1995–1998	≥30	Direct	55	0.2	–
New Zealand *(37)*	1991	≥30	Direct	26	NA	–
United States *(38)*	1994	≥30	Direct	92	2.7	–
United States *(39)*	1995	≥30	Direct	263	7.3	–
United States *(40)*	1995	≥29	Direct	194	5.4	–
			Direct + indirect	371	–	1.4
United States *(41)*	1998	≥25	Direct	285	7.1	–
United States *(42)*	2000	≥30	Direct	199	4.8	1.2
			Indirect	183	–	

[a] PPP = purchasing power parity. PPP controls for differences in purchasing power, which means that a dollar may have more value in terms of consumption in one country than in another.

[b] When both direct and indirect costs have been calculated in the same study, the total cost as percentage of gross domestic product (GDP) is the sum of both direct and indirect costs.

[c] NA = not available.

From: World Health Organization, 2007.

Calculations in the United States indicate that people with a BMI exceeding 30 kg/m^2 had 36% higher annual health care costs than those with BMI 20,0–24,9 kg/m^2, and that people with a BMI 25,0–29,9 kg/m^2 had 10% higher annual health care costs than those with BMI 20,0–24,9 kg/m^2 (Thompson, 2001).

Studies in the WHO European Region indicate that, in general, the direct health care costs of obesity account for 2–4% of national health expenditure (World Health Organization, 2003b). The total direct and indirect annual costs of obesity in 2002 in the 15 countries that were European Union (EU) members before May 2004 were estimated to be €32,8 billion per year. In particular, in Italy the annual costs of obesity are €5,435 billion per year (Fry, 2005). The direct health care costs of obesity were approximately 3% of total health care cost or 0,24% of PIL. PIL (Prodotto Interno Lordo) or GDP (Gross Domestic Product), is one of the ways for measuring the size of a region's economy. It is an economic indicator of the welfare of a country.

Another example of obesity costs is done by the study of Degli Esposti (2006) which aim was to evaluate the impact of comorbidities associated with overweight and obesity on the costs of drug treatment from the perspective of the Italian national health system. Compared with normal-weight subjects, overweight and obese subjects had significantly higher mean drug costs (this study considers only the costs of drugs reimbursed by the local health unit). The total mean annual drug costs were €132,71 for a normal-weight subject, €246,19 for an overweight subject, and €335,64 for an obese subject. The mean drug costs for overweight and obese subjects were 85,5% and 152,9% higher, respectively, than those for a normal-weight subject.

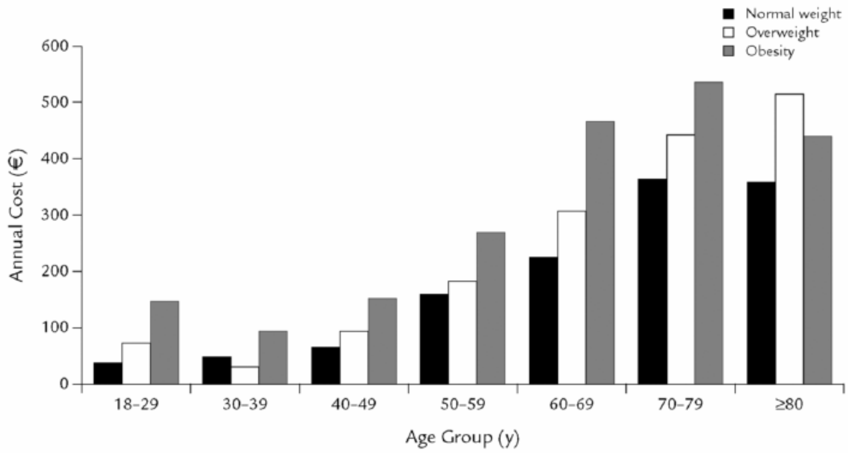


Figure 3. Mean annual drug costs per patient, by age group and body mass index (BMI) category. Normal weight = BMI ≤24.9 kg/m²; overweight = BMI 25 to 29.9 kg/m²; obesity = BMI ≥30 kg/m².

From: Degli Esposti: Clin Ther. 2006 Sep;28(9):1472-81.

Growing levels of both inactivity and obesity pose major health problems in Western society. The most recent statistical data on the spread of overweight and obesity in Italian society reveal that the phenomenon has reached a dimension that, albeit not as serious as in other Western countries, constitutes a serious threat to public health and to the national budget (De Marchi, 2007).

1.1.3 Determinants of obesity

The steady increase in the prevalence of obesity over the last two decades in the US, the UK and other European countries cannot readily be attributed to genetic factors (the available data indicate that the genetic contribution to variability in body fatness lies somewhere between 25 and 70%). Instead, it suggests that behavioral and lifestyle changes in wide sectors of the population are responsible for a sustained imbalance between the total energy intake (food intake) and the energy expenditure through resting metabolism and physical activity. The process of modernization, urbanization and changes in world trade in both developing and developed countries has brought about a number of consequences affecting nutritional and physical activity patterns that contribute to the development of obesity (WHO, 1998). Thus, the food system has improved the nutritional quality of diets and the availability of nutrients, while the sedentary lifestyle with motorized transport and many labour-saving devices as well as other physically inactive pursuits (TV viewing, computer work, etc.) have risen over the last few decades.

The most likely explanation for the high prevalence of obesity is an environment that produces constant pressure toward positive energy balance by promoting energy intake and discouraging physical activity (Hill, 1999).

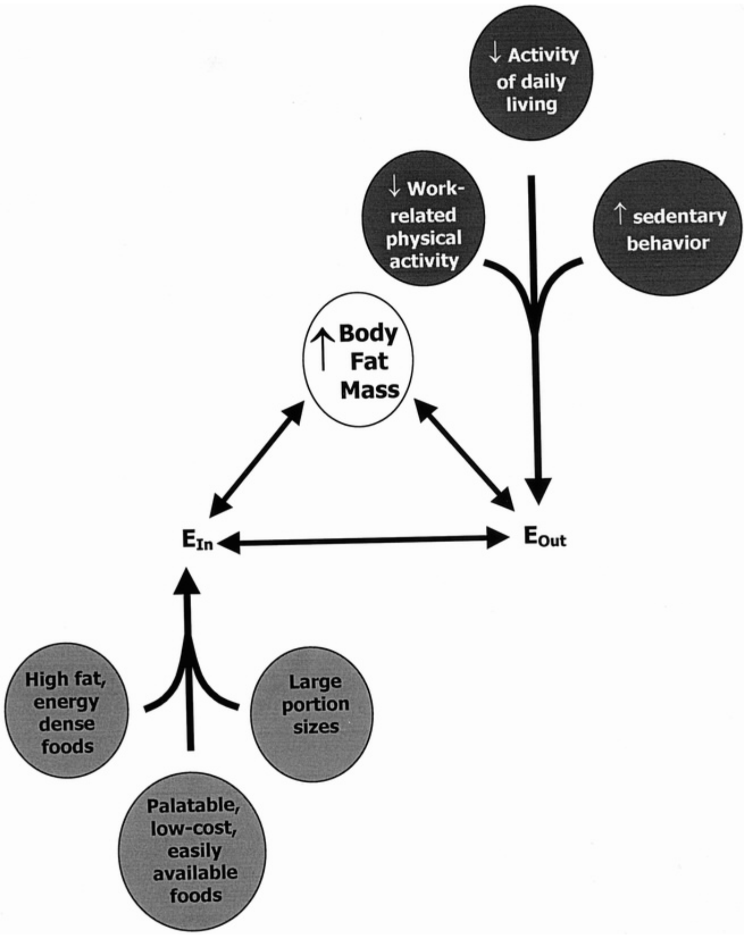


Figure 1 The effect of environmental factors on energy balance. When energy intake (E_{in}) equals energy expenditure (E_{out}), the system is in energy balance and body fat mass stable. In the current environment, factors (in circles) on the left are driving E_{in} up, whereas factors on the right are driving E_{out} down, creating a state of positive energy balance, leading to an increase in the body fat mass.

From: Hill: Med. Sci. Sports Exerc., Vol. 31, No. 11, Suppl., pp. S515–S521, 1999.

The explanatory causes of obesity are multiple and include increasing consumption of energydense foods high in saturated fats and sugars, and decreasing levels of physical activity (WHO, 2002). Diverging trends of decreasing energy intake and increasing body weight suggest that reduced physical activity may be the main determinant of the rising prevalence of obesity (Heini, 1997). There are substantial data to suggest that differences in amount of physical activity contribute to differences in body weight and body fatness and play an important role in whether obesity develops (Hill, 1999).

Genetic&Hormonal_Genetic factors explain a large proportion of the population variance in central adiposity, although the genotypic characteristics remain obscure. Hormonal factors such as endogenous sex steroid levels, the menopause, hormone replacement therapy and cortisol may influence body fat partitioning (Samaras, 1997). Leptin resistance is strongly associated with extreme obesity and appears to be a heritable trait. The determination of its genetic causes will aid in understanding the role of leptin in common forms of human obesity (Lee, 2001).

Developmental origins_While genetic factors, increasingly sedentary lifestyles and overnutrition have all been cited as important components of the obesity crisis, recent epidemiological and experimental evidence suggests that developmental factors, especially those that occur in utero and during early postnatal life, play a significant role in the pandemic (Benyshek, 2007). Recent research has identified critical factors that, as they accumulate and interact over an individual's life span, may put a person at risk for obesity. These factors include rapid weight gain in infancy and childhood, early puberty, and excessive weight gain in pregnancy (Johnson, 2006). Early growth is indeed associated with the prevalence of obesity later in the life course (Monteiro, 2005). Different factors have been identified in childhood which might influence the development of obesity in adulthood: offspring of obese parent(s); low socio-economic status (SES) in early life; clear relationship for increased fatness with higher birth weight; a relationship between earlier maturation and greater subsequent fatness (Parsons, 1999; Lahmann, 2000). Previous BMI has also been identified as an important predictor of future weight gain and obesity (Brien, 2007).

Environmental factors_Environmental factors contributing to obesity include technological and social changes leading to less physically demanding work, increasing dependence on cars, the rise in technology in the home and more passive leisure pursuits. All indications are that work-related physical activity has declined. Similarly, there is reason to believe that household related physical activity has declined rapidly over the past two to three decades. One can, for example, estimate the energy savings due to proliferation of energy-saving devices such as washing machines, dishwashers, computers, remote control devices, and microwave ovens. On a secular basis, participation in leisure time physical activity (LTPA) has not increased enough to offset significant declines in other aspects of physical activity, leading to a situation that favors positive energy balance in a large percentage of the population (Hill, 1999).

In addition, the marketing, wide-availability, low cost and convenience of so-called 'fast' foods and '"super-sized' portions are also considered to be important factors, along with increasing availability of high sugar drinks and declining availability of healthy food and drink choices in some food outlets (Hill, 2003).

Social determinants of health are also implicated in the causes of overweight and obesity. The rapid increase in obesity rates over recent years suggests that cultural and societal influences are affecting the adjustment in the energy balance equation in addition to other physiopathological or genetic determinants (Hill, 1998). Educational attainment decreased significantly the risk of obesity (Stam-Moraga, 1999; Dennis, 2000; Lahti-Koski, 2000; Santos, 2003; Halkjaer, 2004; Moreira, 2006). Illiteracy and marriage were factors associated with obesity (Azadbakht, 2005). Women who were overweight/obese were unemployed, had low education, poorer psychosocial conditions, low emotional and instrumental support, were daily smokers, had a sedentary lifestyle, had poor self reported global health, and had lack of internal locus of control compared with normal weight women (Ali, 2006). In women again a strong association between symptoms of depression, anxiety or distress, low levels of social support or impaired quality of life with waist circumference has been described (Räikkönen, 1999).

The reasons of obesity may be linked to economic as well as socio-environmental influences on behavior. Inequalities in the distribution of obesity across different socio-economic groups are also apparent (Lobstein, 2007). Obesity in the developing world can no longer be considered solely a disease of groups with higher socio-economic status (SES); the burden of obesity in each developing country tends to shift towards the groups with lower SES as the country's gross national product (GNP) increases (Monteiro, 2004).

The prevalence of obesity has been increasing due to a convergence of factors including fewer opportunities for sport and physical exercise and so very low physical activity (Stam-Moraga, 1999; Lahmann, 2000; Sherwood, 2000; Santos, 2003; Azadbakht, 2005; Boeckner, 2006; Kouris-Blazos, 2007; Lobstein, 2007). Higher levels of physical activity are associated with lesser amounts of central fat, both cross-sectionally and in intervention studies (Samaras, 1997). Cardiorespiratory fitness has also been identified as an important predictor of future weight gain and obesity (Brien, 2007).

The amount of energy expenditure required for daily living also appears to be declining due to an increase in attractive sedentary activities such as television watching, video games, and computer interactions. Increasing levels of physical inactivity and sedentariness are contributing to the current overweight and obesity epidemic. Time spent sitting per day (Brown, 2003) and the rise of TV viewing (Kouris-Blazos, 2007) are both related to BMI.

The prevalence of obesity has been increasing due to a convergence of other factors: smoking is associated with lower total body fat (Samaras, 1997; Dennis, 2000; Lahmann, 2000; Santos, 2003; Onat, 2007). Our preference for takeaway and pre-prepared foods, the trend towards more computer-bound sedentary jobs (Kouris-Blazos, 2007); social norms and peer pressure relating to fast foods reinforced by intensive food industry marketing running counter to healthy eating messages (Eckersley, 2001); inadequate transport for delivery of healthy foods to rural and remote areas (Lee, 2002).

Dietary determinants of obesity_The increase in obesity may have resulted from a decline in energy expenditure that was not matched by an equivalent reduction in energy intake (Hill, 1999). Obesity has been related to changes in dietary patterns (Lobstein, 2007). Diets high in fat have been suggested to increase the risk of overeating and obesity; a positive association between dietary fat intake and weight gain has been demonstrated by several authors (Stam-Moraga, 1999; Sherwood, 2000)

There are substantial data to suggest that energy intake is influenced by the energy density (energy per weight of food) of the diet. Foods with a high energy density, sugar-rich drinks and large portion sizes each increases the risk of over-consumption of energy. Traditional dietary patterns such as the 'Mediterranean' diet, rich in fruit, vegetables and unrefined carbohydrate, may be associated with a decreased risk, while diets rich in fat and added sugars and low in fibre, energy-dense foods typical of a 'fast food' culture, may increase the risk of weight gain (Jebb, 2007).

Findings from prospective cohort studies conducted in adults, taken in conjunction with results from short-term feeding trials, support a positive association between soda consumption and weight gain, obesity, or both. Experimental studies have suggested that the likely mechanism by which sugar-sweetened beverages may lead to weight gain is the low satiety of liquid carbohydrates and the resulting incomplete compensation of energy at subsequent meals. Consumption of sugar-sweetened beverages (SSBs), particularly carbonated soft drinks, may be a key contributor to the epidemic of overweight and obesity, by virtue of these beverages' high added sugar content, low satiety, and incomplete compensation for total energy. The weight of epidemiologic and experimental evidence indicates that a greater consumption of SSBs is associated with weight gain and obesity (Malik, 2006).

In Europe some authors tried to understand the variables independently associated with obesity in the European Union. Martinez in 1999 showed that the percentage of overweight and obese individuals among EU males and females varies with age, socioeconomic factors and education levels as well as depending on marital and smoking status. The information about marital status reveals that single individuals were less prone to be obese than couples or widowed/divorced people. Smoking status was statistically linked to the prevalence of obesity, since smokers or ex-smokers for more than 1 year presented a higher tendency to have a BMI >30. A low participation in sport activities, a lack of interest in being involved in exercise/physical activity (precontemplation) and an increasing number of hours sitting down at work appeared to be statistically significant predictors of obesity.

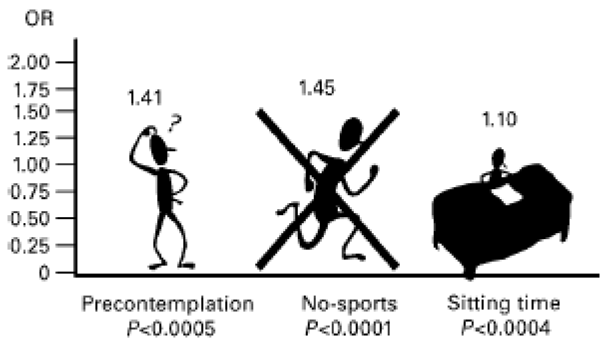


Fig. 4 Odds ratios (OR) of precontemplation, no physical activity and sitting time (hours per week) for obesity (BMI $\geq 30\ kg\ m^{-2}$) versus normal or underweight individuals (BMI $< 25\ kg\ m^{-2}$) in Europe

From: Martinez: Public Health Nutr. 1999 Mar;2(1A):125-33.

This pan-EU survey found a strong, independent and consistent inverse association between non-sedentary activity levels in leisure time and the prevalence of obesity in a representative sample of the 15 member states; a reduction in energy expenditure must be the main determinant of the current epidemic of obesity. An indicator of sedentary lifestyle (hours spent sitting down per week) was found to be positively correlated with obesity. The longer the time spent sitting down, the higher the BMI, the prevalence of overweight and of obesity among both men and women. Those who likely to have gained weight in the last 6 months, had lower social and educational achievements, and a greater proportion of them were current smokers (Martínez-Gonzalez, 1999).

In Italy Tavani in 1994 investigated the influence of some socioeconomic, behavioral, dietary and reproductive factors on BMI. Mean BMI increased with age until 35-44 years in men and 45-54 years in women. In both sexes BMI was inversely associated with education and social class. Smokers tended to be leaner than non-smokers, but no consistent trend was observed with increasing numbers of cigarettes. Alcohol drinkers had mean BMI similar to non-drinkers, except heavy drinking women who were lighter. BMI was not significantly associated with coffee, decaffeinated coffee, tea, bread, vegetable and fruit consumption. No relation was observed between total estimated caloric intake and BMI. In women BMI was directly associated with marriage and number of children, and inversely with oral contraceptive use.

A more recent study, the Progetto Menopausa Italia Study Group, 2003 showed that the mean BMI was higher in less educated women than in those with high-school education or a university degree, in non-smokers than in smokers, in never-users of hormone replacement therapy (HRT) than in ever-users of HRT and in women self-reporting no physical activity than in those reporting regular physical activity.

1.1.4 Comorbidities of obesity

Obesity is associated with many serious diseases that may be life threatening; common conditions that increase risk of more serious diseases; rare conditions; and health complaints that can reduce quality of life. It is well documented that obesity is associated with increased risk of many common chronic diseases including:

- coronary heart disease (angina pectoris, nonfatal myocardial infarction, and sudden death) (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006; Tsai, 2006),
- stroke (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006),
- some cancers (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006; Tsai, 2006),
- diabetes mellitus (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006; Tsai, 2006),
- hypertension (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006; Tsai, 2006),
- dyslipidemia (increased levels of triglycerides and decreased high-density lipoprotein cholesterol (HDL-C) (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006).

There is also evidence linking obesity with:

- osteoarthritis (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006),
- gallbladder disease, gallstones and their complications (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006),
- asthma (Patterson, 2004),
- depression (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006),
- sleep disorders such as sleep apnea (Pi-Sunyer, 1999; Patterson, 2004; Lang, 2006).

The independent association of obesity seems also clearly established for insulin resistance, glucose intolerance, hyperuricemia, heart failure, cardiac arrhythmia, menstrual irregularities (Pi-Sunyer, 1999). Few studies have reported on the association of obesity with rare conditions (e.g., congestive heart failure, pancreatitis) or with health complaints (e.g. bladder infections, headaches, fatigue) (Patterson, 2004). Being overweight significantly increases the risk for gynaecological abnormalities, and stress incontinence. Overweight and obesity are major risk factors for chronic diseases like hyperlipidemia, and other conditions, such as, respiratory problems, hyperinsulinemia, and vascular disorders. Obesity also poses an increased risk of premature death (Lang, 2006). In an industrial population Tsai et al. (2006) found that obesity was associated with increased death rates for all causes.

The epidemic levels of overweight and obesity seen in the United States, combined with the associated health burden, suggest that obesity has the potential to be the most serious public health threat faced by this nation (Patterson, 2004).

1.1.5 Overweight and obesity in the mortality rate data

Several studies have investigated the relationship between obesity and mortality or cardiovascular disease (CVD) reporting conflicting results. In most population studies, the association between BMI and mortality is described by a J-shaped relation (Singh, 1999) or a U-shaped curve (Landi, 2000), with augmented risk in the lowest and highest percentiles of the distribution, even when controlling for comorbid disease, age, and smoking. However, the association between body weight and mortality remains controversial. In particular, important questions remain about the impact of age on the relationship between overweight conditions and mortality (Landi, 2000). Most deaths occur among older adults; estimates of deaths attributable to obesity can vary widely depending on the assumptions about the relative risks of mortality associated with obesity among the elderly (Flegal, 2004b). Landi (2000) and Heiat (2001) support the hypothesis that the optimal weight for longevity may be higher in older people.

The literature is dominated by studies in young adult and middle-aged white inhabitants of North America and Europe. In those populations, it seems well accepted that lowest mortality is in the range of BMI between 18,5 and 25 kg/m^2 (Seidell, 1999) or 25,0-29,9 (Livingston, 2005). When BMI reached values of 30 kg/m^2 or more, mortality is substantially elevated by about 50–150%. These results may not be generalizable to other populations (Seidell, 1999).

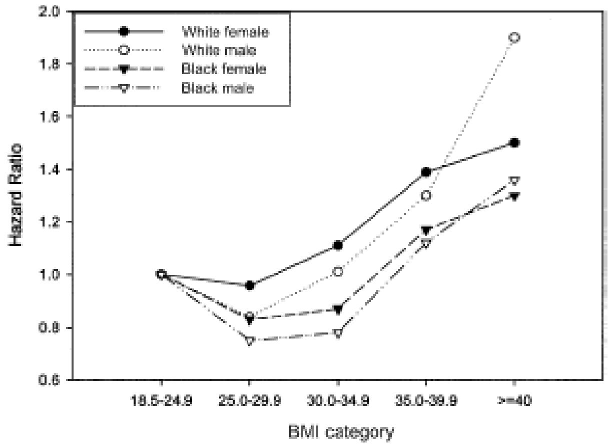


Figure. Hazard ratio for age-adjusted all-cause mortality as a function of BMI, gender, and race. All respondents were included; there was no stratification for diabetes or hypertension. The reference population for each hazard ratio was those individuals having BMIs ranging from 18.5 to 24.9. Note that BMI = 25.0-29.9 was associated with the least mortality.

From: Livingston. Surgery. 2005 Jan;137(1):16-25.

Using relative hazards associated with elevated BMI in 6 US studies, the national distribution of adult BMI, and estimates of population size and total deaths from the same era, Allison et al. (1999) estimated the annual number of deaths attributable to obesity to be about 280000. The mean estimate based on analyses of Hazard Ratios measured in nonsmokers or never-smokers was about 325000 and that found using HRs from ostensibly healthy, weight-stable nonsmokers or never-smokers was about 374000. Banegas et al. (2003) have found a similar results for European populations. A minimum of approximately 279000 annual deaths were attributable to excess weight in the EU, about two-thirds deriving from obesity and one-third from overweight in the mid-1990s. This represents 7,7% of all deaths registered among adults ≥25 y. At least one in 13 annual deaths in the EU were therefore likely to be related to overweight or obesity. The highest numbers of attributable deaths were observed for Germany, the UK and Italy, and the lowest for Luxembourg, Ireland and Finland (data not shown), in line with population size. The attributable proportion varied from 5,8% for France to 8,7% for the UK.

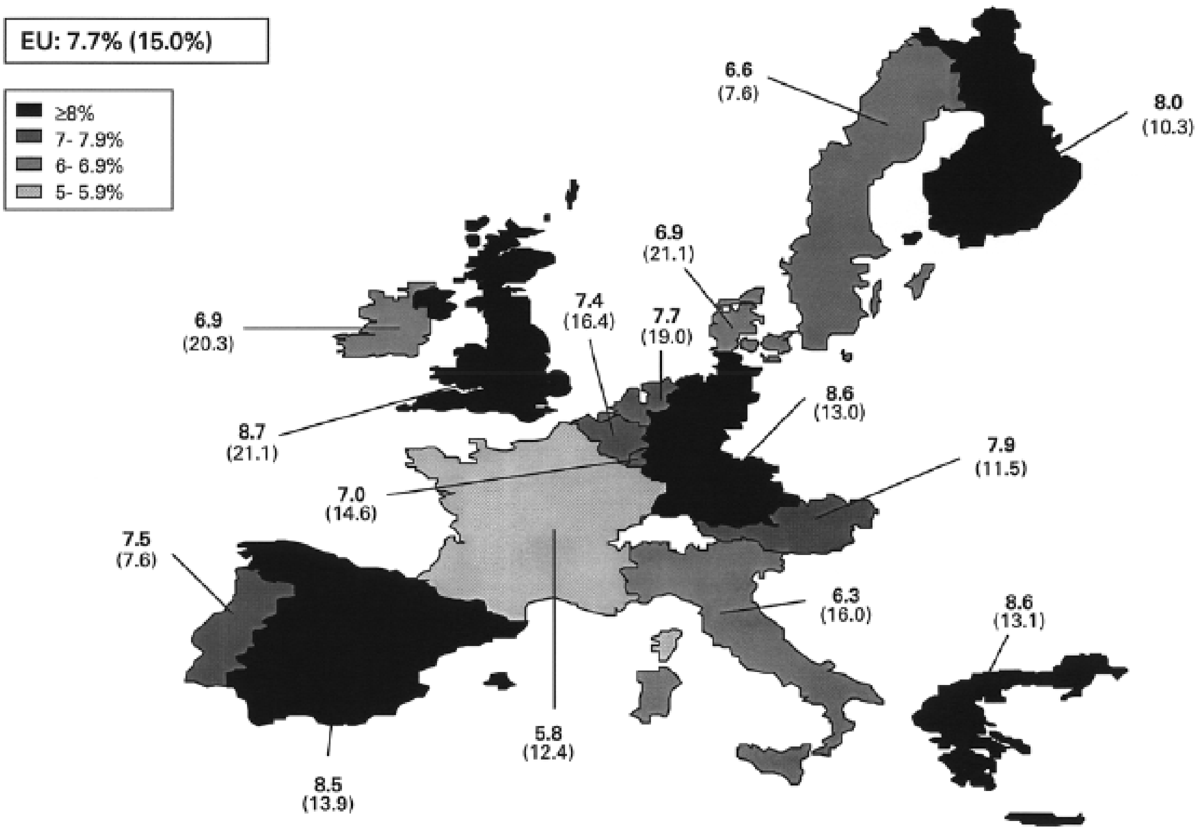


Figure 1 Proportion of all-cause deaths attributable to excess weight and to smoking (the latter in parentheses) in EU countries. Black and white gradation of countries in the map corresponds to their proportion of deaths due to excess weight. Calculations of deaths attributable to excess weight were based on prevalence data from the Pan-EU (Institute of European Studies, Trinity College, Dublin, 1999) and relative risks from CPS I (Allison *et al*, 1999). Deaths due to smoking were taken from Peto *et al* (1994).

From: Banegas: Eur J Clin Nutr. 2003 Feb;57(2):201-8.

In Italy Menotti et al. (1992) and Seccareccia et al. (1998) confirmed the parabolic relationship of BMI to all causes mortality but the high levels of BMI carrying the minimum risk of death in these studies were rather high: 27-29 units. Similar findings are obtained even with the exclusion of smokers, former smokers, and early deaths.

Stevens et al. (1999) showed that moderate obesity generally results in a 1- to 3-year reduction in life expectancy, depending on age. This trend can be increased by the age obesity has been developed; in fact Engeland et al. (2004) have found that high BMI in adolescence is predictive of both subsequent obesity and subsequent mortality. Singh et al. (1999) underlined that obesity remains an important risk factor for fatal disease even among adults who exhibited a low (alcohol use, saturated fat intake) or zero (cigarette smoking) prevalence of other traditional risk factors for chronic disease. Moreover, being fit does not completely reverse the increased risk associated with excess adiposity (Stevens, 2002).

The discrepancies existing between different estimates of mortality attributable to obesity in the literature can be partly explained by correcting biases in estimates of mortality attributable to obesity (Greenberg, 2006). Some authors found that correcting for putative biases yielded increases in all-cause mortality HRs for obesity that translate into substantial increases in estimates of excess mortality attributable to obesity in the US population (Greenberg, 2007). With appropriate control for smoking and reverse causality, both overweight and obesity are associated with important increases in all-cause and cause-specific mortality, and in particular with cardiovascular disease mortality (Lawlor, 2006). On the other hand, Flegal et al. (2007) demonstrated that residual confounding by smoking or pre existing illness had little effect on previous estimates of attributable fractions from nationally representative data with measured heights and weights (Flegal, 2007). With these discrepancies existing, it may be difficult to estimate deaths attributable to obesity with adequate accuracy and precision. Because mortality attributable to excess weight is a major public health problem, efforts urge to improve the data and methods for estimating this statistic.

1.1.6 Treatment of obesity

Dietary recommendations_One aspect of energy balance that can affect body weight is energy intake. An examination of the weight loss literature shows that changes in energy intake play a significant role in reducing body weight. In simplistic terms, when energy intake is reduced below the energy needs of the body, weight loss will occur. It is common for weight loss programs to reduce energy intake to 1000–1500 kcal/d to induce weight loss in overweight adults (ACSM, 2001). However, the absolute energy intake should be adjusted based on body weight to elicit an energy deficit of 500–1000 kcal/d. Thus, with this level of energy deficit, a minimum weight loss of 0,5–0,9 kg per week would be realistic, and studies have consistently shown weight loss of approximately 9,0 kg within the initial 16 to 26 wk of treatment (ACSM,2001). Currently, there is no evidence that a faster rate of weight loss or greater magnitude of initial weight loss will improve long-term weight loss outcomes compared with more conservative approaches.

The evidence to date suggests that the best dietary changes that facilitate modest weight loss or for weight management include: decreasing total fat intake, increasing lean protein to enhance satiety from a meal, promoting a low glycemic index diet to those known to be insulin resistant, watching portion sizes, avoiding excessive liquid calorie intake and giving advice regarding healthy alcohol consumption. There may be some debate regarding the protein and carbohydrate proportions that assist in weight loss. To date the evidence suggests that reduced carbohydrate intake works in the short term, but may not provide any weight loss advantage in the long term. In contrast, there is very good evidence that a low fat diet lowers energy intake, reduces long term energy intake and assists in the longer term maintenance of weight loss (Astrup, 2000; Dixon, 2006).

Low calorie diets (LCD) providing around 1200-1500 kcal should be used for those with a BMI 27-30 kg/m^2 or risk adjusted BMI 20-27 kg/m^2. Chief among these approaches is the use of meal replacements, in the form of shakes and bars. Meal replacements provide patients a fixed amount of food with a known calorie content. They also simplify food choices, require little preparation, and allow dieters to avoid contact with problem foods. This may increase patients' adherence to their targeted calorie goals (Kouris-Blazos, 2007).

Very-low-calorie diets (VLCD) are defined as energy intake <800 kcal/d, and the use of a VLCD can greatly increase the magnitude and rate of weight loss compared with more conservative reductions in energy intake. However, due to the low energy value of these diets, they are used for relatively short periods of time (e.g., 12–16 wk), are used in conjunction with dietary supplements, and require medical supervision. The energy deficit when using a VLCD is typically greater than 500–1000 kcal/d, which results in greater initial weight loss compared with more conservative dietary approaches. However, when compared with these more conservative dietary approaches, long-term weight loss may not be improved with a VLCD. Therefore, use of a VLCD may not be recommended for weight loss in most individuals, but use of a VLCD may be appropriate when medically indicated (ACSM,2001).

Commercial programs recommend various combinations of macronutrient compositions for weight loss including high fat, high protein, and high- and low-carbohydrate diets. Despite the popularity of many of these dietary approaches, the optimal macronutrient composition of the diet for weight loss has not been determined. However, current scientific evidence suggests (ACSM,2001) that the level of energy intake has the greatest impact on weight loss short-term and that changes in the composition of the diet affects weight loss by ultimately affecting energy intake. One area that has received attention is the impact of dietary fat reduction on weight loss. There is evidence that targeting reductions in fat intake may result in a spontaneous reduction in *ad libitum* energy intake, which can significantly affect body weight (ACSM,2001). Thus, weight loss resulting from a reduction in dietary fat intake (<30%) appears to be a result of a concomitant reduction in total energy intake. Continuing to maintain a low fat intake may also be important for maintaining weight loss long-term. There is some theoretical rationale to suggest that diets that are high in protein and carbohydrate may be beneficial for weight loss and weight maintenance. The studies in this area suggest that increasing protein intake can increase thermogenesis and satiety (ACSM, 2001), which may impact energy balance by altering energy intake and/or expenditure. However, another possibility is that similar to dietary fat intake, changes in protein or carbohydrate intake may simply reduce overall energy intake, which will result in a reduction in body weight. Despite these potential mechanisms for how changes in protein intake may affect weight loss, evidence from clinical trials supporting optimal protein and carbohydrate intake for long-term weight loss and weight maintenance is lacking.

Behavioral recommendations for weight-loss treatment_ People who are overweight or obese benefit from psychological interventions, particularly behavioral and cognitive-behavioral strategies, to enhance weight reduction. They are predominantly useful when combined with dietary and exercise strategies (Shaw, 2005). There is evidence that including behavioral principles within a weight loss program improves long-term outcomes. Thus, it is assumed that it is important to maintain treatment focusing on healthful eating and exercise behaviors to maintain weight loss and prevent weight regain long-term. Strategies, based on learning principles such as reinforcement, that provide tools for overcoming barriers to compliance with dietary therapy and/or increased physical activity are helpful in achieving weight loss and weight maintenance. Specific strategies include self-monitoring of both eating habits and physical activity, stress management, goal setting, stimulus control, problem solving, contingency management, cognitive restructuring, and social support (NHLBI, 1998).

Another important component of behavioral weight loss programs is self-monitoring of eating and exercise behaviors. There is consistent evidence that individuals who selfmonitor these behaviors are more successful at weight loss than those individuals who are inconsistent with self-monitoring. Thus, despite the potential inaccuracy of current self-monitoring techniques, overweight individuals should be encouraged to self-monitor their eating and exercise behaviors to improve weight loss outcomes. It is also important to identify strategies that may facilitate the adoption and maintenance of exercise behaviors in previously sedentary overweight or obese adults. For example, home-based exercise or nonsupervised exercise may improve participation compared with requiring individuals to attend supervised exercise sessions. Thus, despite the advantage to supervised exercise for research purposes, there may be advantages to not requiring supervised exercise within clinical weight loss programs. In addition, it may be important to provide exercise options, such as the use of intermittent or lifestyle approaches to exercise, which may improve the adoption and facilitate the maintenance of a physically active lifestyle (ACSM, 2001).

A well-controlled study found that group treatment induced a larger initial weight loss than did individual treatment (Renjilian, 2001). This held true even for patients who indicated that they preferred individual treatment but were randomly assigned to receive group care. These individuals lost more weight than people who preferred individual treatment and received it. Group treatment also is more cost-effective than usual care. In addition, about 80% of patients who begin treatment complete it (Jones, 2006). Numerous studies have shown the benefits of patients continuing to attend weight maintenance classes after completing an initial 16-26 week weight-loss program. Maintenance sessions appear to provide patients the support and motivation needed to continue to practice weight control skills, such as keeping food records, maintaining calorie goals, and exercising regularly (Jones, 2006). Recent studies indicate that the internet and e-mail can be used to provide both short- and long-term behavioral treatment. These studies, taken together, underscore the importance of completing behavioral assignments (e.g., food and activity records) and suggest that even the most effective internet interventions are likely to produce only half the weight loss of traditional on-site behavioral programs (Jones, 2006). Internet-delivered interventions, for both the induction and maintenance of weight loss, currently are not as effective as traditional face-to-face behavioral interventions. Nonetheless, internet-based programs do induce clinically significant weight losses and potentially could be provided to the millions of overweight and obese individuals who do not have access to behavioral weight control, as delivered at academic medical centers (Jones, 2006).

Lifestyle modification_The NHLBI/NAASO algorithm (NHLBI, 2000) recommends that individuals with a BMI ≥30 kg/m^2, as well as those with a BMI of 25.0–29.9 kg/m^2 plus two or more disease risk factors, attempt to lose weight by adhering to a program of diet, exercise, and behavior therapy. These three components are frequently referred to as lifestyle modification and are the cornerstone of obesity treatment. Lifestyle modification is distinct from dieting. Dieting implies adhering to a particular regimen for a discrete period of time, whereas lifestyle modification involves implementing dietary and behavioral changes that can be sustained indefinitely to promote health.

Complementary and alternative therapies_In addition to the traditional methods of weight loss, acupuncture and hypnosis have been studied in the treatment of obesity. Acupuncture does not appear to have any benefit greater than placebo. Hypnosis has also been reviewed and likely adds little, if any, benefit beyond that of placebo. Most studies of both acupuncture and hypnosis suffer from the difficulties of performing adequate control groups, and meta-analyses have demonstrated mixed results (Allison, 1995; Ernst, 1997).

Brown adipose tissue_A brown adipose tissue (BAT) phenotype of the adipose organ in rodents is important for the prevention of obesity and diabetes. The adipose organ of rodents can be manipulated, and a 'brown' phenotype can be artificially induced. The physiological role of BAT in the human adipose organ is debated, but in vivo and in vitro data suggest that the human adipose organ react similarly to the murine adipose organ. These data open the possibility to new avenues for the future treatment of obesity and its related disorders (Cinti, 2006).

Pharmacological weight-loss treatments_Although lifestyle interventions are helpful for many obese individuals, without recurrent contacts by health care professionals, most individuals regain their lost weight within 3–5 yr (Perri, 1995). These poor long-term results, and the understanding that obesity is a chronic disease requiring lifelong management, have led to the development of pharmacologic approaches that may minimize weight regain and enhance long-term weight loss. All current guidelines consider pharmacotherapy to be an adjunct to lifestyle modification interventions and limit their use to patients with a BMI >30 kg/m^2 (obese), or a BMI >27 kg/m^2 (overweight) with additional comorbidities (such as hypertension, dyslipidemia, or type 2 diabetes) (ACSM, 2001; NHLBI, 1998). Medication is generally reserved for those whose health is impaired and who have been unsuccessful at losing weight in other ways (Caterson, 2006). Despite the interest in the potential use of pharmacotherapy for the management of body weight, there are few drugs approved for this use. Currently, there are only two prescription drugs that are approved in the United States by the Food and Drug Administration (FDA) for long-term use: sibutramine and orlistat. Many published trials have shown sibutramine and orlistat to be effective for weight loss and weight maintenance when used with lifestyle modifications (McTigue, 2003; Avenell, 2004b; Padwal, 2004; Mathys, 2005). The use of both of these weight-loss agents should be used only under direct supervision of a physician.

Sibutramine is a serotonin and noradrenaline reuptake inhibitor (McNeely, 1998). It has been studied in a large number of randomized, double-blind, placebo-controlled trials lasting up to 24 months (ACSM, 2001). Dose-response relationships have been reported and weight losses have been significantly greater in sibutramine-treated subjects than in those receiving a placebo. Moreover, there is some evidence that sibutramine enhances the main maintenance of weight loss for 6–18 months after initial weight loss (James, 2000).

Orlistat is a lipase inhibitor that works in the gastrointestinal tract to reduce the body's absorption of fat (Guerciolini, 1997). In conjunction with a hypocaloric diet and moderate exercise, orlistat is an effective drug for use in the management of obesity in adults (Hennes, 2006). There have been a number of randomized, doubleblind, placebo-controlled trials of orlistat lasting up to 24 months (ACSM, 2001). In all of the studies, patients who took orlistat lost significantly more weight than patients who took a placebo. Mean weight losses are about 6–10% at 6 months, with reasonably good maintenance with continued use of orlistat over the following 6–18 months. Decreases in total and low-density lipoprotein cholesterol, systolic and diastolic blood pressure, and fasting insulin and glucose have been reported.

Two factors need to be emphasized. The first is the role of pharmacotherapy in weight loss maintenance, a concept rather like the long-term control of hypertension. Secondly, the absolute necessity for diet, activity and behavior change (a "lifestyle program") to underpin abdominal fat loss, weight loss and maintenance (Caterson, 2006).

Surgical interventions_ Intra gastric balloons act to produce an early sense of satiety with eating a meal and allow substantial weight loss (14–15 kg) during the period of up to 6 months when they remain in the stomach. The current balloons must be removed at 6 months after placement. Whilst a patient could have a balloon placed on a second or subsequent occasion its efficacy and safety as long-term weight loss therapy is not established (Dixon, 2006). For those who need to achieve and sustain greater than 15 kg of weight loss and have failed other attempts to lose weight, surgery should be considered (Kouris-Blazos, 2007). Bariatric surgery appears to be an effective weapon in the battle against the current pandemic of obesity (Karmali, 2005). Effective weight loss was achieved in morbidly obese patients after undergoing bariatric surgery (Profumo, 2004; Buchwald, 2004; Sheperd, 2005). Bariatric surgery, the most intensive treatment for obesity, is appropriate only for those individuals with a BMI ≥40 kg/m^2 or BMI ≥35 kg/m^2 in the presence of comorbidities (NHI, 1998; NHLBI, 1998; Msika, 2002). Typically, people who seek bariatric surgery have exhausted the more conservative weight loss options without satisfactory results. The two most common surgical procedures for obesity are vertical banded gastroplasty (VBG) and gastric bypass (GB). Both entail isolating a small (15- to 30-ml) pouch of stomach with a line of staples, thereby drastically limiting food intake. In VBG, the pouch empties into the remaining stomach, where the digestive process continues as normal. GB, however, not only restricts food intake, but also reduces absorption by bypassing the remaining stomach and 45–150 cm of small intestine (Latifi, 2002). Bariatric surgery produces average reductions of 25% (VBG) to 30% (GB) of initial weight (Sugerman, 1989) and significant improvements in hypertension, asthma, sleep apnea, and diabetes (Kral, 1992). Improvements in mood have also been reported, but they appear to wane with time (Karlsson, 1998). Randomized trials have shown that GB is associated with significantly better maintenance of weight loss than is VBG (Livingston, 2002). This has been attributed to the "dumping syndrome" associated with GB, in which patients experience nausea, cramping, and other gastrointestinal symptoms after eating high-sugar/highfat foods. Patients learn to avoid these foods, whereas VBG patients can continue to eat them and thus may regain weight. Patients treated by GB maintained a loss of 50% of excess weight as long as 14 years postoperatively (Albrecht, 1999). These findings undoubtedly have contributed to the recent surge in popularity of bariatric surgery, as has the ability to perform the procedures laparoscopically. Laparoscopy reduces hospital stay time, as well as operative morbidity and mortality (Schauer, 2001). The screening process for bariatric surgery is rigorous. Candidates must meet weight and medical requirements and also should undergo a comprehensive multidisciplinary assessment to identify behavioral contraindications to surgery (as described by Wadden et al., 2001). Pre-surgical counseling is appropriate to ensure that patients have realistic weight loss expectations and understand the postoperative dietary requirements. In addition, candidates should be fully informed of the risks of bariatric surgery, which include an operative mortality rate of ~1,5% (Albrecht, 1999; Pories, 1995). An integrated program must be in place to provide guidance on diet, physical activity, and behavioral and social support both prior to and after the surgery. The gentleness, safety, and reversibility combined with extensive publication of favorable outcome data regarding nutrition, body composition, pregnancy, and psychosocial measures make the Laparoscopy Gastric Bypass (LAGB) the logical choice as a primary bariatric surgical procedure. Recent publications also indicate that obesity surgery increases life expectancy (Dixon, 2006).

The longitudinal gastrectomy with duodenal switch is a safe and effective primary procedure for the treatment of morbid obesity. It has the advantage of allowing acceptable alimentation with a minimum of side effects while producing and maintaining significant weight loss. These results are achieved without developing significant dietary restrictions or clinical metabolic or nutritional complications (Anthone, 2003).

Combined therapy_Counseling was most effective when intensive and combined with behavioral therapy (McTigue, 2003). Effective strategies of weight loss require management strategies in a combined approach of dietary therapy and physical activity by using behavioral interventions (Lang, 2006). Intensive behavioral treatment with meal replacements is a safe and effective weight-loss strategy for selected severely obese individuals (Anderson, 2007).

Research studies have found that interventions that combine a low-calorie diet, increased physical activity, and behavior therapy are most effective for weight loss and maintenance. Furthermore, extended length of treatment contact, weight loss satisfaction, and social support may promote positive long-term outcomes in obese adults (Avenell, 2004a; Williamson, 2005).

A combined intervention of behavior therapy, an LCD, and increased physical activity provides the most successful therapy for weight loss and weight maintenance. This type of intervention should be maintained for at least 6 months before considering pharmacotherapy (NHLBI, 1998).

A combination of a diet (with lower calories) and increased physical activity is reported to produce more weight loss than diet alone or physical activity alone. A combination of behavior therapy and drug therapy could prove to be an effective treatment for obesity. Drug therapy appears to assist in the adherence to dietary therapy (low-fat, low-calorie diet), and may improve maintenance of weight loss (AOA, 1998).

Treatment for obesity includes lifestyle management, consisting of diet therapy, physical activity, and behavioral modification, and may include pharmacotherapy or surgery based on level of risk (Kushner, 2002).

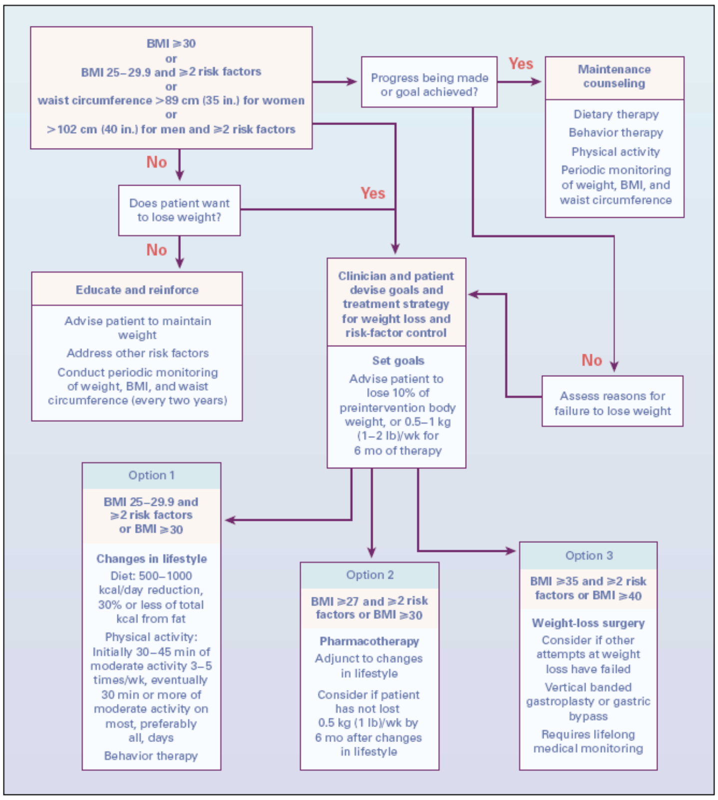


Figure 3. Evidenced-Based Algorithm for the Treatment of Obesity.
Adapted from the National Institutes of Health.[54] BMI denotes body-mass index.

From: Yanovski. N Engl J Med. 2002 Feb 21;346(8):591-602.

Primary care_Physician referral for weight loss is beneficial for at least some patients and should be encouraged (Binks, 2002). Despite the existence of explicit evidence-based consensus reports on the health risks of obesity and the health benefits of even moderate amounts of weight loss, many patients do not receive advice from their health care providers to lose weight or on how to do so effectively (McInnis, 2003b). In fact, obesity is under-recognized in primary care (Laws, 2004). The first goal of management of the obese patient will involve dietary and behavioral modification and a program of physical exercise. In primary care settings, general practitioners (GP) are suitably placed to assess and manage obese patients (Banning, 2005; Peate, 2005; Ruser, 2005; Davis, 2006)

The role of the GP in this Community health problem is essential at two levels: 1) Treatment of weight excess: a moderate and sustained loss, such as of 5 to 10% of the initial body weight, already significantly decreases the risks of morbi-mortality. The first role of GP will be to target the patients at particular risk and to treat them while adapting to their motivation. 2) Systematic prevention: all patients, all families, must have access through their GP to information of quality concerning the nutrition and the management of weight. This information should be adapted to each patient, according to the various stages of life. Nutritional imbalances and sedentarity should be detected systematically (Kacenelenbogen, 2006).

The following case scenario illustrates how the guidelines may be used in the management of a typical adult patient assessed in clinical practice. The Figure summarizes the assessment and stepwise management of the overweight or obese adult.

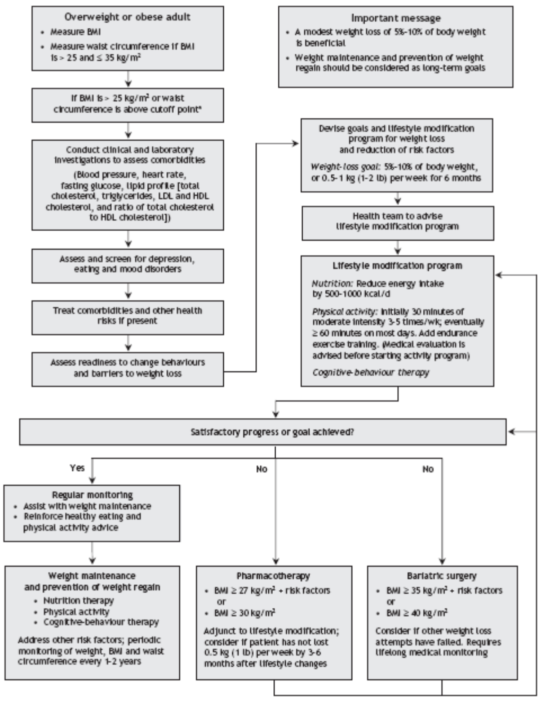


Fig. 1: Algorithm for the assessment and stepwise management of the overweight or obese adult. LDL = low-density lipoprotein, HDL = high-density lipoprotein. *Body mass index (BMI) and waist circumference cutoff points are different for some ethnic groups; see Table 3 for ethnic-specific waist circumference cutoff points.

From: Lau. CMAJ. 2007 Apr 10;176(8):S1-13.

1.1.7 Level of PA and inactivity in adults

The benefits of physical activity are now well documented, at least in adults, and exercise is now included in most health promotion recommendations. Its absence, on the contrary, can have harmful effects on health and well being, increasing the risk for coronary heart disease, diabetes, certain cancers, obesity, and hypertension (CDC, 1996). It has been observed that: there is an inverse dose–response relationship between physical activity levels and all-cause mortality rates for both genders and all age groups; physical activity is inversely related to all-cause mortality independent of adiposity and changes in physical activity levels are predictive of all-cause mortality rates such that people who increase or maintain high levels of physical activity are at a lower risk of mortality than those who maintain consistently low levels of physical activity (Katzmarzyk, 2003).

Predictor variables of inactivity_Energy expenditure requirements have reduced in many facets of daily life over the past 50 years. These are well accepted and include:

• fewer jobs requiring physical work as the UK has changed from an industrial to service-based economy;
• increased labor-saving technology in the home, work and retail environments;
• changes in work and shopping patterns – from local to distant – that have resulted in greater reliance on motorized transport;
• increased self-sufficiency in the home, including entertainment, food storage and preparation, controlled climates and greater comfort;
• reductions in walking and cycling.

Overall average reduction in daily expenditure over the past 50 years has been roughly estimated to be 250–500 kcal/d (Fox, 2007).

The population surveys that assess physical activity generally find that (1) men are more active than women; (2) activity levels decline with increasing age; (3) activity levels are consistently higher in those with higher education and income; (4) activity levels are inversely associated with adiposity (Troiano, 2001; Livingstone, 2003; Atienza, 2006). The study of Petersen (2004) did not support that physical inactivity, as reported in the freely living adult population in the long term, is associated with the development of obesity, but the study indicates that obesity may lead to physical inactivity. Most surveys reveal also that non-Hispanic whites are more active than people of minority race and ethnicity (Troiano, 2001; Atienza, 2006). Another study identified other sedentary subgroups: inactive respondents were not married, have smoked 100+ cigarettes in their lifetimes; and less likely to live in metropolitan areas, be in poorer general health, have health insurance, believe that exercise lowers cancer risk, and eat 5+ servings/day of fruits and vegetables compared with more active respondents. Regarding communication channels, inactive respondents read newspapers and magazines less, watched TV more, were less likely to have accessed the Internet, and were less likely to attend to health messages on all media channels compared with more active respondents (Atienza, 2006). Berrigan et al. (2002) examined the relationship between leisure-time walking behavior and home age, a potential proxy for aspects of urban form that mediate walking behavior. They found that walking ≥1 mile ≥20 times per month is associated with living in an urban/suburban residence built before 1974 in US. This study supports the hypothesis that home age is a proxy measure of aspects of urban form that influence one aspect of physical activity. It has been suggested that physical activity at the age of 9 to 18 significantly predicts adult physical activity. Persistent physical activity at a young age considerably increases the probability of being active in adulthood. School physical education, organized sports, and other programs influencing physical activity among young people should be given all possible support in efforts to develop and implement effective physical activity programs (Telama, 2005). Physical activity level is also characterized by a significant degree of familial resemblance, and that inactivity has a slightly higher heritability level than moderate to strenuous physical activity or total physical activity phenotypes. The pattern of familial correlations suggests that shared familial environmental factors along with genetic factors are also important in accounting for the familial resemblance in physical activity level (Simonen, 2002).

Methods_ Presently there are a large number of techniques for the assessment of physical activity, which can be grouped into five general categories: behavioral observation; questionnaires (including diaries, recall questionnaires, and interviews); physiological markers like heart rate (HR); calorimetry; and motion sensors. However, calorimetry, more specifically the doubly labeled water (DLW) method, is becoming a gold standard for the validation of field methods of assessing physical activity. So far, three field methods for the assessment of physical activity have been validated with the DLW technique as a criterion measure: questionnaires, heart rate monitoring, and motion sensors. The triaxial accelerometer came out as the best field method for the assessment of physical activity (Westerterp, 1999). Although questionnaires do not provide as precise an account of physical activity levels as more objective methods such as pedometry, heart rate monitoring or doubly labelled water, they have acceptable validity and reliability for population studies, particularly when the intent is to distinguish between those with 'high' vs. 'low' physical activity levels (Katzmarzyk, 2003). Two new devices are available now on the market: a portable Armband device, which implements an accelerometer with a wide range of physiological parameters, that has been validated with DLW (St-Onge, 2007) and the Actiheart, a combined HR and movement sensor, which has been validated against indirect calorimetry during a wide range of free-living activities in a field setting (Crouter, 2007).

PA level USA_Survey data show that lack of physical activity is a public health problem and that the scope of the problem is virtually unchanged over approximately the past 10 y. In the USA physical activity surveillance data and trends are collected as part of three major national surveys on health and health bihavior: the National Health Interview Survey (NHIS) (US Department of Health and Human Services, 1996; Jones, 1998); the Behavioral Risk Factor Surveillance System (BRFSS) (Remington, 1988; Centers for Disease Control, 1995); the National Health and Nutrition Examination

Survey (Crespo, 1996). Although, until recently, these surveys have been primarily concerned with providing data on leisure-time activity, they show that inactivity is also a major public health problem in the USA (Troiano, 2001; Livingstone, 2003).

Persons are categorized as vigorously physically active if they report 3 or more sessions per week of 20 min or greater duration of activity at an intensity equal to 50% or more of their age and gender specific maximum cardiorespiratory capacity. Persons are defined to be moderately physically active if they report 5 or more sessions per week of any activity included in the BRFSS, and the total activity time for the week equals 150 min or more. All activity sessions must be at least 10 min long. Inactivity or no physical activity refers to no reported leisure-time physical activity during the past month (Pratt, 1999). Data are expressed as %.

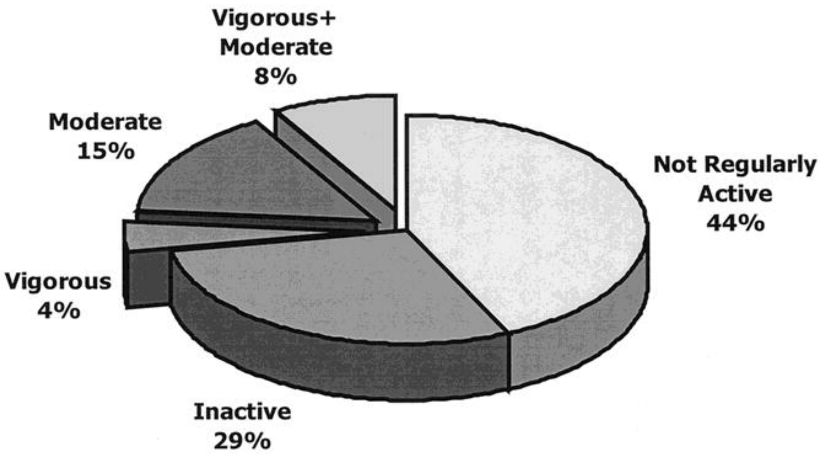
TABLE 1. Participation in physical activity, U.S. adults, BRFSS 1996.

Demographic Group	Inactive	Vigorous	Moderate	Recommended
Overall	29.2	12.6	23.4	27.7
Men	27.2	11.6	24.3	28.2
Women	30.9	13.8	22.7	27.6

From: Pratt: Med Sci Sports Exerc, Volume 31(11) Supplement 1.November 1999.S526

While the prevalence estimates vary between surveys, it appears that 23–40% of the US adults are sedentary in their leisure time (Troiano, 2001; Livingstone, 2003).

National data from the 1996 BRFSS indicate that 29,2% of adults are inactive in their leisure time, 43,1% participate in some activity but not enough to ensure health benefits, and 27,7% are physically active at recommended levels. Of the 27,7% who are regularly active, 23,4% report 5 or more sessions of activity totaling at least 150 min and are estimated to meet the recommendation for accumulating 30 min of moderate intensity activity 5 or more days per week. Among adults, 12,6% meet the vigorous activity recommendation (20 min or more of vigorous intensity activity 3 or more times per week) (Pratt, 1999).



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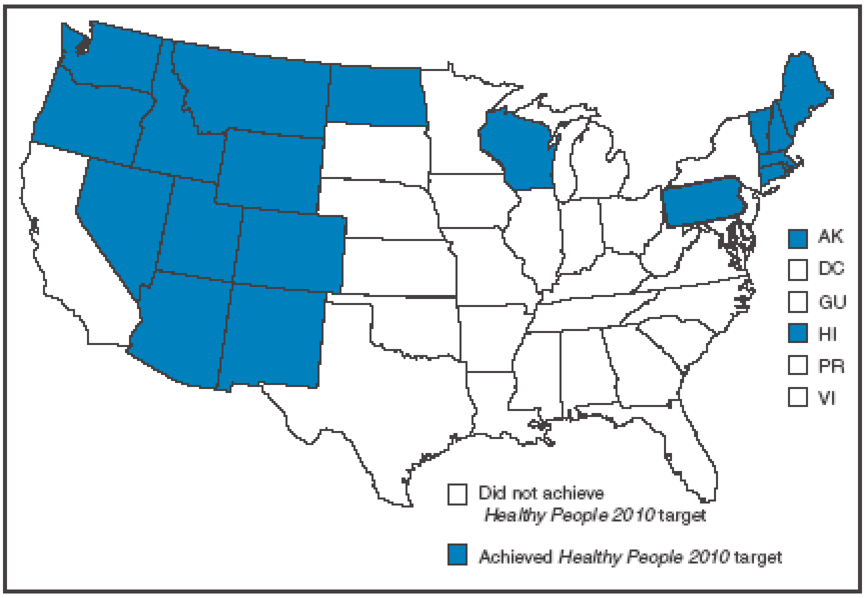
National data from the 1998 BRFSS indicated that 30% of the adults are inactive during leisure time, a further 43% participate in some activity, but of insufficient intensity to achieve a health benefit, leaving 27% who are physically active at recommended levels (Macera, 2000).

From 2001 to 2003, the age-adjusted prevalence of adults participating in physical activity at the minimum recommended level remained similar (45,3% in 2001 and 45,9% in 2003). In 2001 and 2003, the overall prevalence of lifestyle inactivity (i.e., no activity of at least 10 minutes per week of moderate or vigorous intensity) was similar (16,0% in 2001 versus 15,6% in 2003) (CDC, 2005).

FIGURE. States and territories that achieved or exceeded the national *Healthy People 2010* target* for adult participation in recommended levels of physical activity — Behavioral Risk Factor Surveillance System, United States, 2003

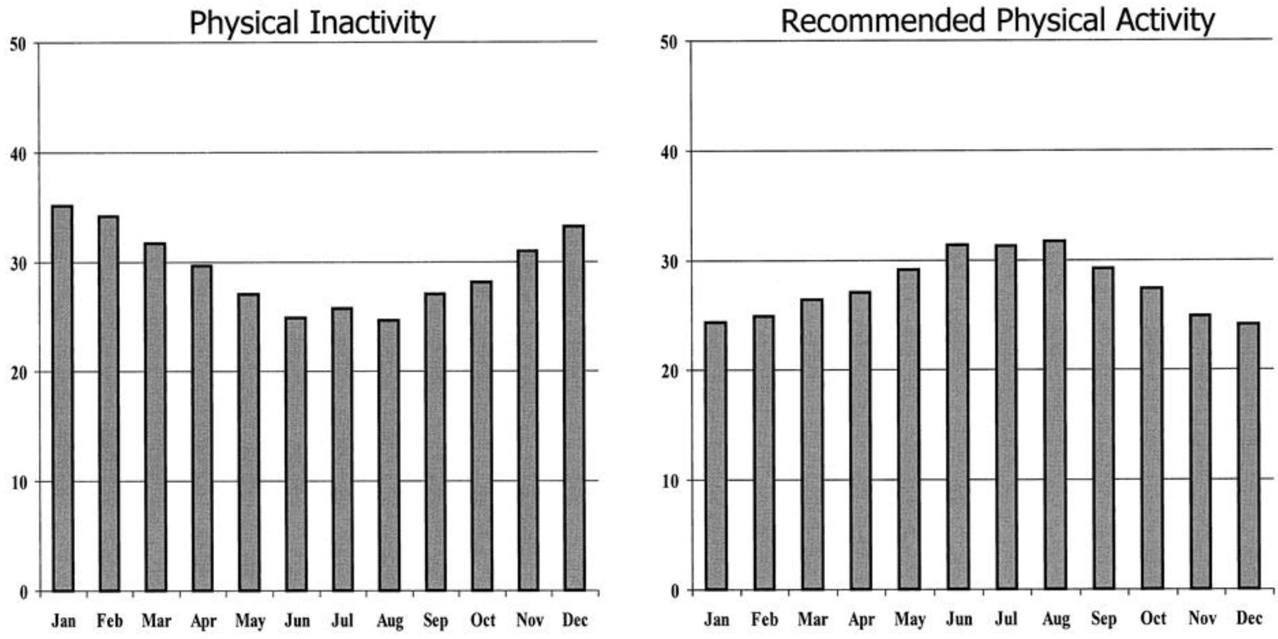


* To increase the proportion of adults who engage in regular moderate- or vigorous-intensity activity to at least 50% (objective 22-2).

From: Centers for Disease Control and Prevention, MMWR Morb Mortal Wkly Rep. 2005 Dec 2;54(47):1208-12.

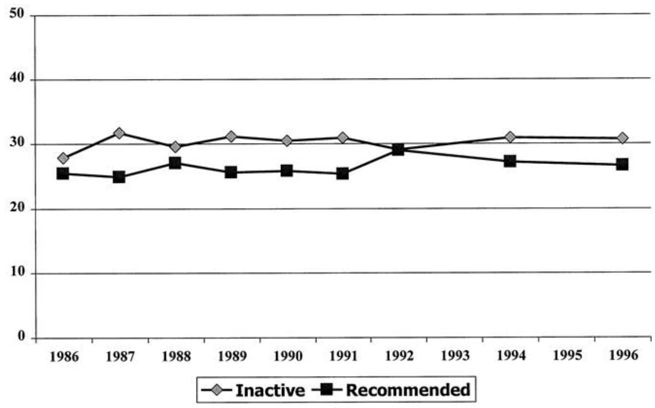
About 13% of the adults meet the recommended levels of activity for the promotion of cardiovascular fitness (≥ 20min of vigorous intensity activity three or more times per week). Broadly similar patterns of activity to the USA have been observed in Australia and Canada (Stephens, 1994). In 2002, it was estimated that more than half the adult population were taking part in sport less than once per month, with participation rates highest in young white men and lowest in disadvantaged groups such as those in lower socioeconomic groups and ethnic minorities. 30 minutes of moderate physical activity five times a week: current participation is estimated to be 30% of the population. Health clubs reflect similar problems, with average attendance by private health club members averaging once per week and 40% of members quitting their membership each year. The reasons for this resistance are unknown, but research has indicated that it may be rooted in people's self perceptions about their sport competence as well as their views of sport itself as an athletic and demanding pursuit and incompatible with their identity (Fox, 2007).

There are clear and consistent seasonal differences in participation in physical activity. Vigorous, moderate, and recommended activity peaks in the summer months, whereas inactivity peaks in the winter. The range between the highest and lowest months is 10,4% for inactivity (January vs August) and 7,6% for recommended physical activity (August vs December) (Pratt, 1999).



From: Pratt: Med Sci Sports Exerc, Volume 31(11) Supplement 1.November 1999.S526

It is widely believed that participation in physical activity is declining among adults in the United States. However, national survey data are not able to support this contention. Levels of physical activity and inactivity as measured by the BRFSS and NHIS have been remarkably stable during the past decade. Data sources consistent enough to adequately assess trends before 1985 do not exist. A synthesis of noncomparable surveys suggests that leisure-time physical activity probably increased between the 1960s and 1980s. The stability of leisure time physical activity over the past decade or more may mask an overall decline in physical activity.



From: Pratt: Med Sci Sports Exerc, Volume 31(11) Supplement 1.November 1999.S5

PA level Europe_On average, nearly three-quarters of the EU population participated in some kind of activity. In general, the highest proportions of participants were found in the Nordic countries (Finland 92% and Sweden 90%) and the lowest in the southern ones (Spain 64%, Italy 62%, Greece 61% and Portugal 40%), Belgium (61%) and France (65%). At the European level the five activities with the highest level of participation include walking, gardening, cycling, keep fit and swimming (Vaz de Almeida, 1999).

Table 2a Percentage of subjects in each member state involved in various activities in a 1-week interval

Country	Total	Walking	Gardening	Cycling	Keep fit	Swimming	Football	Dancing	Racquet sports
Austria	85	41	36	38	13	20	6	6	10
Belgium	61	26	14	19	10	10	6	5	7
Denmark	76	30	34	28	12	10	5	4	10
Finland	92	68	10	28	22	15	2	10	7
France	65	30	16	13	8	10	5	2	6
Germany	70	23	23	28	7	12	4	6	5
Greece	61	24	10	2	15	4	5	3	2
Ireland	87	55	26	15	8	13	12	8	4
Italy	62	25	12	7	11	5	8	6	3
Luxembourg	82	43	28	17	20	18	5	6	6
Netherlands	83	24	31	52	15	17	8	6	8
Portugal	40	20	3	3	4	4	10	2	1
Spain	64	36	3	7	10	6	8	5	4
Sweden	90	61	26	39	24	12	5	8	5
UK	77	42	23	9	13	11.5	7	7	4
EU average*	69	31	18	17	10	10	6	5	5

* Weighted according to population size.

Table 2b Percentage of subjects in each member state involved in various activities in a 1-week interval

Country	Team sports	Fishing	Winter sports	Athletics	Hill walking	Martial arts	Golf	Water sports	Equestrian sports	Others
Austria	4	2	14	3	19	1	1	1	1	2
Belgium	3	2	2	2	1	2	1	1	1	2
Denmark	5	5	2	4	1	1	1	1	2	3
Finland	7	10	17	1	0	1	1	2	1	4
France	2	5	4	0	1	3	1	1	1	4
Germany	3	2	2	3	0	1	1	1	1	6
Greece	8	4	1	2	1	2	0	1	1	2
Ireland	6	4	0	3	4	2	7	1	2	2
Italy	4	2	3	6	1	1	0	0	1	3
Luxembourg	4	1	4	3	2	1	1	1	1	5
Netherlands	5	4	3	3	2	2	0	2	1	8
Portugal	3	4	1	3	1	2	1	1	1	3
Spain	3	2	1	2	2	1	0	0	0	1
Sweden	6	6	7	1	1	2	5	1	2	4
UK	3	3	1	1	3	2	4	1	1	3
EU average*	3	3	3	3	2	2	1	1	1	4

* Weighted according to population size.

From: Vaz de Almeida: Public Health Nutr. 1999 Mar;2(1A):105-13.

In general, across the EU member states, there were similar patterns of time distribution dedicated to physical activity during 1 week, most Europeans falling into the two extremes of our classification: 31% not participating in any activity and 59% spending more than 3,5 hours per week in one or more activities (Vaz de Almeida, 1999).

Table 4 Percentage of subjects in each member state in the different categories of time dedicated to leisure-time physical activity (number of hours per week)

Country	None	< 1.5 h	1.5–3.5 h	> 3.5 h
Austria	13	1	7	77
Belgium	38	2	9	50
Denmark	23	2	7	67
Finland	8	1	6	84
France	35	2	9	54
Germany	30	1	8	61
Greece	40	1	6	54
Ireland	13	1	6	80
Italy	38	3	8	52
Luxembourg	18	4	10	68
Netherlands	16	1	9	73
Portugal	60	3	7	30
Spain	37	3	11	49
Sweden	10	2	5	83
UK	23	1	9	67
EU average*	31	2	8	59

* Weighted according to population size.

From: Vaz de Almeida: Public Health Nutr. 1999 Mar;2(1A):105-13.

In terms of non-participation in any physical activity, more countries were found to be below the EU average, with Finland, Sweden, Austria and Ireland having the lowest numbers of non-participants, while Spain, Italy, France, Belgium, Greece and Portugal were all above the EU average. When the indicator of daily activity (which excluded the contribution of engagement in specific activities) was calculated, 28% of Europeans were found to have a reduced activity level during the week at work and during leisure time, 30% a moderate activity level and 42% a more than moderate level (Vaz de Almeida, 1999).

Table 6 Percentage of subjects in each member state in the different categories of the indicator of daily activity levels

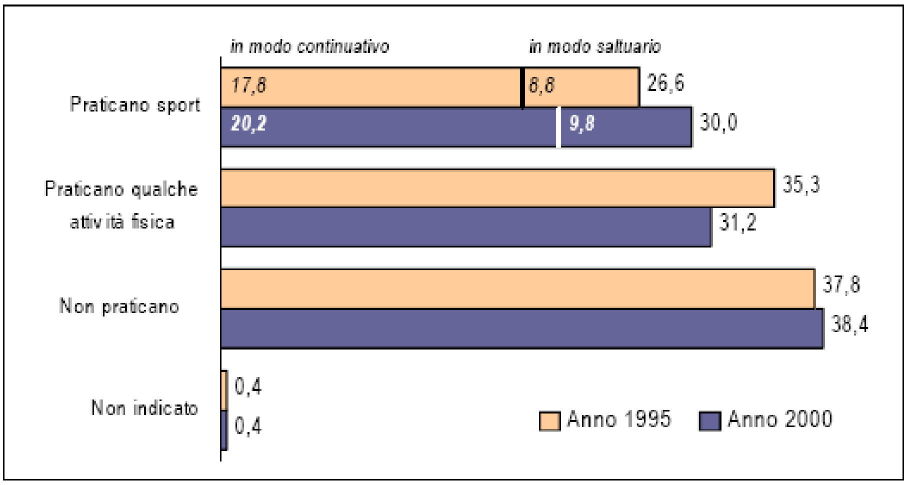
Country	Reduced	Moderate	More than moderate
Austria	24	27	50
Belgium	26	26	49
Denmark	32	35	33
Finland	33	30	37
France	19	26	55
Germany	39	34	28
Greece	28	27	45
Ireland	20	25	54
Italy	21	28	52
Luxembourg	21	34	45
Netherlands	35	32	32
Portugal	24	29	47
Spain	22	25	53
Sweden	23	33	44
UK	34	32	34
EU average*	28	30	42

* Weighted according to population size.

From: Vaz de Almeida: Public Health Nutr. 1999 Mar;2(1A):105-13.

PA level Italy_ In general, the population is characterized by low levels of physical activity at work, with more than 50% of the sample reporting sedentary occupations. During leisure time, only a small percentage of subjects compensated for the inactivity at work by engaging in energy-consuming activities (Salvini, 2003). In 2000 30% of the population declared to practice sports in leisure time continuously (20,2%) or occasionally (9,8%). 31,2% of the population engaged in light physical activities such as walking, swimming or cycling. 38,4% of the population are sedentary (ISTAT, 2002).

Persone di 3 anni e più che praticano sport o qualche attività fisica e persone che non praticano sport. Anni 1995 e 2000, *composizioni percentuali*



From: ISTAT: 17 dicembre 2002.

41,3% of the population participated in some sports or in some physical activity program. Men are more active than women: 45,5% vs 37,2%. The number of people who practice some sports decreases from North toward South. The highest level of active people is in the Northeast (38%), followed by the Northwest (34,2%) and the Center (30,7%), while in the South and in the Islands active people don't reach 23%. Specific types of activity seemed to characterize subjects in the different areas of the country, reflecting local traditions or specific living situations (Salvini, 2003).

In comparison with 1995 the level of people engaging continuously in sport activity has increased of 3,4%, as well as occasional practice (from 8,8% to 9,8%). This growth is more evident for women (4,1 %) than for men (2,8 %) (ISTAT, 2002).

Perceived benefits_The top three reasons for participation in physical exercise are 'to maintain good health', 'to release tension' and 'to get fit'. Forty-one per cent of Italian subjects cited 'to release tension' as an important reason for participation in physical activity (Zunft, 1999). Sport is practiced for fun (62,9%), to take one's mind off things (49,8%), to maintain good health (49,2%9, to release stress (26%), to socialize (20,7%) and to be out of doors in contact with nature (10,3%) (ISTAT, 2002).

Table 1 Percentage of subjects in each member state selecting different perceived motivating factors for participation in physical activity

Country	To maintain good health	To release tension	To get fit	To be out of doors	To socialize	To control weight	For fun	Do not participate
Austria	44	22	21	38	22	9	13	4
Belgium	45	26	33	14	14	12	10	16
Denmark	44	25	22	22	35	9	18	6
Finland	41	33	32	37	9	14	5	<1
France	28	33	29	16	12	7	10	18
Germany	49	24	34	25	13	11	7	7
Greece	49	23	24	9	6	25	8	17
Ireland	38	27	27	32	17	19	14	5
Italy	47	41	27	18	12	15	7	9
Luxembourg	39	27	29	9	16	10	16	14
Netherlands	34	39	26	9	22	13	19	9
Portugal	21	18	8	15	12	7	8	49
Spain	55	38	32	17	13	16	9	4
Sweden	44	16	36	27	15	17	11	5
UK	37	22	34	19	16	15	12	8
EU average*	42	30	30	20	14	13	10	11

* Weighted according to population size.

From: Zunft: Public Health Nutr. 1999 Mar;2(1A):153-60.

Perceived barriers_On observation of the EU average, 'work/study commitments' is the most frequently perceived barrier cited for not increasing participation in physical activity at 28%, followed by 'not the sporty type' at 25%. The percentage of EU subjects selecting 'looking after children/elderly relatives' and 'no need to do any more' is 12%. There were, however, significant variations between countries, particularly for the barrier 'work/study commitments' with 46% of the Italian respondents selecting this barrier in comparison to only 13% of the German respondents (Zunft, 1999). Lack of time (40,6%) is the major reason for inactivity, followed by lack of interest (29,7%), too old (24,7%), no energy/laziness (13,5%), poor health (13,2%) (ISTAT, 2002).

Table 5 Percentage of subjects in each member state selecting different perceived barriers to increasing levels of physical activity/exercise

Country	Work/study	Not the sporty type	Looking after children/elderly	No need	Poor health	No energy	Too old	Other
Austria	32	22	16	13	13	10	11	42
Belgium	23	33	8	10	9	8	14	16
Denmark	21	15	13	13	13	11	7	19
Finland	16	12	10	6	14	19	3	30
France	31	26	9	15	9	9	5	12
Germany	13	33	10	18	10	15	10	20
Greece	44	17	15	6	13	5	9	12
Ireland	25	18	16	12	9	11	6	16
Italy	46	24	13	8	6	6	6	8
Luxembourg	26	18	22	11	9	12	13	12
Netherlands	25	21	11	9	12	13	11	12
Portugal	23	26	6	8	10	7	12	11
Spain	37	31	16	10	26	13	21	3
Sweden	17	25	10	6	10	16	6	21
UK	27	15	13	8	10	11	11	3
EU average*	28	25	12	12	11	11	10	12

* Weighted according to population size.

From: Zunft: Public Health Nutr. 1999 Mar;2(1A):153-60.

In another study (Reichert, 2007) lack of money (40,3%) and feeling too tired (38,1%) were the most frequently reported barriers to physical activity.

1.1.8 PA in the treatment of the adulthood obesity

• Does exercise alone produce weight loss?

The consensus opinion concerning studies of the effectiveness of exercise in weight loss programs seems to be that "exercise alone produces modest weight losses" (Wing, 1999; Dohm, 2002; Fabricatore, 2003; Racette, 2003; Hill, 2005). Although regular, moderate physical activity alone results in a limited weight loss over the long term, it is an essential and high-priority element of any weight-management program (Hill, 2005). Despite the importance of exercise, there is little evidence that suggests that exercise alone produces magnitudes of weight loss that are similar to what can be achieved with dietary modification. Most important is the question of why the effect of exercise on weight loss is so modest. Perhaps this is caused in part by the short duration of many of the studies. If participants are asked to increase their exercise by 1000 kcal/wk, and the study lasts only 4–6 months, then differences in weight loss of only 2–3 kg would be expected. In many of the studies cited, this is close to the magnitude of the difference that is observed. It is also possible that individuals in diet plus exercise programs compensate for the energy expended in exercise by reducing physical activity at other times in the day or by eating somewhat more. Thus, the failure of exercise to produce a magnitude of weight loss similar to diet in studies of free-living individuals may be a result of individuals compensating by increasing energy intake and/or failing to achieve adequate levels of energy expenditure (ACSM, 2001). Despite the results of clinical intervention studies that demonstrate that changes in energy intake may have a greater impact on body weight than exercise alone, there are studies that suggest that exercise can be as effective as diet for precipitating initial weight loss. For example, the study by Bouchard et al. (1990) on the long term impact of significant amounts of exercise provides the best data on the effect of exercise independent of changes in diet. In this 100-d long study conducted at a residential facility, the five male participants exercised twice a day, 6 d/wk, at 55% of their maximal oxygen consumption ($\dot{V}O_2max$) and their intake was held constant. Subjects in this study lost 8 kg over the 100 d. This study is the clearest proof that exercise alone can produce weight loss. Ross et al. (2000) compared the effect of a 700 kcal/d energy deficit on 3 mo weight loss when produced via reduction in energy intake versus an increase in energy expenditure (exercise). The investigators reported comparable weight losses of 7,6 kg in the energy restriction and energy expenditure groups, respectively. These results provide some evidence that exercise can be as effective as changes in diet for producing weight loss. However, it should be noted that a 90,7 kg (200 lb) individual would need to engage in 115,7 min/d (1 h 57 min/d) of brisk walking (for metabolic equivalents) to expend 700 kcal/d in exercise to produce this magnitude of weight loss. These data highlight why clinical interventions typically report greater initial weight loss with changes in diet versus changes in exercise, because most overweight and obese individuals may be unlikely to engage in sufficient levels of exercise to produce the magnitude of weight loss typically observed with reductions in energy intake. Another study that demonstrates that regular exercise can markedly reduce body weight and fat mass without dietary caloric restriction in overweight or obese individuals is the one by Catenacci (2007) which shows that similar weight losses (approximately 6 kg in women and 8 kg in men) occurred in both the diet-only and exercise-only groups, suggesting that if a large negative energy balance is successfully created by exercise substantial weight loss can occur, provided that there is not a compensatory increase in energy intake. In the absence of dietary change, moderate to vigorous exercise (about 600 kilojoules a day) at the level usually prescribed—three to five hours a week—produces a modest weight loss, about 2 kilograms over one year. When, however, the volume of physical activity is high (for example, 3000 kilojoules a day), matching that of energy reduction through diet, weight loss has been shown to be much higher, at up to 7,5 kilograms, even after 12 weeks (Smolander, 2000). In some studies it has been demonstrated that, despite moderate weight-loss, physical activity appears to be associated with a reduction in abdominal fat and that physical activity as part of a weight-loss program can help decrease total body fat while generally preserving fat-free mass. When examining the effect of exercise on body weight, it has been suggested that there may be "responders" and "nonresponders" to the same exercise intervention (ACSM, 2001). In a classic study, Bouchard et al. (1994) examined the effect of exercise on weight loss both within and between pairs of identical twins. Results of this study showed that the variance for changes in body weight was 6,8 times greater between pairs than within pairs, suggesting that the effect of exercise may be influenced by genetic differences between individuals. The effectiveness of exercise for weight management may also be influenced by gender, with Wood et al. (1991) reporting that exercise resulted in greater weight loss in men compared with women. These factors should be considered when examining the effectiveness of exercise for managing body weight across individuals.

• Hypotheses as to how exercise may enhance weight loss

Dohm in 2002 summarized the reasons why physical activity may enhance weight loss:

Increased energy expenditure_The energy that we expend each day (total energy expenditure or TEE) can be portioned into three parts; resting energy expenditure (REE which is also sometimes referred to as the basal metabolic rate), the energy expended after a meal (thermic effect of a meal or TEM), and the energy of physical activity (activity energy expenditure or AEE). The most variable component of TEE is the energy of physical exercise (AEE). There are basically 2 ways that exercise can increase energy expenditure: (1) energy is expended while exercise is being performed and (2) REE is increased for a period after the finish of exercise.

Decreased appetite_Increasing activity from very light or light to moderate or heavy does not cause appetite to increase. Thus, energy expenditure can be increased without a compensatory increase in food intake.

Increased fat oxidation_Since obesity results from the storage of excess fat, the question arises whether obesity is linked to an inability to burn fat. Individuals who burn less fat are at higher risk of becoming obese. If this is true, then anything that increases fat oxidation may be important for preventing obesity, improving weight loss during dieting, and maintaining weight loss. At rest, approximately half of the energy expenditure is covered by fat oxidation with the remainder coming primarily from carbohydrate. Less than 5% of the energy comes from protein metabolism. Fat continues to make a significant contribution to energy expenditure at low intensities of exercise, but carbohydrate oxidation is proportionately increased with exercise intensity and contributes 100% at very high work rates (such as in sprinting). This relationship between fat oxidation and exercise intensity has led to the recommendation by some physicians that low intensity exercise was best for weight loss. One of the important adaptations to endurance exercise training is an increase in the respiratory capacity of skeletal muscle that accompanies an increase in the number of mitochondria. This adaptation increases the ability to oxidize fat during exercise. Thus, being fit provides 2 advantages for weight loss and maintenance; (1) an individual can exercise at a higher intensity and for a longer period before becoming fatigued (thus expend more energy), and (2) fat oxidation is higher at all intensities of exercise than in an unfit individual. The practical question for the physician and patient is how much exercise is needed to get the adaptation in fat oxidation. Luckily, adaptations in fat oxidation seems to occur relatively rapidly. Thus, it appears that a realistic exercise prescription can induce sufficient changes in fat oxidation.

• Does exercise in combination with diet produce greater weight loss than diet alone?

The conclusion to this question is that in most studies exercise does not significantly increase initial weight loss over and above that obtained with diet only. However, in almost all studies the diet plus exercise group lost somewhat more weight than the diet alone condition (Wing, 1999). So the combination of diet plus exercise is recommended for obese patients desiring to lose weight (ACSM, 2001). Reductions in energy intake (e.g., diet) have a greater impact on body weight than changes in energy expenditure via exercise, with the combination of diet plus exercise having the greatest impact on weight loss (Jakicic, 2005). Besides, the addition of an exercise regimen within a dietary restriction programme does not seem to induce a substantially greater fat-mass loss than dietary restriction alone (Hansen, 2007). The scientific evidence suggests that the combination of dietary modification and exercise is the most effective behavioral approach for weight loss (ACSM, 2001; Jakicic, 2002). Combining modest reductions in energy intake with modest increases in energy expenditure to elicit a 500 to 1000 kcal/d energy deficit may be the most practical approach to achieving 1 to 2 pounds of weight loss per week (Jakicic, 2006).

• Other positive effects of physical activity

When performed in combination with restriction of calories, regular, moderate physical activity achieves the following results: fosters cardiovascular health (Bensimhon, 2006; Sharma, 2006), reduces cardiovascular risk (AACE/ACE Obesity Task Force, 1998 Revision; Shaw, 2006); has positive psychological effects, including stress reduction and an improved sense of well-being and optimism; reduces insulin resistance; and may provide other health benefits (some normalization of blood lipids, glucose, and insulin), even when the patient remains overweight. Some studies show lower mortality in active persons in comparison with those who are sedentary or physically unfit (AACE/ACE Obesity Task Force, 1998 Revision). In addition, it has a benefit in reducing diabetes risks beyond that produced by weight reduction alone (NHLBI, 1998). Additional evidence indicates that weight loss and the associated diuresis reduce blood pressure in both overweight hypertensive and nonhypertensive individuals, reduce serum TG levels, increase high-density lipoprotein cholesterol levels, and may produce some reduction in low-density lipoprotein cholesterol concentrations (Poirier, 2001). Limited evidence from a number of studies suggests a beneficial influence of physical activity on reduction in abdominal and visceral fat in overweight and obese subjects when imaging techniques are used to quantify changes in abdominal adiposity. Reductions in visceral and total abdominal fat may occur in the absence of changes in body mass and waist circumference. Waist-to-hip ratio is not a sensitive measure of change in regional adiposity in exercise studies (Kay, 2006). Increased physical activity may decrease the risk of cardiovascular morbidity and mortality, even in the absence of achieving normal body weight (Kouris-Blazos, 2007). Of interest, even if weight loss is minimal, obese individuals showing a good level of cardiorespiratory fitness are at reduced risk for cardiovascular mortality than lean but poorly fit subjects. Numerous adaptive responses take place with physical training. These adaptations result in a more efficient system for oxygen transfer to muscle, which is now able to better utilize the unlimited lipid stores instead of the limited carbohydrate reserves available (Poirier, 2001; Fabricatore, 2003; Racette, 2003). Obese individuals should increase their physical activity to improve their health, regardless of its impact on their weight (Kouris-Blazos, 2007).

1.1.9 Type of PA

Amount_Amount of exercise necessary to improve fitness_ overweight individuals can realize significant improvements in health by achieving the minimum public health recommendation for physical activity and by improving their level of cardiorespiratory fitness (ACSM, 2001).

Amount of exercise necessary for successful long-term weight loss_ The recommendation to progress overweight adults to 200–300 min of exercise per week or 2000 kcal/wk may present a significant challenge for interventionists and public health professionals. Therefore, this recommendation should be viewed in the context of the exercise level that most individuals are willing to adopt and maintain.

In response to this concern, it is recommended that individuals be progressed to these higher levels of exercise gradually over time and that a variety of behavioral strategies be used to facilitate the adoption of this level of exercise (ACSM, 2001).

Intensity_Currently, there are long-term clinical interventions being conducted that focus primarily on the impact of exercise intensity on long-term weight loss and the prevention of weight regain. Thus, it appears that a sufficient amount of moderate-intensity (55–69% of maximal heart rate) exercise can be beneficial for management of body weight, with limited published scientific evidence from randomized trials to support the necessity of more vigorous (70% of maximal heart rate) forms of exercise for management of body weight long-term (ACSM, 2001). A recent study demonstrated that high-intensity (85-95% of maximal heart rate) aerobic interval training was better than moderate-intensity (60-70% of maximal heart rate) aerobic training for improving aerobic work capacity and endothelial function (Schjerve, 2008).

Exercise intensity can favorably impact on energy expenditure in a number of ways. First, exercise-associated energy expenditure is increased by decreasing exercise efficiency and increasing work rate. Second, resistance training that increases muscle mass, in turn increases resting energy expenditure. Third, aerobic exercise >70% $\dot{V}O_2max$, increases resting energy expenditure separate from any change in muscle mass. High-intensity exercise training has the added benefit of improving fitness, thus making low-intensity exercise less difficult and more easily tolerated. Although continuous intense exercise is difficult to maintain for extended periods of time, intense interval exercise can be easily endured and may be an important adjunct to lifestyle modifications for body weight control (Hunter, 1998).

Type_For very immobile obese patients, a reduced weight-bearing form of activity (such as swimming, walking in water, or cycling) may be best in the early stages of a weight-loss program, until their fitness increases and weight-bearing activities (such as walking) can be more easily carried out (NHMRC, 2003; Hills, 2006). After that, considering the relationship between caloric expenditure during training and fat-mass loss, walking (and/or running) exercise seems to be the preferred type of exercise in obese patients (Hansen, 2007).

Perceived lack of time is a commonly reported barrier to participation in physical activity. However, there is some evidence that recommending the accumulation of physical activity across multiple intermittent periods throughout the day should be considered as an alternative intervention approach to facilitate the adoption of physical activity in previously sedentary overweight adults (Jakicic, 2005b). Intermittent exercise has typically been defined as accumulation of 30–40 min of exercise per day through participation in multiple 10- to 15-min exercise sessions daily. There has been interest in this form of exercise because early studies showed that intermittent exercise effectively increased cardiorespiratory fitness and favorably impacts coronary heart disease risk factors. This resulted in the Centers for Disease Control and Prevention and the American College of Sports Medicine recommending the "accumulation" of at least 30 min of moderate intensity activity per day, yet at the time of this recommendation, there was no evidence that this would be an effective strategy for overweight adults seeking weight loss. The use of intermittent exercise may be advantageous for individuals that dislike continuous exercise or perceive barriers to continuous exercise. These factors should be considered when prescribing exercise to overweight adults seeking weight loss treatment (ACSM, 2001). This strategy may be most effective for improving the initial adoption of physical activity in overweight and obese individuals. This should be considered as an alternative strategy that may facilitate participation in physical activity during periods when there are barriers to participation in more traditional periods of physical activity (Jakicic, 2005b).

An additional alternative to tradition forms of exercise may be lifestyle approaches to physical activity. This approach emphasizes seeking opportunities in one's lifestyle to engage in physical activity. An example of a lifestyle physical activity is to use walking rather than motorized alternatives (e.g., automobiles, elevators, and escalators) for the purpose of transportation and mobility (Jakicic, 2005b). Lifestyle activity may be an effective option for increasing fitness and modifying body weight in overweight adults. Lifestyle activity appears to be a promising alternative to structured forms of exercise. Therefore, overweight adults should be encouraged to engage in activities that are at least moderate in intensity as part of a physically active lifestyle. Further research is necessary to examine the effectiveness of specific forms of lifestyle physical activity to change both body weight, cardiorespiratory fitness, and risk factors that may be common in overweight adults (ACSM, 2001). Lifestyle-based changes that increase the physical activity volume significantly above the baseline level are likely to be the most successful for long-term weight loss (NHMRC, 2003). There is an increasing use of pedometers to promote the increase in steps walked, and promoting lifestyle forms of physical activity may enhance the accumulation of steps.

Resistance training may provide benefits in terms of retention of lean body mass (Geliebter, 1997; ACSM, 2001; NHMRC, 2003; Racette, 2003; Hansen, 2007), but it offers no apparent extra advantages, for either weight loss or fat loss, over accumulated aerobic activity (Dohm, 2002; NHMRC, 2003; Jakicic, 2005a). In the absence of energy restriction, it appears that resistance exercise has a minimal impact on changes in body weight (ACSM, 2001). However, resistance exercise may be important for overweight and obese adults because of the potential improvements in strength, which may have a positive impact on physical function in these individuals (Jakicic, 2005a, 2006; Hills, 2006), e.g., getting out of a chair, lifting one's own body weight, which may facilitate the adoption of a more active lifestyle in sedentary overweight and obese individuals (ACSM, 2001). The ability to lift one's own body weight may facilitate opportunities for physical activity in these individuals, which may improve physical activity levels and/or enhance function, which also results in improvement in quality of life (Jakicic, 2005b). Preserving fat free mass (FFM) will prevent declines in REE that are often observed with weight loss. However, intervention studies do not support this belief, with the majority of studies showing that resistance training does not prevent the decline in REE that occurs with diet-induced weight loss (Geliebter, 1997). Moreover, the addition of resistance exercise to endurance exercise and diet modification did not minimize the loss of FFM compared with endurance exercise combined with dietary modification or dietary modification alone (ACSM, 2001). A study review (de Mello Meirelles, 2004) has analyzed the effect of resistance exercises on energy expenditure, considering each of its related variables – intensity, duration, number of sets, interval between sets, movement velocity and type of training (circuit or multiple sets). The reviewed studies showed that resistance exercises may induce an acute increase in energy expenditure, through the energy cost of the exercise session itself and through the excess post-exercise oxygen consumption (EPOC). It is also recognized that the many variables related to resistance exercises influence the results in different ways. Number of repetitions, load, rest interval between sets and number of sets, when manipulated in order to increase volume or intensity, may significantly increase the energy expenditure of a typical exercise session. In general, considering all the limitations of the reviewed studies, the literature indicates that volume is the variable with greatest impact on energy expenditure during the training session, and that intensity has its largest impact on EPOC. Strength training may serve as a substitute training program when whole-body aerobic exercise is contra-indicated or difficult to perform, because it improve aerobic work capacity, endothelial function and cardiovascular health (Schjerve, 2008).

Physical activity (PA) in Primary Care_Public health interventions helping obese people to become physically active remain a challenge and further emphasize the importance of the one-on-one interaction between the clinician/health care professional with the obese individual "at risk" of CVD. This notion is critical, as it has been shown that less than half of obese adults have reported being advised to lose weight under the guidance of health care professionals (Poirier, 2001). Clinicians' counseling plays a crucial role in helping obese people to adopt a more active lifestyle and to start a physical activity program on a regular basis. Physicians should ensure that their patients understand the limitations of immediate weight loss through exercise without dietary changes. This understanding will help them avoid unrealistic expectations and stress the importance of combining a balanced diet with routine physical activity (McInnis, 2003a). Patients who engage in physical activity with the goal of losing weight should understand that physical activity is not associated with rapid weight loss. Rather, physical activity — in conjunction with dietary management — is a tool for attaining and maintaining a healthy weight (AMA, 2003). Adherence to formal exercise programs is typically poor among obese individuals but physician counseling can play an important role in motivating patients to exercise (Dohm, 2002).

Different topics can be manage by clinicians:

1. Role of Physical Activity in Body Weight Regulation

Physical activity benefits are well summarized in different papers for Primary Care (Lyznicki, 2001; EASO, 2004). Physical activity has benefits over and above its contribution to increased energy expenditure and weight loss:

- Physical activity reduces body fat, abdominal fat, and increases lean (muscle and bone) mass.
- Physical activity moderately enhances diet-induced weight loss and can diminish the loss of lean body mass that accompanies weight loss from dietary restriction.
- Physical activity may attenuate the diet-induced decline of resting energy expenditure.
- Exercise, independent of diet and weight loss, can reduce blood pressure, improve glucose tolerance, reduce elevated blood insulin, and improve lipid profile.
- Physical activity improves fitness.
- Physical activity improves compliance to the dietary regimen and has a positive influence on the long-term weight maintenance.
- Physical activity has a positive influence on the general feeling of well-being and self-esteem.
- Physical activity has a positive influence on the emotional state, and may reduce anxiety and depression and thus contribute to improved mental health.

2. Educating Patients About the Benefits of Activity (Lyznicki, 2001; Dohm, 2002)

Regular physical activity helps persons achieve and maintain weight loss, particularly when exercise is combined with a reduction in energy intake, and regular physical activity plus the fitness that results confers a variety of health-related benefits in obese patients even if they lose no weight. An emphasis on the health benefits of regular physical activity can be incorporated into effective counseling sessions for overweight and obese patients:

- Study results show significant reductions in cardiovascular morbidity and mortality in patients who are overweight but achieve even a moderate level of cardiorespiratory fitness versus those who are overweight and remain unfit. In all persons, a low level of aerobic fitness is an independent risk factor for all cause mortality.
- Hypertension, insulin resistance, elevated blood glucose levels, and dyslipidemia have been shown to improve as a result of enhanced physical activity and increased fitness level in adults who are overweight or obese, even in the absence of weight loss.
- As much as 50 percent or more of the weight loss achieved through dieting can occur at the expense of lean body mass, causing a loss of muscular strength that is amplified by feelings of fatigue and reduced basal metabolic rate— all of which can have a detrimental effect on long-term, successful weight management. Conversely, endurance-type exercise and strength training have been shown to attenuate the diet-induced loss of lean body mass, particularly when used in conjunction with low or moderate energy-restricted diets. In addition, endurance and strength training facilitate reduction of fat mass during weight loss, effectively adding to favorable changes in body composition associated with exercise during caloric restriction.
- Increased cardiorespiratory fitness and greater muscular strength to perform activities of everyday life may improve the mobility, functional abilities, and quality of life in obese persons. Moreover, an enhanced sense of psychologic well-being, including reduced feelings of stress, anxiety, and depression, and improved sleep patterns are associated with enhanced levels of physical activity and improved fitness.
- Results of numerous studies support the conclusion that successful weight maintenance in persons who have lost weight is highly dependent on the level of physical activity they sustain.

3. Guidelines for Activity Prescription

Exercise programs for patients who are overweight or obese should meet criteria for safety, effectiveness, and education/motivation. On the basis of the preparticipant evaluations, individually appropriate "prescriptions" for aerobic activity, resistance (strength) training, and daily lifestyle activities should be developed with particular attention to modifying exercise for conditions that may worsen during certain activities. Appropriate warm-up and cool-down periods should be emphasized (McInnis, 2003a).

TABLE 4
The FITT Principle*

Component	*Recommendations*
Frequency	Three to five days per week. More frequent exercise is desirable, but care should be taken to first establish a regular exercise habit before recommending levels that may not be sustainable in the long term.
Intensity	To avoid musculoskeletal injuries and promote compliance, start at a low to moderate intensity† and gradually progress over the course of several weeks or months to more vigorous efforts (if desired by the patient).
	Emphasis should be on increasing duration rather than intensity, with the goal of optimizing caloric expenditure.
Time	30 to 60 minutes, using a gradual progression
	Multiple short bouts produce similar benefits as a single long bout of the same total duration.[32]
Type	Low-impact activities (e.g., walking, cycling, low-impact aerobics, water exercise) that are convenient, accessible, and perceived as enjoyable by the participant

FITT = frequency, intensity, time, and type of exercise.

**—Components of the exercise prescription to improve cardiorespiratory fitness in healthy, overweight, or obese adults. Specific advice on the components of frequency, intensity, time, and type of exercise provides a framework of evidence-based recommendations for a safe and effective exercise program for overweight and obese adults.*

†—An example of moderate intensity can be estimated using 55% to 70% of the age-predicted maximal heart rate (i.e., 220 – age × 0.55 – 0.70) or a rating of perceived exertion of 3 to 5 on a scale of zero (easiest) to 10 (hardest) effort.

From: McInnis. Am Fam Physician. 2003 Mar 15;67(6):1249-56.

Patients with cardiovascular disease, diabetes, or other chronic diseases should undergo a medical evaluation before initiating any exercise program more vigorous than walking (Dohm, 2002). To set appropriate guidelines for exercise participation, many overweight and obese individuals will benefit from receiving exercise advice and direct supervision during training from an experienced professional with an exercise science degree and certification from the American College of Sports Medicine.

- How much exercise is enough? It is important to start at an exercise level that can be maintained without discouragement or injury. The Compendium of Physical Activities provides an excellent source of information for extrapolation of energy expenditure into exercise intensity and duration.

- What intensity and duration of exercise is best? In many cases a discussion of exercise intensity with an individual starting a weight loss program is irrelevant because many are not fit enough to perform more than low intensity exercise. If possible, it is advisable to perform an exercise stress test prior to initiating an exercise program. An exercise stress test which monitors EKG tracings is suggested to detect possible ischemia and clear the subject to initiate an exercise training program. It is important that the individual be increasing the exercise intensity to the highest level that they can be sustained without injury or noncompliance. Programs that make exercise enjoyable and easy to adhere may improve compliance.
- What is the best form of exercise? The best form of exercise is dependent on the physical ability and the likes/dislikes of the individual. The choice between an organized exercise program and a home based-exercise regimen may also be important. Participation in an organized exercise program may provide motivation from others in the group. However, obese individuals are often self-conscious about their appearance in situations that may contrast their physique with that of slim members of the group. In addition, over a period of time individuals tend to drop out of organized programs (or health clubs) and not continue to exercise. Weight maintenance is a long-term goal that will require life style changes and home-based programs may have advantages. Thus, it is essential that an interest inventory be conducted to help individuals decide what form of exercise they would enjoy and continue to do for the rest of their lives. A mixture of different exercises may provide the best compliance, since boredom can be a danger of repeating the same exercise on consecutive days.

4. Lifestyle Activities

Daily lifestyle activities also should be emphasized as a way to increase overall physical activity levels and energy expenditure. Climbing stairs, walking greater distances, gardening, and house cleaning are all examples of this type of physical activity. Another approach to the promotion of physical activity is to emphasize spending less time being physically inactive (e.g., decrease sedentary behaviors), as well as becoming more physically active. The end points are hopefully the same—a more active patient.

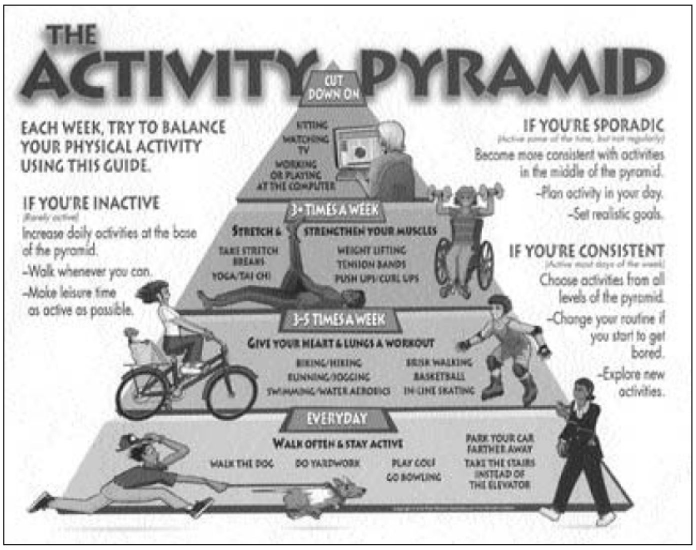


FIGURE 1. The Activity Pyramid. This pyramid, which is analogous to the U.S. Department of Agriculture's Food Guide Pyramid, has been suggested as a model to facilitate public and patient education for the adoption of a progressively more active lifestyle.

From: McInnis.. Am Fam Physician. 2003 Mar 15;67(6):1249-56.

Treatment aims to help the patients reduce sedentary behavior (e.g. less television viewing) and increase daily activities (e.g. walking or cycling instead of using a car, climbing stairs instead of using elevators). Patients should be advised and helped in undertaking (or increasing) exercise. Exercise advice must be tailored to the patient's ability and health, and focus on a gradual increase to levels that are safe. Physicians should recognize where psychological or psychiatric issues interfere with successful obesity management, e.g. depression. Psychological support and/or treatment will then form an integral part of management and in special cases (anxiety, depression and stress), referral to a specialist may be indicated. Self-help lay and the support of the obesity treatment group may all be useful in this setting (EASO, 2004).

1.1.10 Physical activity role in long-term maintenance of weight-loss

Despite the short-term success of professional behavioral techniques for obesity, weight losses are typically regained following treatment (Latner, 2001). In fact, patients tend to relapse and frequently regain all, or almost all, of their lost weight within 1 to 5 years (Perri, 2002). However, whereas increasing daily physical activity and regular exercise does not significantly effect the rate of weight loss in the induction phase, it plays an important role in the weight maintenance phase due to an impact on daily energy expenditure(Astrup, 2006; Bensimhon, 2006; Sharma, 2006; Wadden, 2007) and also to a direct enhancement of insulin sensitivity (Astrup, 2006). As compliance to an exercise programme is a main factor determining the efficacy and long term weight maintenance, low-intensity exercise programmes seem to be preferred when designing combined dietary and exercise intervention programmes to reduce bodyweight/fat mass in obese patients (Hansen, 2007).

Definition_Long-term weight loss was defined as losing at least 10% of initial body weight and maintaining the loss for at least 1 y (Wing, 2005). Stevens et al. (2006) have changed the previous definition defining that weight maintenance should be larger than usual expected variations in weight driven by normal fluid balance and expected measurement error, but should be smaller than what has become generally recognized as a meaningful change in body weight. Long-term weight maintenance in adults can be defined as a weight change of ±3% of body weight (BW) under standardized conditions.

Weight maintenance predictors_BW maintenance after BW loss seems to be a multifactorial issue, including mechanisms that regulate an individuals' energy expenditure, body composition, and eating behavior in such a way that energy homeostasis is maintained. The best predictors for weight maintenance after weight loss were an increase in dietary restraint during weight loss, a high baseline resting metabolic rate, a relatively high baseline fat mass favoring a fat-free mass–sparing effect during weight loss, a rather stable BW, and a low frequency of dieting (Vogels, 2005). In fact, factors contributing to post-treatment weight gain seem to result from a complex and variable interaction of physiological, environmental, and psychological factors. The combination of these factors and the lack of reinforcers to maintain adherence to changes in diet and physical activity after active treatment ends often lead to discouragement followed by ineffective weight maintenance (Lang, 2006). Other factors associated with weight regain included Mexican American ethnicity, greater percentage of maximum weight lost, fewer years since reaching maximum weight, attempting to control weight, greater daily screen time, and not meeting physical activity recommendations (Weiss, 2007). Low social status or economic problems may also increase the risk of weight gain (Sarlio-Lähteenkorva, 2007).

Successful strategies_ The National Weight Control Registry provides information about the strategies used by successful weight loss maintainers to achieve and maintain long-term weight loss. To maintain their weight loss, members report engaging in high levels of physical activity (approximately 1 h/d), eating a low-calorie, low-fat diet, eating breakfast regularly, self-monitoring weight, and maintaining a consistent eating pattern across weekdays and weekends (Wing, 2005). Numerous post hoc analyses of weight loss intervention studies show that a greater initial weight loss, usually achieved in the first 2–4 weeks of treatment, is associated with a better long-term outcome, e.g. a sustained weight loss 1–5 years later. Auxiliary therapy has to be supplied at least in the weight maintenance phase of the program (Astrup, 2000). Weight maintenance is more common among advantaged groups; continuing adherence to diet and exercise strategies and various behavior modification strategies such as having regular eating patterns and self-monitoring of weight or behaviors seem to be important for weight loss maintenance (Astrup, 2000; Sarlio-Lähteenkorva, 2007). Successful very-low-energy diets (VLEDs) were associated with significantly greater weight-loss maintenance than were successful hypoenergetic balanced diets (HBDs) at all years of follow-up (Anderson, 2001a). Physical activity has an important role in maintaining weight loss (Shaw, 2006; Catenacci, 2007) and it seems that groups who exercised more had significantly greater weight-loss maintenance than did those who exercised less (Anderson, 2001a). Only exercise expenditures >2500 kcal/wk were substantially better at promoting long-term weight loss. Those participants reported not only high physical activity levels but also significant decreases in energy intake and dietary fat intake. Thus, their successful weight loss probably relates to combined changes in diet and activity, which is consistent with the findings from the National Weight Control Registry (Tate, 2007). Given that FFM represents a key determinant of the magnitude of resting metabolic rate (RMR), it follows that a decrease in lean tissue could hinder the progress of weight loss. Therefore, with respect to long-term effectiveness of weight-loss programs, the loss of fat mass while maintaining FFM and RMR seems desirable. A key role can be played by strength training and by macronutrient content of the energy-restricted diet (Stiegler, 2006). In addition to engaging in high levels of physical activity, perhaps the best way for patients to achieve long term weight control is by participating in weight maintenance sessions, after losing weight. Such sessions appear to provide participants the support and motivation needed to continue to practice weight control bihaviors that include regularly monitoring food intake, physical activity, and body weight (Wadden, 2007).

The long-term maintenance of treatment effects will probably require ongoing, continuing care. The most promising means of providing continuing care that is both feasible and effective is through interventions based on self-help. Modalities of self-help include purely self-prompted help, self-administered manuals, computer-assisted therapy, professionally assisted correspondence courses, and non-profit and commercial self-help groups (Latner, 2001). The use of the internet may provide an option for reducing the patient burden associated with perpetual clinic visits, internet being an effective vehicle for promoting long-term clinically significant levels of weight loss (Harvey-Berino, 2004). In psychotherapeutic intervention weight loss maintenance was predicted by cognitive control and current physical activity on follow-up (Wiltink, 2007).

• Does exercise in combination with diet produce better maintenance of weight loss than diet alone?

Regular physical activity is the most important predictor of long-term weight maintenance. Correlational studies and randomized trials have shown that patients who diet and exercise regularly are much more likely to maintain weight loss than those treated by diet alone, and regular physical activity is especially beneficial for male patients with a high waist-to-hip ratio (AACE/ACE Obesity Task Force, 1998 Revision; NHLBI, 1998; ACSM, 2001; Poirier, 2001; Fabricatore, 2003; Racette, 2003; Hill, 2005; Jakicic, 2005b; Shaw, 2006; Catenacci, 2007; Kouris-Blazos, 2007). The correlational analyses support the possibility that the failure to see a significant effect of exercise in the randomized trials may be related to poor long-term adherence to exercise in those assigned to the diet plus exercise condition or to adoption of exercise in the diet only condition (Wing, 1999).

• Hypotheses as to how exercise may enhance weight maintenance

Physical activity may be especially important for preventing or minimizing weight regain after initial weight loss. Maintaining energy balance is the key to weight maintenance and prevention of weight regain after initial weight loss.

The components of energy balance include both energy expenditure and energy intake, and it is important to understand the impact and influence of physical activity on each of these components_The largest component of energy expenditure is the resting component. REE is positively correlated with both total body mass and fat-free mass, and individuals with greater body mass or fat free mass typically have a higher REE compared to that of individuals with lower body mass and fat-free mass. Certain forms of physical activity have been shown to affect fat-free mass, and it may be hypothesized that the increase in fat-free mass will ultimately lead to an increase in REE. Therefore, it is unlikely that physical activity prevents initial weight gain or weight regain solely through the impact on REE. The most variable component of energy expenditure is the energy expended in various forms of physical activity. This physical activity component consists of activities of daily living and other lifestyle activities, leisure-time and recreational activity and other forms of structured exercise. Therefore, all forms of physical activity can affect energy balance, and it is important to engage in sufficient amounts of physical activity to affect body weight. Although it is apparent that an adequate amount of physical activity is necessary to effectively manage body weight, physical activity may be part of a constellation of behaviors that are important for successfully controlling body weight. Although physical activity is part of a cluster of behaviors that are important for body weight management, it has not been clearly shown that physical activity causes a change in dietary behaviors (Jakicic, 2002, 2005a). Data from the National Weight Control Registry demonstrate that individuals who successfully maintain significant weight loss in the long term report engaging in both high levels of leisure-time physical activity and consuming a moderate energy intake (Jakicic, 2006).

A review of studies that measured body composition changes during weight loss demonstrates that more fat and less lean tissue is lost when exercise is combined with dieting. Sparing of lean tissue is especially true when resistance exercise is combined with caloric restriction. The hypertrophic stimulus of resistance exercise may spare muscle from loss when there is an energy deficit. Changes in visceral fat may be another positive facet of using exercise in obesity treatment. Visceral fat deposits have been associated with insulin resistance and increased cardiovascular disease, so that a decrease in visceral fat would have profound health benefits. Exercise has positive effects on reducing abdominal obesity. Even when there was no loss of weight, exercise led to a decrease in the dangerous visceral fat. There are two aspects of weight maintenance that must be considered; (1) maintenance of a normal weight (prevention of obesity), and (2) weight maintenance after successful treatment of obesity. Evidence to support an important role for exercise in prevention of obesity can be found in relationships among the prevalence of obesity, energy intake, and inactivity. Longitudinal studies also support a relationship between physical activity and maintenance of body weight. It is possible that the better weight maintenance is not due to exercise per se, but that exercise is just part of a constellation of weight controlling behaviors (or a marker for this constellation); e.g., people who are motivated to keep their weight off may also be motivated to exercise. However, the evidence available seems to suggest that long-term weight maintenance after successful treatment of obesity is improved when exercise is included in the program (Dohm, 2002).

Long-term (more than two years) studies have demonstrated that physical activity can limit fat mass and weight regain more effectively than diet. There are two reasons for this. First, weight loss by exercise generally does not change resting metabolic rate because it is associated with less loss of fat-free mass, whereas energy restriction produces a small yet significant decrease in resting metabolic rate that can be sustained over several years. Second, exercise can reduce body fat without decreasing circulating plasma leptin levels—in contrast to energy restriction, which reduces leptin levels. This reduced leptin secretion after dieting would be expected to increase a drive to eat. There is an inverse relationship between the volume of physical activity carried out and weight regain (NHMRC, 2003).

In conclusion, the goal of behavioral programs may thus have to be increasing the magnitude of weight loss achieved during treatment, with acceptance that, even with high activity levels, some weight regain is going to occur (Tate, 2007). Characteristics such as the ability to increase dietary restraint and maintain this high level of restraint, fat free mass sparing, and a relatively high baseline BMI and fat mass were associated with successful long-term weight maintenance (<10% regain after 2 years) (Vogels, 2007).

1.2 Statement of research objectives

Obesity is a worldwide large epidemiological problem. The obesity epidemic is one of the most serious public health problems across many countries. Obesity can lead to many serious health consequences. Though the most serious disorders are cardiovascular diseases, diabetes type 2 and some cancers. In the nearest future diseases related to obesity will probably become the main cause of death in many countries. The treatment costs of obesity and related diseases are constantly increasing (Jarosz, 2007). Physical activity and dietary restriction play an important role in producing weight loss and in maintaining weight loss, but the average BMI of individuals enrolled in the different studies ranged from 25 to 37-38 kg/m^2. The exercise interventions ranged from 60 min to 300 min per week. Little or no supervised intervention was prescribed in the maintenance period (Catenacci, 2007). Few studies had participant groups with mean or median BMIs ≥40 kg/m^2. Some of these, focused on lifestyle modification, were initially successful, but they were not effective in producing long-term changes in behavior, weight, or physiological parameters (Wing, 1998). For this reason, more studies are needed in high-risk populations, whether defined by BMI, ethnic group, older age, cardiovascular risk factors or co-morbidities (Avenell, 2004).

average BMI of individuals enrolled in the different studies ranged from 25 to 37-38 kg/m^2

Trying to analyze the different treatments considered for Obesity Class II (BMI 35-39,9) and III (BMI ≥ 40), the more frequently used is VLDs (Lang, 2006). Intensive behavioral weight loss program using very-low or low-energy diets (with meal replacements) is a safe and effective weight-loss strategy for selected severely obese individuals (Anderson, 2007). VLEDs can cause weight loss of 1.5 to 2.5 kilograms a week in very obese patients (BMI greater than 40) who have poorly controlled risks (NHMRC_2003).

Regardless of which intervention is selected, all are designed to help patients reduce their calorie intake, and patients must exercise regularly to achieve optimal cardiovascular health and long-term weight control (Wadden, 2007). Even if clinical studies (Donnelly, 1991; Whatley, 1994; Weinstock, 1998) did not identify any advantage of using various exercise regimens in combination with a VLCD over a VLCD alone with respect to RMR, body-weight loss, body-composition or insulin sentitivity changes, combination of moderate diet and physical activity seems to be the more effective intervention for morbid obese patients. It has been demonstrated that, even if exercise has minimal effects on loss of body weight, aerobic exercise was a major determinant of the changes in body composition (promoting the loss of FM even during low-energy feeding) and played an important role in maintaining TEE during weight reduction. Furthermore, aerobic exercise improved aerobic fitness, decreased blood pressure, improved a sense of well-being and also caused a reduction in the waist-to-hip ratio. Lowering this ratio may decrease the risk for illnesses such as coronary artery disease, diabetes, and hypertension (Sweeney, 1993; Racette, 1995). The use of weight training did not appear to moderate declines in FFM or RMR compared with diet alone or diet plus endurance exercise. However, increases were realized for work capacity and strength by the groups that underwent exercise training compared with those on a VLCD only (Donnelly, 1991).

Pharmacotherapy is recommended for persons with a body mass index of 30 kg/m^2 or greater (or a body mass index ≥27 kg/m^2 in the presence of comorbid conditions) who are unable to lose weight with lifestyle modification alone (Jain, 2004; Wadden, 2007).

If attempts to lose weight have failed, and the BMI is >40, surgical therapy should be considered (NHLBI_1998). In fact, weight loss surgery is an option in carefully selected patients with clinically severe obesity (i.e., persons with a BMI ≥40 kg/m^2 or with a BMI ≥35 kg/m^2 with comorbid conditions) when less invasive methods have failed and the patient is at high risk for obesity-related morbidity and mortality (Lyznicki, 2001; Fabricatore, 2003; McTigue, 2003; NHMRC_2003; Racette, 2003; Suastika, 2006; Wilding, 2007). In these people, surgery is the most effective intervention for producing weight loss (Jain, 2004). Surgical therapy is usually combined with dietary therapy and/or a behavior counseling/lifestyle modification program (Douketis, 2005). Expert panels convened by both the World Health Organization and the National Institutes of Health have recommended that obese individuals attempt to lose 10% of their initial weight by consuming a reduced calorie diet and increasing their physical activity, before undertaking weight-loss surgery (Wadden, 2007) .

For the morbidly obese (BMI of 40 or more), activity may be nearly impossible until some weight has been lost (Salazar, 2006). For example, in Rcette study (2001) the intervention group received an energy-restricted diet for 1 week, before starting a lifestyle program of reduced dietary fat and increased physical activity for 1 year. The more effective activities could be swimming, aerobic exercise, strength training, walking, and ergometer bicycling with an estimated intensity of 50% to 60% of $\dot{V}O_2max$ (Christiansen, 2007). Combining aerobic exercise and a VLCD resulted in a significant decrease in body weight, lean body mass, and RMR. The relative percent change in weight after 12 weeks of VLCD was significantly greater in the standard treatment control aerobic training versus resistance training group. The results from the present study indicate that the addition of a high intensity high volume resistance training program to a VLCD can attenuate the loss of Lean Body Mass and increase RMR while still producing a significant weight loss (Bryner, 1999).

for the morbidly obese (BMI of 40 or more),

activity may be nearly impossible until some weight has been lost

Anderson (1992, 1999, 2007b) demonstrated that most patients were able to maintain their weight fairly well over several years. The keys to long-term maintenance of weight loss, as taught in our maintenance classes, seem to be: physical activity of 48,4 mJ (2000 kcal)/week, five vegetables or fruits daily and two meal replacements daily to decrease fat and energy intake (Anderson, 2007). Wadden (1997) showed that a program of VLCD and lifestyle modification facilitated long-term weight control. Leser (2002) proved that limiting dietary fat intake and maintaining physical activity are both important factors for the prevention of weight regain. A high initial weight loss has been also detected as a predictor of weight loss maintenance (Christiansen, 2007). Subjects with successful weight loss maintenance reported a significantly higher level of daily physical activity compared with subjects with weight loss maintenance below 10% (Christiansen, 2007). No structured maintenance program after therapy, allowed only a modest weight loss maintenance, retaining improvements of obesity-related psychosocial problems and physical functioning (Kaukua, 2003).
A suggested goal for severely obese patients with BMIs > 35, is a deficit of up to 500 to 1000 kcal/day that will lead to weight losses of about 1 to 2 lb/week and a 10 percent weight loss in 6 months (NHLBI_1998).

1.2.1 Aim of the study

This study deals with the comparison of different training protocols for healthy morbid obese subjects (mean BMIs ≥40 kg/m^2).

very few studies deal with Grade III obesity and there is no agreement
about the role of different types of physical activity for weight loss and weight maintenance

The aim of this PhD thesis is to try to give an answer to some questions about obesity and physical activity:

- which is the importance of physical activity in weight-loss and weight maintenance?
- is it important to customize the training program or is it enough to walk 30 min a day?
- which are the advantages due to a strength training added to a cardiovascular training?
- is it worth full to increase cardiovascular and strength intensity?

These questions have already emerged from the analysis of the literature but it was difficult to give clear answer to the set questions because tests' protocols, training programs and the duration of the interventions vary according to the study.
The interest of this thesis is that we have controlled for all studies the tests' protocols and the duration of the interventions, changing from one study to another only one parameter of the training program.

1.2.2 Subjects

After approval of the study by the Ethical Committee of Istituto Auxologico Italiano, obese subjects were admitted to the study giving their written informed consent. Subjects were selected on the basis of the following criteria: age ≥18 y; BMI ≥30 kg/m^2; absence of hearth, kidney, liver, endocrine and other major disease; premenopausal state for women; no previous participation in an intensive body weight reduction program during the year preceding the study and motivation to take part in a structured weight loss program. Obesity was defined according to the National Institutes of Health (NHI, 1998) and the World Health Organization (WHO, 2000) classifications.

All subjects were in-patients of the 3rd Division of Metabolic Diseases (Istituto Auxologico Italiano, Piancavallo, Italy), where they had been admitted for an integrated body mass reduction program (duration: 3 weeks), consisting in: a) energy-restricted diet, b) nutritional education, c) psychological counseling, d) exercise training.

1.2.3 Diet

All subjects underwent a controlled restriction of the caloric intake attained with a diet (1200-1800 kcal/d) containing 21% protein, 53% carbohydrate and 26% lipid. The amount of energy to be given with diet was calculated by subtracting approximately 500 kcal from the measurement of the basal energy expenditure.

1.2.4 Testing protocol

All tests were performed the day before the beginning of the integrated program and repeated after 3 weeks (end of the first intervention phase of the program) and once again during a day hospital organized 1 y after the beginning of the treatment.

Fat-free mass and fat mass were assessed by bioelectric impedance analysis, performed in the early morning after an overnight fast, according to a conventional standard technique (Deurenberg, 1994).

$\dot{V}O_2$max was determined using an indirect graded submaximal test on cycle ergometer. ACSM formula (ACSM, 2000) was used to estimate $\dot{V}O_2$max. Simultaneous rating of perceived exertion (RPE, Borg scale, Borg, 1982) was collected.

Maximal force production (1maximal repetition, 1RM) was tested using an indirect method and 1RM value was calculated by the Brzycki formula (Mayhew, 1995) on three different isotonic machines.

Maximum anaerobic alactic power output (Wmax) of lower limbs was derived by the measurement of the flight and contact time of feet with ground during a series of five consecutive jumps, according with the procedure devised by Bosco et al. (1983).

After the intensive intervention, subjects were left on their own and were encouraged to control their diet and to exercise to avoid body weight gain. Individuals were also encouraged to maintain the type and quantity of physical activity performed at the hospital during the 11-month period, but they did not try any additional diet/activity treatment during this period.

In all patients participating to the study, the intensity of a personal routine of freely chosen physical activity after hospital dismission evaluated by a self-reported standardized rating (Jackson, 1990) on a 7-point scale and body weight trends were assessed 6 months after the end program by a telephonic interview.

1.2.5 Exercise training

Different training protocols has been studied: non customized, customized with only an aerobic component, customized with cardiovascular and strength training, customized with an increase of intensity.

All subjects underwent daily sessions of exercise training for 5 days/week, individually supervised by a certified "personal trainer" and a physician. HR was recorded with a heart rate monitor recording device, wore by subjects throughout the training sessions.

Subjects (group EPNS), following a non tailored training program, performed: A) an aerobic training consisting in 30 min of bicycle ergometer exercise at constant work load (60W) or 50-70 min outdoor guided leisure walking on mainly flat terrain on a predetermined track (about 3,5 km); B) strength training during 30 min of indoor activity consisting in dynamic standing and floor calisthenics focalized on strength exercise with arms and legs using body weight as movement resistance.

Customized training protocols were designed in agreement with the guidelines dictated by the American College of Sport Medicine (ACSM, 2000).

Subjects (groups DEPAST&EPP&AF&MI) of some tailored groups performed: A) aerobic training consisting, for every session, in 10 min of cycloergometer pedaling (50-60 rpm) and 20 min of treadmill walking (incline 0-3%), at 50% of individual $\dot{V}O_2max$ during the first week of the program and 60% in the following two weeks; B) strength training performed on three isotonic machines for different muscle groups of upper and lower limbs, consisting in a single series of 15 repetitions at 40% of 1RM during the 1st week, 50% of 1RM during the 2nd week and 60% of 1RM during the 3rd week.

Subjects performing only aerobic exercise (group A) entailed daily sessions (5d/week) on cycloergometer (10 min), treadmill (20 min) and armergometer (5 min) for a total duration of 35 min/d at an intensity corresponding, for each exercise type, to 50% of individual $\dot{V}O_2max$ during the first week of program and at 60% in the following two weeks.

Subjects performing aerobic plus strength exercise (group HI) at a higher intensity underwent, after a session of aerobic exercises, a strength training workout on a daily basis (5d/week) on each of the three isotonic machines. The aerobic component of the exercise consisted in a session on cycloergometer (10 min) and treadmill (20 min) at an intensity corresponding to 60% of individual

$\dot{V}O_2max$ during the first week of the program and at 60% in the following two weeks for a total duration of 30 min. Strength training consisted in a single series of 15 repetitions at 50% 1RM during the 1st week, 60% 1RM during the 2nd week and 70% 1RM during the 3rd week on each machine.

1.2.6 Statistical Analysis

All of the values are given as means±SD. The main effects of Physical Activity and Sex and the interaction effect of Physical Activity by Sex were tested by a Multivariate Analysis of Variance (MANOVA). A two way ANOVA was performed to detect if Sex and Physical Activity were significant factor in dependent variables modification. Average results of the experimental testing observed before and after the program within each group were compared in the descriptive part using Student's *t* test for paired data, while comparison between groups are performed with a Student's *t* test for unpaired data. The normality and the homogeneity of variances of the distribution of the different populations were then controlled. Possible confounders have been detected. Other specific tests were performed to analyze more deeply the different results, in particular the correlation analysis. *p* values less than 0,05 were considered statistically significant.

1.2.7 Suggestions for further work

- A modified training protocol, decreased in intensity but isocaloric with MI, can be applied to a comorbid population of obese adults giving positive results?

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Conflict of interest: none declared.

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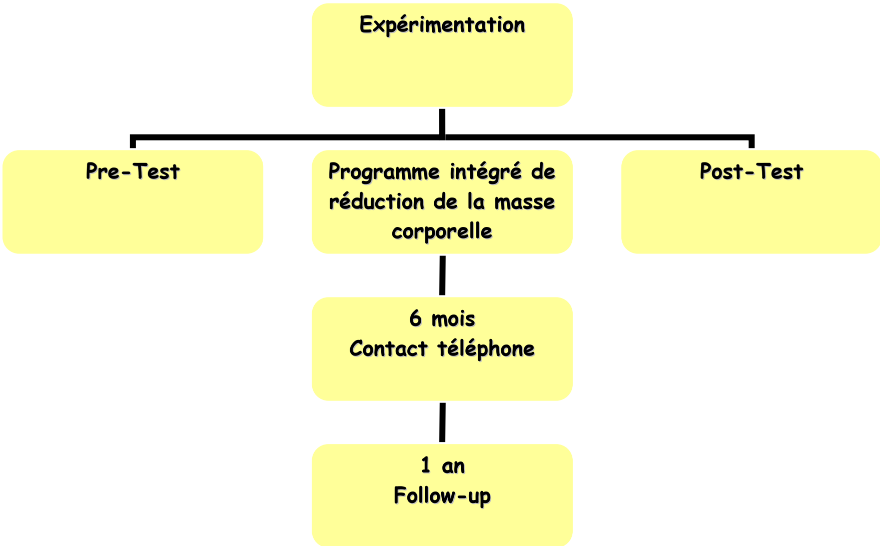
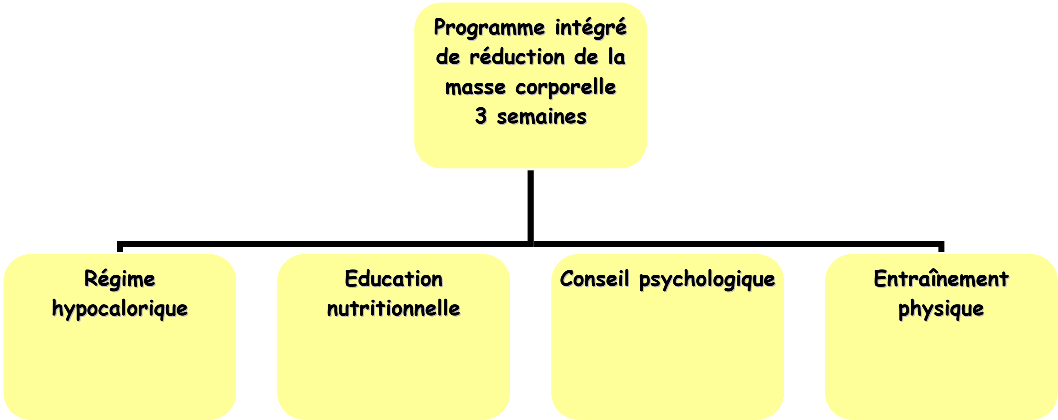
2 Matériel & Méthode

Le protocole d'étude a reçu l'approbation du Comité Ethique de l'Istituto Auxologico Italiano. Tous les sujets ont été hospitalisés au sein de la 3ème Division des Maladies Métaboliques (Istituto Auxologico Italiano, Piancavallo, Italie) pour suivre un programme intégré de réduction de la masse corporelle (RMC). L'expérimentation s'est articulé en six phases : (1) une session de test au tout début du programme (pre-test); (2) 3 semaines de programme contrôlé avec régime hypocalorique et entraînement physique (programme intégré de réduction de la masse corporelle); (3) une nouvelle session de test (post-test); (4) un programme libre avec (5) un contact par téléphone après six mois et (6) une nouvelle session de test après 1 an (follow up).



La recolte des données à commencé en 2001 et terminé en 2004 avec les derniers follows up à 1 an des sujets inclus dans la thèse. Les sujets ont commencé le programme de réduction de la masse corporelle au fur et à mesure qu'ils venaient hôspitalisés. Aucun abandon n'a été observé pendant le programme à court terme. Les patients souffrant de problèmes au niveau du foie, du cœur, des poumons ou des reins ont été exclus de l'étude. Les patients présentant des signes et/ou des symptômes de maladies cardiovasculaires, orthopédiques et neuromusculaires ont été également exclus du programme. De même les patients présentant des maladies liée à l'obésité, tout comme diabète et hypertension, ont été exclus. Des questions spécifiques posées pendant l'examen physique initial ont permis de vérifier qu'aucun ne pratiquait d'activité physique systématique avant d'être admis à cette étude.

Le programme intégré comprenait les éléments suivants : régime hypocalorique, éducation nutritionnelle, conseils psychologiques et entraînement physique.



2.1 Populations non morbides

125 sujets sédentaires obèses ont participé à l'étude, après avoir fourni par écrit leur consentement éclairé. Les sujets admis dans le protocole avaient un âge compris entre 18 et 51 ans et un BMI supérieur à 35.

Pour donner réponse aux quatre questions posées sur les thèmes obésité et activité physique l'étude a porté sur sept groupes de sujets obèses graves :

- pour répondre à la question 1) quel est le rôle de l'activité physique dans la perte de poids et le maintien du poids après amaigrissement? on a analysé les effets d'un entraînement personnalisé en intensité et volume pour l'entraînement cardiovasculaire et force (groupe DEPAST) ;

DEPAST
Activité physique personnalisée
Intensité modérée
Durée modérée
Entraînement CV + force

- pour répondre à la question 2) est-ce qu'il est important de personnaliser le programme d'entraînement sur la base du niveau de performance du sujet ou est-ce qu'il suffit de conseiller de marcher 30 min par jour? on a analysé les différences entre un entraînement standard (EPNS) et un entraînement personnalisé (EPP) ;

EPP	EPNS
Activité physique personnalisée	Activité physique non personnalisée
Intensité modérée	Intensité faible
Durée modérée	Durée élevée
Entraînement CV + force	Entraînement CV + ex 'calistenics'

- pour répondre à la question 3) quels sont les avantages d'un entraînement en force en plus d'un entraînement cardiovasculaire? on a analysé les différences entre un entraînement personnalisé cardiovasculaire (A) et un entraînement cardiovasculaire+force (AF) ;

A	AF
Activité physique personnalisée	Activité physique personnalisée
Intensité modérée	Intensité modérée
Durée modérée	Durée modérée
Entraînement CV	Entraînement CV + force

- pour répondre à la question 4) est-ce qu'il est nécessaire d'augmenter le niveau d'intensité ou est-ce qu'une intensité moyenne peut suffire? on a analysé les différences entre entraînements personnalisés cardiovasculaire+force à moyenne (MI) et haute intensité (HI).

MI	HI
Activité physique personnalisée	Activité physique personnalisée
Intensité modérée	Intensité vigoureuse
Durée modérée	Durée modérée
Entraînement CV + force	Entraînement CV + force

Tous les sujets ont suivi un programme intégré de réduction de la masse corporelle (RMC) d'une durée de trois semaines et ont été analysés la veille du début du programme intégré et à la fin de celui-ci (soit au bout de 3 semaines et à la fin d'une année de follow up). Cela a porté à une diminution des sujets tout au long de l'étude :

Groupes	N	Follow up 6 mois - N	Follow up 1 an - N	Taux de drop out - %
DEPAST	71	71	44	38%
EPNS	15	15	9	40%
EPP	15	15	11	27%
A	26	26	20	30%
AF	26	26	20	30%
MI	32	32	15	53%
HI	35	35	9	81%

Données des populations à court terme

Population	Sujets (N)	Age (ans)	BMI (kg/m^2)
DEPAST	N71	29,4 ± 7,1	41,1 ± 4,3
EPNS vs EPP	N30	33,8 ± 9,5	40,2 ± 4,0
A vs AF	N52	29,3 ± 7,2	41,4 ± 4,7
MI vs HI	N67	25,0 ± 4,4	42,0 ± 5,3

Données des populations à long terme

Population	Sujets (N)	Age (ans)	BMI (kg/m^2)
DEPAST	N44	29,8 ± 6,8	40,8 ± 3,4
EPNS vs EPP	N20	35,1 ± 9,7	40,0 ± 3,7
A vs AF	N40	29,4 ± 6,6	41,0 ± 3,4
MI vs HI	N24	26,4 ± 4,7	42,6 ± 5,3

2.1.1 Population non personnalisée_EPNS

Données à court terme

Les données anthropométriques de base des sujets participants au groupe EPNS figurent sur le tableau 1.

Tableau 1 - Caractéristiques physiques moyennes (± DS) des sujets soumis à un entraînement non-spécifique (EPNS) à court terme.

	EPNS (N = 15)
Age (ans)	34,1 ± 11,2
Taille (m)	1,67 ± 0,1
Poids corporel (kg)	111,1 ± 13,8
BMI (kg/m^2)	40,0 ± 4,7
Hommes/Femmes	6 / 9

Données à long terme_suivi à 6 mois

Les même sujets ont été suivis à 6 mois par interview téléphonique pour connaître le poids actuel et le niveau d'activité physique maintenu pendant les 6 mois qui ont suivis l'interruption du programme de réduction de la masse corporelle.

Données à long terme_suivi à 1 an

Les données anthropométriques de base des sujets participants au groupe EPNS figurent sur le tableau 2.

Tableau 2 - Caractéristiques physiques moyennes (± DS) des sujets soumis à un entraînement non-spécifique (EPNS) à long terme.

	EPNS (N = 9)
Age (ans)	37 ± 11,9
Taille (m)	1,66 ± 0,1
Poids corporel (kg)	108,1 ± 10,7
BMI (kg/m^2)	39,4 ± 5,2
Hommes/Femmes	2 / 7

2.1.2 Population personnalisée_DEPAST

Données à court terme

Sujets - 71 sujets obèses (18 hommes, 53 femmes; poids moyen ± DS : de 84,0 kg à 163,6 kg ; taille : de 1,47 m à 1,87 m ; BMI : 34,9 - 58,0 kg/m^2 ; âge : 29,3 ± 0,8 ans)

Population analysée pour le test Puissance

Sujets : 53 sujets obèses (14 hommes, 39 femmes)

Le Tableau 3 montre les données anthropométriques principales des sujets qui ont participé à l'étude.

Tableau 3 - Caractéristiques physiques moyennes (± DS) relevées chez les sujets participant à l'étude. Les fourchettes de valeurs sont indiquées entre parenthèses.

	Hommes (N = 14)	Femmes (N = 39)
Age (ans)	26,9 ± 6,6 (18 - 43)	30,0 ± 7,3 (19 - 46)
Taille (m)	1,77 ± 0,06 (1,65 – 1,87)	1,61 ± 0,07 (1,47 – 1,74)
Poids corporel (kg)	130,5 ± 16,2 (104,5 – 163,6)	108,3 ±14,9 (84,0 – 152,2)
BMI (kg/m^2)	41,3 ± 4,2 (35,3 – 51,1)	41,4 ± 4,9 (35,0 – 58,0)

Données à long terme_suivi à 6 mois

Les même sujets ont été suivis à 6 mois par interview téléphonique pour connaître le poids actuel et le niveau d'activité physique maintenu pendant les 6 mois qui ont suivis l'interruption du programme de réduction de la masse corporelle.

Données à long terme_suivi à 1 an

Le Tableau 4 montre les données anthropométriques principales des sujets qui ont participé à l'étude.

Tableau 4 - Caractéristiques physiques moyennes (± DS) des sujets soumis à un entraînement spécifique (DEPAST) à long terme.

	DEPAST (N = 44)
Age (ans)	29,8 ± 6,8
Taille (m)	1,66 ± 0,1
Poids corporel (kg)	113,2 ± 19,5
BMI (kg/m^2)	40,8 ± 3,4
Hommes/Femmes	14 / 30

2.1.3 Population personnalisée_EPP

Données à court terme

Les données anthropométriques de base des sujets participants au groupe EPP figurent sur le tableau 5.

Tableau 5 - Caractéristiques physiques moyennes (± DS) des sujets soumis à un entraînement personnalisé (EPP) à court terme.

	EPP (N = 15)
Age (ans)	33,5 ± 7,8
Taille (m)	1,66 ± 0,10
Poids corporel (kg)	111,5 ± 14,6
BMI (kg/m^2)	40,4 ± 3,3
Hommes/Femmes	6 / 9

Données à long terme_suivi à 6 mois

Les même sujets ont été suivis à 6 mois par interview téléphonique pour connaître le poids actuel et le niveau d'activité physique maintenu pendant les 6 mois qui ont suivis l'interruption du programme de réduction de la masse corporelle.

Données à long terme_suivi à 1 an

Les données anthropométriques de base des sujets participants au groupe EPP figurent sur le tableau 6.

Tableau 6 - Caractéristiques physiques moyennes (± DS) des sujets soumis à un entraînement spécifique (EPP) à long terme.

	EPP (N = 11)
Age (ans)	33,6 ± 7,8
Taille (m)	1,21 ± 0,8
Poids corporel (kg)	105,8 ± 19,5
BMI (kg/m^2)	38,8 ± 4,6
Hommes/Femmes	4 / 7

Les sujets du programmes personnalisé ont été comparés avec les sujets du programme non personnalisé. Les sujets étaient répartis en mesure égale par sexe dans les deux groupes différents et assignés au hasard dans l'un ou l'autre de ces groupes pour suivre un protocole d'exercice différent, tout le reste du programme intégré étant identique : un premier groupe effectuait un type d'entraînement physique non spécifique (groupe EPNS - 15 personnes), tandis que le second effectuait un entraînement physique personnalisé (groupe EPP - 15 personnes).

Les données descriptives de base à court terme les deux groupes ensemble sont présentées ci de suite : 30 sujets obèses (12 hommes et 18 femmes, âge moyen ± DS: 33,77 ± 9,46 ans ; BMI : 40,20 ± 4,00 kg/m^2).

Les données descriptives de base à longt terme les deux groupes ensemble sont présentées ci de suite : 20 sujets obèses (5 hommes et 15 femmes, valeurs moyennes ± DS poids : 109,3±12,4 kg ; taille : 141,3±60,8 cm ; BMI : 40,0±3,7 kg/m^2 ; âge : 35,1±9,7 ans)

2.1.4 Population personnalisée_AvsAF

Données à court terme

Sujets : 52 sujets obèses (14 hommes et 38 femmes, âge moyen ± DS: 29,26 ± 7,23 ans ; BMI : 41,40 ± 4,67 kg/m^2).

Les patients ont été répartis en deux groupes sur la base de l'âge et du sexe : un groupe faisant de l'entraînement aérobie (A ; N = 26) et un groupe faisant un entraînement aérobie + entraînement de force (AF ; N = 26), tout le reste du programme intégré étant identique. Les données anthropométriques de base des deux groupes de participants figurent sur le tableau 7.

Tableau 7 - Caractéristiques physiques moyennes (± DS) des sujets effectuant un entraînement aérobie (A) et un entraînement aérobie + entraînement de force (AF). Les fourchettes de valeurs sont indiquées entre parenthèses.

	A (N = 26)	AF (N = 26)
Age (ans)	29,1 ± 6,6 (18 - 46)	29,8 ± 7,9 (19 - 44)
Taille (m)	1,66 ± 0,10 (1,47 - 1,87)	1,65 ± 0,09 (1,48 - 1,81)
Poids corporel (kg)	115,8 ± 20,6 (90,5 – 163,6)	112,5 ± 15,5 (84,0 – 148,0)
Hommes/Femmes	7 / 19	7 / 19

Données à long terme_suivi à 6 mois

Les même sujets ont été suivis à 6 mois par interview téléphonique pour connaître le poids actuel et le niveau d'activité physique maintenu pendant les 6 mois qui ont suivis l'interruption du programme de réduction de la masse corporelle.

Données à long terme_suivi à 1 an

Sujets : 40 sujets obèses (14 hommes et 26 femmes, valeurs moyennes ± SD poids : 114,5 ± 19,8 kg ; taille : 166,5 ± 10,0 cm ; BMI : 41,0 ± 3,4 kg/m^2 ; âge : 29,4 ± 6,6 ans)

Les données anthropométriques de base des deux groupes de participants figurent sur le tableau 8.

Tableau 8 - Caractéristiques physiques moyennes (± DS) des sujets effectuant un entraînement aérobie (A) et un entraînement aérobie+force (AF).

	A (N = 20)	AF (N = 20)
Age (ans)	29,3 ± 6,3	29,5 ± 7,1
Taille (cm)	167,1 ± 10,4	165,9 ± 9,9
Poids corporel (kg)	115,1 ± 19,3	113,9 ± 20,7
Hommes/Femmes	7 / 13	7 / 13

2.1.5 Population personnalisée_MIvsHI

Données à court terme

Sujets : 67 sujets obèses (20 hommes et 47 femmes, âge moyen ± DS: 25,01 ± 4,38 ans ; BMI : 42,01 ± 5,26 kg/m^2).

Les patients ont été répartis en deux groupes sur la base de l'âge et du sexe : un groupe faisant un entraînement aérobie + un entraînement de force à moyenne intensité (MI ; N = 32) et un groupe faisant le même type d'entraînement à haute intensité (HI ; N = 35), tout le reste du programme intégré étant identique. Les données anthropométriques de base des deux groupes de participants figurent sur le tableau 9.

Tableau 9 - Caractéristiques physiques moyennes (± DS) des sujets effectuant un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI). Les fourchettes de valeurs sont indiquées entre parenthèses.

	MI (N = 32)	HI (N = 35)
Age (ans)	25,6 ± 4,6 (19 - 33)	24,5 ± 4,1 (18 - 32)
Taille (m)	1,66 ± 0,8 (1,53 - 1,86)	1,67 ± 0,09 (1,54 - 1,87)
Poids corporel (kg)	114,7 ± 19,0 (84 – 162)	118,6 ± 21,8 (92 – 187)
Hommes/Femmes	10 / 22	10 / 25

Données à long terme_suivi à 6 mois

Sujets : 43 sujets obèses (14 hommes et 29 femmes, valeurs moyennes ± DS, âge : 25,23 ± 4,2 ans ; BMI : 42,29 ± 5,14 kg/m^2).

Les données de base des deux groupes de participants figurent sur le tableau 10.

Tableau 10 - Caractéristiques physiques moyennes (± DS) des sujets effectuant un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI).

	MI (N = 24)	HI (N = 19)
Age (ans)	24,8 ± 4,2	25,7 ± 4,3
Hommes/Femmes	7 / 17	7 / 12

Données à long terme_suivi à 1 an

Sujets : 24 sujets obèses (8 hommes et 16 femmes, valeurs moyennes ± SD poids : 119,2 ± 23,6 kg ; taille : 1,67 ± 0,09 m ; BMI : 42,6 ± 5,3 kg/m^2 ; âge : 26,4 ± 4,7 ans)

Les données anthropométriques de base des deux groupes de participants figurent sur le tableau 11.

Tableau 11 - Caractéristiques physiques moyennes (± DS) des sujets effectuant un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI).

	MI (N = 15)	HI (N = 9)
Age (ans)	26,3 ± 4,6	26,6 ± 5,2
Taille (m)	1,67 ± 0,09	1,66 ± 0,11
Poids corporel (kg)	116,6 ± 20,9	123,5 ± 28,3
Hommes/Femmes	5 / 10	3 / 6

2.2 Protocoles

2.2.1 Protocole des tests

Au moment des prises de mesures, tous les sujets s'étaient déjà bien familiarisés avec les instruments expérimentaux et avec la technique d'exécution des différents tests.
Toutes les prises de mesure se rapportant à un même patient ont été effectuées dans la même journée. Tous les tests ont été effectués la veille du début du programme intégré et répétés à la fin de celui-ci (soit au bout et à la fin de trois semaines). Les mesures de poids, taille et composition corporelle ont été prises le matin, après une nuit de jeûne.

Poids et taille - Le poids corporel et la taille ont été mesurés d'après l'*Anthropometric Standardization Reference Manual* (Lohmann, 1988). La taille a été mesurée par le biais d'une toise Harpenden (Holtain Ltd, UK) et le poids au moyen d'une balance électronique (Selus, Italie).

Body Mass Index (BMI) – Le BMI est le rapport entre le poids corporel exprimé en kg du sujet et la taille exprimée en mètres. La formule qui permet son calcul est la suivante : BMI = poids / taille^2.

Composition corporelle - On a déterminé la masse grasse (MG ou FM) et la masse maigre (MM ou FFM) totales par le biais d'une analyse par bioimpédancemétrie (BIA) aux fréquences de 1, 5, 10, 50 et 100 kHz, 0,8 mA, en utilisant un pléthysmographe d'impédance tétra-polaire (Human-IM Scan DS-Medigroup, Milan, Italie) et en se conformant aux procédures standardisées (Deurenberg, 1994). Les mesures étaient faites tôt le matin, avec le sujet couché sur le dos, les électrodes étant placées au poignet et à la cheville droites. La FM a été calculée par le logiciel relié à la BIA qui a été intégré avec les formules de Gray et al. (1989) pour les sujets adultes obèses des deux sexes.

Photo 1 : Human-IM Scan DS-Medigroup, Milan, Italie

Puissance aérobie maximale ($\dot{V}O_2max$) - On a déterminé la puissance aérobie maximale individuelle ($\dot{V}O_2max$) par le biais d'un test indirect sous-maximal sur cycloergomètre (Technogym, Gambettola, Italie), conformément à la procédure standardisée par Åstrand and Rhodal (1977).

Photo 2 : Recline XT, Technogym, Italie

Après 6 minutes d'échauffement en pédalant à 50 W (50 rpm), les sujets effectuaient 3 différents paliers, de 4 minutes chacun, à 60, 70 et 80 W (60 rpm). On interrompait le test si le sujet atteignait 75% de la FCmax théorique (220-âge). La fréquence cardiaque était lue par un cardiofréquencemètre et enregistrée sur une montre (Polar, Finlande) pour calculer la fréquence cardiaque (FC) moyenne pendant la dernière minute de chaque palier.

Photo 3 : T31C, Polar, Finlande

On a utilisé la formule double stage model de l'*American College of Sport Medicine* (ACSM 2000) pour évaluer la $\dot{V}O_2max$ et l'on notait en même temps le taux d'effort perçu (RPE, échelle de Borg, 1982).

Force maximale (1RM, une répétition maximale) - Quant à la production maximale de force, on l'a contrôlée, avant le programme et à la fin de celui-ci, au moyen de la formule de Brzycki (Mayhew, 1995) sur trois machines isotoniques différentes : Vertical Traction (VT), Chest Press (CP), Leg Press (LP) (Technogym, Gambettola, Italy). Après un échauffement (une série de 15 répétitions), le test comprenait des séries répétées de 8-10 répétitions à charge progressive, l'objectif étant d'atteindre un RPE de 8-10 (OMNI-RES, Gearhart, 2001 ; Lagally, 2006) à la fin d'une série de 8-10 répétitions.

Photo 4 : Vertical Traction, Chest Press, Leg Press, Isotonic Line, Technogym, Italie

Test de saut (CMJ, counter movement jump) - Les sujets ont effectué une série de 5 sauts successifs, dans des conditions d'effort maximal, mains aux hanches, et genoux bien pliés à 90-100° environ pendant la phase de contact au sol entre les sauts, conformément à la procédure étudiée par Bosco et al (1983). Un opérateur vérifiait la bonne exécution de l'exercice et, en cas d'échec, faisait répéter le test après 10 minutes de repos environ. Les temps de vol ($T_{f,j}$) et de contact ($T_{c,j}$) de chaque saut de la série ont été mesurés avec un chronomètre numérique (± 0,001 s) relié à un système optique d'acquisition (Optojump, Microgate, Italie) ; celui-ci était constitué de deux batteries de photocellules montées tout près l'une de l'autre (0,02 m), sur deux barres (d'1 mètre de long) placées l'une en face de l'autre, au sol, à une distance d'environ 1 m. Tous les temps de vol et de contact étaient acquis par un ordinateur qui les affichait en ligne pendant que le sujet effectuait la séance de sauts.

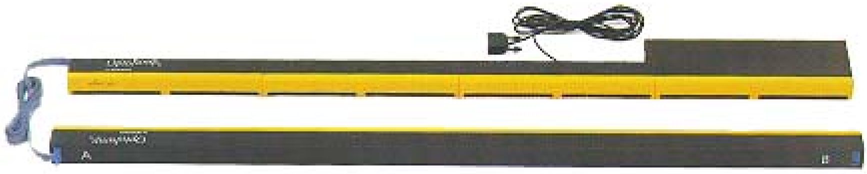


Photo 5 : Optojump, Microgate, Italie

Le déplacement total du centre de gravité (ΔCG) pendant le vol a été obtenu pour chaque saut sur la base de :

$$\Delta CG = (g \, T_{f,j}^2) / 8$$

où g est l'accélération de la gravité (9.81 m/s). Dans ces conditions expérimentales, la puissance mécanique spécifique moyenne de la phase de travail positive de chaque saut, exprimée par unité de masse corporelle ($W_{spec,j}$), a été calculée par le biais de la formule suivante :

$$W_{spec,j} = g^2 \, T_{f,j} \, (T_{c,j} + T_{f,j}) / (4 \, T_{c,j}).$$

La puissance absolue (W,j) a ensuite été déterminée en multipliant Wspec,j par la masse corporelle du sujet. Pour chaque sujet, on a sélectionné le meilleur résultat, en termes de puissance, obtenu dans la série de 5 sauts.

Des analyses précédentes montrent que cette technique est également appropriée pour déterminer la puissance maximale (Wmax) chez les patients obèses (Lafortuna, 2002 ; Sartorio, 2003).

Framingham (évaluation des facteurs de risques liés aux maladies cardiovasculaires - coronary heart disease, CHD) – Le calcul du score a été effectué utilisant un modèle de prédiction des maladies cardiovasculaires développé par Wilson et al. (1998) qui comprend le sexe, l'âge, le poids, la taille, le BMI, le diabète, l'habitude de fumer, la tension, le cholestérol total et le cholestérol HDL. Ces variables sont considérées comme les facteurs de risque indépendants et biologiquement importants pour les CHD et le score utilisé est donc un moyen simple de prédiction des CHD pour des patients qui ne les ont pas encore contractées.

Le score est attribué selon différents classes d'âge (9 sous-groupes de 30 à 74 ans), le taux de cholestérol total (5 sous-groupes de <160 à ≥ 280 mg/dl), de HDL (5 sous-groupes de <35 à ≥60 mg/dl) et de tension (valeur systolique : 5 sous-groupes de <120 à ≥160 mmHg ; valeur diastolique : 5 sous-groupes de <80 à ≥100 mmHg). Le diabète et l'habitude de fumer étaient évalués sur deux catégories (oui/non). Si les valeurs de tension tombaient dans deux catégories différentes, le score plus élevé était considéré.

L'existence de diabète a été évaluée en fonction du traitement médical avec insuline ou médicaments hypoglycémiques oraux, ou un taux de glucose sanguin supérieur à 140 mg/dl. On a considéré fumeurs toute personne fumant au moins une cigarette par jour pendant les derniers 12 mois. Les valeurs de tension et de cholestérol total et HDL on été considérées sans tenir compte des médicaments anti-hypertension et anti-lipidiques. La tension artérielle, pour calculer les valeurs systolique et diastolique, a été prise deux fois avec le sujet assis depuis au moins 5 minutes et la valeur moyenne a été retenue. La prise de sang été faite le matin avec le sujet à jeun et les valeurs de cholestérol total et HDL et de glucose été mesurées immédiatement par méthode enzymatique-colorimétrique (Hitachi Instrument, Japan).

Les traitements médicaux dus à d'autres maladies étaient continués.

Protocole des tests

Evaluation anthropométrique et facteurs de risques CHD	Test des qualités aérobies
Taille Poids BMI Composition corporelle Framingham % de risque (CHD score)	$\dot{V}O_2max$ RPE

Evaluation de la force musculaire	Evaluation de la puissance musculaire
1RM (LP, CP, VT)	CMJ

2.2.2 Protocole expérimental

Régime hypocalorique : Dans le cadre de la réduction de l'apport énergétique, le régime avait été fixé à 1200-1800 kcal/j. L'apport énergétique devant être fourni par le régime a été calculé en soustrayant 500 kcal environ des dépenses énergétiques basales (RMR) mesurées par calorimétrie indirecte (Sensormedics Deltatrac MBM100, Sensormedics Italia, Milano). Le sujet restait allongé dans une pièce isolée au calme pendant 15 min et l'évaluation du métabolisme basal était enregistré en continu et les 5 min de valeurs plus basse ont été considérées pour le calcul du RMR. En ce qui concerne les principaux éléments nutritifs, le régime présentait la composition suivante : 21% de protéines, 53% d'hydrates de carbone et 26% de lipides. On a estimé à 1000 ml par jour la teneur en eau des apports alimentaires, tandis que le contenu en sels était de 1560 mg de Na, 3600 mg de K et 900 mg de Ca. On encourageait les patients à absorber au moins 2000 ml/jour de liquides. Des diététiciens contrôlaient chaque jour que les sujets se conformaient bien à leur régime.

Education nutritionnelle : Des séances, basées sur des conférences, des démonstrations et des discussions de groupe (avec ou sans superviseur) avaient lieu quotidiennement pendant la durée du programme.

Conseils psychologiques : Cette partie du programme comprenait 2 ou 3 séances par semaine de psychothérapie individuelle ou de groupe, tenues par des psychologues de profession, et mettait en place les démarches suivantes : l'apprentissage de méthodes pour maîtriser les stimuli et de stratégies orientées à la solution des problèmes, l'amélioration des capacités de gestion du stress, la définition des objectifs, l'adoption d'habitudes alimentaires saines, l'amélioration de l'estime de soi, la facilitation de l'inclusion sociale, la restructuration cognitive des pensées désadaptées négatives et l'apprentissage de méthodes/attitudes pour éviter les rechutes - le tout sous la direction de psychologues cliniques. De plus des lectures éducatives, des démonstrations et des discussions de groupe sur l'importance de l'exercice physique, la gestion environnementale, la restructuration cognitive et la prévention des rechutes se déroulaient quotidiennement, avec ou sans superviseur.

Entraînement physique : le programme d'activité physique était différent pour chaque groupe.

Programme de RMC intégré
Régime hypocalorique
Education nutritionnelle
Conseils psychologiques
Entraînement physique

2.2.3 Programmes d'entraînement

Entraînement population non personnalisée

Les sujets effectuaient pour l'entraînement cardiovasculaire soit 30 minutes de pédalage sur cycloergomètre à charge d'effort constante (60 W), 5 jours par semaine - la fréquence cardiaque d'exercice (FCex) moyenne ainsi obtenue correspondait à environ 30-45% de la capacité aérobie maximale individuelle initiale ($\dot{V}O_2max$) ; soit 50/70 minutes de marche guidée en plein air, à un rythme tranquille, sur terrain presque entièrement plat, en suivant une piste établie à l'avance (environ 3,5 km), 5 jours par semaine - la FCex moyenne ainsi obtenue correspondait à environ 45-60% de la capacité aérobie maximale individuelle initiale ($\dot{V}O_2max$). L'entraînement de force, pendant 30 minutes d'activité en salle, 5 jours par semaine, consistait en des exercices pour les bras et les jambes effectués debout et au sol, le poids corporel servant de résistance au mouvement, sous la direction d'un thérapeute.

Analyse de la fréquence cardiaque d'exercice (FCex) : Dans un groupe de 20 patients choisis au hasard pour les groupes EPP et EPNS, la fréquence cardiaque était enregistrée pendant tous les entraînements au moyen d'un système Accurex plus (Polar, Finlande). La corrélation étudiée par l'ACSM (2000) entre %FCmax et %$\dot{V}O_2max$ nous a permis d'estimer le % de $\dot{V}O_2max$ correspondant à l'intensité enregistrée par le cardiofréquencemètre et de calculer les calories consommées grâce à l'équivalence entre MET, kcal et $\dot{V}O_2$:

1 MET = 1 kcal/kg/h

1MET = 3,5 ml/kg/min

Entraînement populations personnalisées

Entraînement aérobie et de la force - Le protocole a été conçu en accord avec les lignes directrices de l'*American College of Sports Medicine* (ACSM, 2000) pour les sujets obèses non morbides. Les séances d'entraînement avaient lieu 5 jours par semaine.

L'entraînement aérobie à moyenne intensité auquel se soumettaient les sujets comportait, à chaque séance, 10 minutes de pédalage sur cycloergomètre (50-60 rpm) et 20 minutes de marche sur tapis roulant (à une inclinaison de 0-3%). Seul le groupe A rajoutait 5 minutes sur un ergomètre à bras, pour un total de 35 min/j car il n'effectuait pas d'exercice de force.
L'intensité correspondait pour les groupes DEPAST_EPP_A_AF_MI à 50% de la $\dot{V}O_2max$ individuelle pendant la première semaine du programme et à 60% pendant les deux semaines suivantes. Pour le groupe HI l'intensité des exercices aérobies était fixée à 60% de la $\dot{V}O_2max$ individuelle pendant la première semaine du programme et à 70% pendant les deux semaines suivantes.
Pendant toutes les séances d'activité physique, les sujets portaient un cardiofréquencemètre (Polar, Finlande) pour enregistrer la FC. On a utilisé un système informatisé de feedback basé sur la fréquence cardiaque (CPR System, Technogym, Gambettola, Italie) qui, pendant ces trois types d'exercice, imposait automatiquement aux sujets le rythme d'effort adéquat pour s'en tenir à une FC cible fixée, correspondant à la fraction de $\dot{V}O_2max$ désirée. La corrélation établie par l'ACSM (ACSM, 2000) été toujours utilisée pour transformer l'entraînement d'une intensité exprimée en % du $\dot{V}O_2max$ en % de la FCmax. Pour les groupes DEPAST_EPP_A_AF_MI on interrompait l'augmentation de la charge si la FCex atteignait 75% de la fréquence cardiaque maximale théorique, calculée avec la formule : 220 - âge (en années). Pour le groupe HI on interrompait l'augmentation de la charge si la FC d'exercice atteignait 85% de la fréquence cardiaque maximale théorique (FCmax).

Calcul des calories (kcal) : Pour les groupes DEPAST_EPP_A_AF on a calculé la dépense énergétique métabolique (exprimée en kcal.), dérivant de l'exercice effectué pendant chaque séance, en prenant en considération l'efficience mécanique globale des deux types de locomotion (Pugh, 1971; di Prampero, 1979). Le protocole d'exercice du groupe A prévoyait une dépense quotidienne moyenne±DS de 267 ± 70 kcal pendant la première, pour atteindre 331 ± 79 kcal la troisième semaine. Le protocole d'exercice du groupe AF prévoyait une dépense d'énergie quotidienne moyenne de 227 ± 55 kcal pendant la première, pour atteindre 284 ± 61 kcal la troisième semaine.

Analyse de l'Indice de Performance d'exercice (IP) : Pour les groupes A_AF on a également calculé un indice de performance (IP) pour les différentes séances d'entraînement tout au long du programme de trois semaines, d'après la formule suivante : IP = {[($\dot{V}O_2ex$ / FCex)- 0.1]/ 0.9} * 100, où $\dot{V}O_2ex$ est l'équivalent métabolique moyen de l'exercice effectué, exprimé en ml/min/kg, et FCex est la fréquence cardiaque moyenne atteinte pendant la même séance, exprimée en pourcentage de la FCmax théorique du sujet.

Entraînement de la force : les sujets faisaient 1 série de 15 répétitions sur chacune des trois machines isotoniques (Leg press, Chest press et Vertical traction, Technogym, Italie). Les trois machines isotoniques permettaient d'entraîner différents groupes musculaires des membres inférieurs et supérieurs.

L'intensité augmentait chaque semaine : pour les groupes DEPAST_EPP_A_AF_MI 40% de 1RM pendant la première semaine, 50% de 1RM la deuxième et 60% de 1RM pendant la troisième ; pour le groupe HI 50% de 1RM pendant la première semaine, 60% de 1RM la deuxième et 70% de 1RM pendant la troisième.

Flexibilité : des exercices de flexibilité selon la méthode de Bob Anderson (1980) ont été rajoutés à la fin de la séance d'entraînement pour allonger les groupes musculaires impliqués pendant les exercices cardiovasculaires et de force. Chaque position été maintenue de 30 à 45 sec pour un total de 5 min d'étirement.

Programmes d'entraînement

Population	Entraînement aérobie	Entraînement force
EPNS	30 min sur cycloergomètre à 60 W ou 50/70 min de marche guidée en plein air	30 min d'activité en salle (exercices pour les bras et les jambes effectués debout et au sol)
DEPAST&EPP &AF&MI	10 min sur cycloergomètre (50-60 rpm) 20 min de marche sur tapis roulant (à une inclinaison de 0-3%) 50% $\dot{V}O_2max$ 1° sem 60% $\dot{V}O_2max$ 2° sem	Leg press, Chest press et Vertical traction 1 x 15 40% 1RM 1° sem 50% 1RM 2° sem 60% 1RM 3° sem
A	10 min sur cycloergomètre (50-60 rpm) 20 min de marche sur tapis roulant (à une inclinaison de 0-3%) 5 min sur un ergomètre à bras 50% $\dot{V}O_2max$ 1° sem 60% $\dot{V}O_2max$ 2° sem	
HI	10 min sur cycloergomètre (50-60 rpm) 20 min de marche sur tapis roulant (à une inclinaison de 0-3%) 60% $\dot{V}O_2max$ 1° sem 70% $\dot{V}O_2max$ 2° sem	Leg press, Chest press et Vertical traction 1 x 15 50% 1RM 1° sem 60% 1RM 2° sem 70% 1RM 3° sem

Après le programme contrôlé, les sujets ont commencé en programme libre de la durée d'un an pendant le quel les sujets ont été encouragés à continuer avec le programme effectué pendant les trois semaines d'hospitalisation.

ALLENANDOTI DURANTE LE ULTIME SETTIMANE HAI OTTENUTO OTTIMI MIGLIORAMENTI.
NON FERMARTI PROPRIO ORA E CONTINUA AD ALLENARTI ANCHE A CASA!
ECCO ALCUNI SEMPLICI SUGGERIMENTI:

LA SCALA DI BORG TI PERMETTE DI MANTENERE UNO SFORZO SEMPRE ADATTO ALLE TUE POSSIBILITA'

SCALA DI BORG (RPE)	
0	nullo
0,5	leggerissimo
1	molto leggero
2	leggero
3	moderato
4	abbastanza duro
5	duro
7	molto duro
10	durissimo

RICORDATI DI ALLENARTI 5 GIORNI ALLA SETTIMANA
PER 30 MINUTI OGNI VOLTA
MANTENENDO UN RPE COMPRESO TRA 3 E 4!

BUON LAVORO!

Le conseil été de s'entraîner 5 jours par semaine pendant 30 minutes par jour en contrôlant la sensation de fatigue (RPE entre 3 et 4). Pour les aider à poursuivre ce but ils devaient remplir tous les mois un mémorandum et s'ils n'avaient pas remplis la tâche, ils devaient trouver une solution, par exemple s'entraîner tôt le matin si le soir ils étaient trop fatigués.

OBIETTIVO
MESE DI

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

OBIETTIVO
MESE DI

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

OBIETTIVO
MESE DI

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31

COME UTILIZZARE QUESTO PLANNING MENSILE:
1) STABILISCI ALL'INIZIO DEL MESE L'OBIETTIVO CHE VUOI PERSEGUIRE (ES. PASSEGGIARE 3 GIORNI ALLA SETTIMANA)
2) OGNI GIORNO CHE FAI ATTIVITA' FISICA CONTINUATIVA (ES. 30 MINUTI) FAI UNA CROCE SUL GIORNO EQUIVALENTE
3) A FINE MESE CONTROLLA SE IL TUO OBIETTIVO E' STATO RISPETTATO E SE CI SONO STATI DEGLI IMPEDIMENTI TROVA IL MODO DI SUPERARLI (ES. FACCIO LA PASSEGGIATA LA MATTINA PRESTO PERCHE' A FINE GIORNATA SONO SEMPRE STANCO)

2.2.4 Suivi à long terme

Follow Up 6mois - 6 mois après la fin du programme, on a contacté par téléphone tous les patients ayant participé à l'étude pour évaluer l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital, sur la base d'un classement standardisé de self-report (Jackson, 1999) sur une échelle à 7 points (PAR – physical activity ratio), ainsi que l'évolution du poids corporel et le suivi du régime diététique (si il leur avait été proposé).

Follow Up 1 an – 1 an après la fin du programme, tous les sujets ayant pris part au sous-groupe étaient convoqués à nouveau pour une journée de day-hospital à l'Istituto Auxologico Italiano, Piancavallo, Italie. Les évaluations suivantes étaient faites :

- PAR (physical activity ratio) durant les derniers 6 mois ;
- poids et taille pour le calcul du BMI ;
- composition corporelle par le biais de la BIA ;
- sexe, âge, tension artérielle, prise de sang (pour calculer les valeurs de cholestérol total et HDL et de glucose) et habitude de fumer pour la détermination des facteurs de risque liés aux maladies cardiovasculaires (Framingham) ;
- puissance aérobie maximale ($\dot{V}O_2max$) par le biais d'un test sous-maximal indirect sur cycloergomètre ;
- force maximale (1RM, une répétition maximale) par le biais d'un test sous-maximal indirect sur trois équipements isotoniques pour les membres inférieurs et supérieurs ;
- test de saut (CMJ, counter movement jump) pour la détermination de la puissance mécanique par unité de masse corporelle (Wspec,j) et de la puissance absolue (W,j).

Follow up 6 mois	**Follow up 1 an**
Poids	Taille
BMI	Poids
PAR	BMI
	Composition corporelle
	Framingham
	$\dot{V}O_2max$
	1RM (LP, CP, VT)
	CMJ

1 Introduction

1.1 Problem statement

1.2 Statement of research objectives

2 Matériel & Méthode

2.1 Populations non morbides

2.2 Protocoles

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3 Résultats

3.1 PREMIERE ETUDE_DEPAST

3.2 DEUXIEME ETUDE_EPNS vs EPP

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3.4 QUATRIEME ETUDE_MI vs HI

4 Discussion

4.1 Materials and Methods discussion

4.2 Results Discussion

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2.3 Analyse statistique

Toutes les valeurs sont données comme moyennes ± DS. Les valeurs de *p* inférieures à 0,05 ont été considérées comme étant statistiquement significatives.

L'analyse des effets principaux et d'interaction des facteurs activité physique et sexe sur l'ensemble des variables dépendantes, considérées dans leur ensemble, a été faite par MANOVA. Les différences dans la réponse entre genres et entre les programmes de RMC ont été testées au moyen d'une analyse de variance à deux voies (ANOVA). Cette analyse a été effectuée avec le logiciel StatView 5.0. La puissance 1 - β, c'est-à-dire la probabilité de ne pas rejeter l'hypothèse alternative quand elle est vraie, a été vérifiée, choisie selon le type d'essai réalisé, généralement de 80 % ou plus. Cette analyse a été effectuée avec le logiciel GPower 3.0.

L'analyse des données s'est déroulée en deux temps : dans un premier temps elle a été effectuée au sein de l'Istituto Auxologico à Piancavallo où la comparaison des valeurs moyennes des variables analysées à court terme (avant et après le programme de RMC) et à long terme (avant et après un an de la fin du programme de RMC) a permis un premier aspect descriptif des données et aussi de contrôler l'efficacité des programmes (Test t de Student pour échantillons appariés ou indépendants). Ces analyses ont porté aux résultats qui ont fait l'objet des publications. Cette analyse a été effectuée avec le logiciel Statistica Base.

Un test de puissance post-hoc a été rajouté, effectué avec le logiciel GPower 3.0.

A un deuxième niveau une analyse plus pointue a été faite au sein de l'Unité de Biologie de l'Effort et de Médecine du Sport. La première analyse a porté sur l'examen des distributions : toutes les données ont été initialement analysées pour contrôler les critères de normalité et d'homogénéité des variances afin de déterminer le type de test qui devait être appliqués aux différents paramètres étudiés (tests paramétriques ou non paramétriques).

Normalité : examen des histogrammes (test de symétrie)
examen des valeurs centrales (moyenne, mode, médiane)
rapport de l'écart type à la moyenne
test de Kolmogorov-Smirnov testant les distributions observées et théoriques

Test d'homogénéité des variances : utilisation du test F de Snédécor

L'analyse de corrélation entre les paramètres (calcul de r de Bravais-Pearson ou test de Spearman) des premiers tests (situation pré programme de réduction de la masse corporelle) et leur comparaison entre les différents groupes d'entraînement (Test t de Student pour échantillons indépendants ou test de Mann-Whitney) a permis de détecter les éventuels facteurs de confusion (paramètres qui différencient les groupes et qui sont corrélés aux Δ). L'influence des facteurs de confusion a été contrôlée et éventuellement l'efficacité du programme en fonction des facteurs de confusion a été à nouveau vérifiée.

Dans la première étude, pour vérifier l'efficacité du traitement les tests ont porté sur l'analyse des deltas (Δ = différence entre les résultats pré et post traitement). Pour les variables paramétriques ont a utilisé le test Test-t univarié, qui évalue la différence par rapport à zéro. Pour les variables non-paramétriques ont a utilisé le test analogue Test des signes univariés.

Pour vérifier si le programme a apporté une différente efficacité selon le sexe, les mêmes tests ont été utilisés pour chaque groupe de sexe.

Avant de comparer l'efficacité du traitement en fonction du sexe on a d'abord recherché des paramètres différentiant le sexe et la relation des paramètres qui différencient les groupes avec les Δ. Ensuite on a effectué la comparaison définitive en tenant compte des facteurs de confusions éventuels.

Recherche des paramètres différentiant le sexe : test t student pour séries appariées pour les variables gaussiennes et test Mann et Whitney comme test non-paramétrique

Relation des paramètres qui différencient les groupes avec les Δ : corrélation de Pearson (paramétrique) et corrélation de Spearman (non-paramétrique)

La comparaison des Δ en fonction du sexe a été effectué grâce au test t student pour séries appariées pour les variables gaussiennes et test Mann et Whitney comme test non-paramétrique.

Les tests de corrélation ont ensuite été appliqués aux données du PAR (physical activity rating) maintenu pendant 1 an pour vérifier son influence sur les résultats successifs du follow up.

L'influence du programme d'entraînement suivi sur le PAR à un an et l'influence du niveau du PAR à un an sur les paramètres à long terme ont été contrôlées par les tests test t student pour séries appariées ou Mann-Whitney. Le groupe a été analysé dans sa totalité sans distinction de sexe car le test-t pour séries appariées utilisé préalablement n'avait pas montré de différences significatives entre les sexes pour le PAR initial et pour celui maintenu pendant un an.

L'étude des corrélations a porté sur tous les paramètres de départ et sur tous les Δ pour exprimer la correspondance qui existe entre les différents valeurs associées et de déterminer le sens et la force de la liaison.

Dans la deuxième étude, à cause de la taille de l'échantillonnage seuls les tests non-paramétriques ont été utilisés.

On a d'abord recherché les paramètres de départ différentiant les deux groupes d'entraînement par le test de U de Mann-Whitney.

Ensuite on a évalué quels sont les différences de variation entre les deux groupes au terme des trois semaines d'hospitalisation en fonction du niveau d'activité physique initiale. Cela a porté sur l'analyse des Δ par le test de U de Mann-Whitney.

Pour vérifier l'efficacité de chaque programme le Test des signes univariés a été appliqué aux Δ.
Pour vérifier si le traitement a apporté une différente efficacité selon le programme, le test de U de Mann-Whitney a été appliqué aux Δ avec comme variable groupe les programmes d'activités physiques suivis.
La même analyse mais avec les donnée éclatées par sexe a été faite pour analyser les variations portées par les entraînements en fonction du sexe et dans chaque programme.
La différence de comportement de chaque sexe en fonction du programme et dans chaque groupe a été recherché par le Test des signes univariés avec les données éclatées non seulement par programme d'entraînement mais aussi par sexe.
L'analyse des résultats à un an a porté dans un premier temps à la comparaison des résultats, les sujets comparés à eux même par le test de Wilcoxon. Une deuxième analyse en fonction du sexe a été faite.
Les tests de corrélation ont ensuite été appliqués aux données du PAR (physical activity rating) maintenu pendant 1 an pour vérifier son influence sur les résultats successifs du follow up.
La différence entre le niveau d'activité de départ et d'arrivé dans chaque groupe a été étudié par le test de Wilcoxon. Le contrôle entre le niveau du PAR initial a été fait par le test U de Mann-Whitney et le manque de différence entre les groupes nous a permis d'effectué l'analyse des différences portées par les deux programmes d'entraînement à un an toujours grâce au test U de Mann-Whitney.
Dans la troisième et la quatrième étude, les paramètres sur lesquels les programmes présentent ou non une efficacité ont été étudiés par le test Test-t univarié.
La même analyse mais avec les donnée éclatées par sexe a été faite pour analyser l'efficacité des programmes en fonction du sexe.
La réponse au sein de chaque sexe en fonction du programme a porté sur l'étude des Δ par le test U de Mann-Whitney.
Les mêmes tests ont été répétés pour les données obtenues au terme d'une année de suivi.
Toute analyse a été effectuée avec le logiciel StatView 5.0.

1 Introduction

1.1 Problem statement

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4 Discussion

4.1 Materials and Methods discussion

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Le MANOVA a mis en évidence qu'ils existent des effets significatifs principaux du facteur activité physique (AP) sur l'ensemble des variables dépendantes analysées dans leur ensemble à Δ_1 (soit après trois semaines de programme contrôlé) et à Δ_3 (soit après 1 an de programme libre). Les effets significatifs principaux du facteur sexe sur l'ensemble des variables dépendantes analysées dans leur ensemble n'existent qu'à Δ_1. Les effets d'interaction des deux facteurs sur l'ensemble de ces variables considérées dans leur ensemble sont significatifs à Δ_3 avec une forte tendance à la significativité à Δ_1.

MANOVA	AP p value power	sexe p value power	AP*sexe p value power
Δ_1	0,0001 1,000	0,0001 1,000	0,0797 1,000
Δ_3	0,01 1,000	ns 0,99	0,05 1,000

Les programmes d'activité physique ont déterminé à Δ_1 une réponse différente des paramètres physiologiques. Les sexes ont répondu significativement différemment pour les variables poids, BMI, masse maigre, les paramètres de santé (% CHD) et la force. L'interaction des deux facteurs a eu effet que sur $\dot{V}O_2max$.

ANOVA Δ_1	AP p value power	sexe p value power	AP*sexe p value power
Body weight	ns 0,629	<0,0001 1,000	ns 0,314
BMI	ns 0,469	<0,001 0,918	ns 0,242
FM	ns 0,232	0,0698 0,426	ns 0,097
FFM	ns 0,173	<0,0001 1,000	ns 0,294
Fram	ns 0,242	ns 0,080	ns 0,244
% CHD	ns 0,280	<0,0001 0,997	ns 0,520
$\dot{V}O_2max$	<0,05 0,794	ns 0,084	<0,05 0,794
LP	<0,001 0,977	0,001 0,972	ns 0,419
CP	<0,0001 1,000	<0,0001 1,000	0,0746 0,707
VT	<0,0001 1,000	<0,0001 1,000	ns 0,653

Les programmes d'activité physique ont déterminé à Δ_3 une réponse différente des paramètres de santé (Framingham) et de la variable $\dot{V}O_2max$. Les sexes ont répondu significativement différemment pour la variable masse grasse. L'interaction des deux facteurs a eu effet que pour les paramètres de santé (Framingham).

ANOVA Δ_3	AP p value power	sex p value power	AP*sex p value power
Body weight	ns 0,264	ns 0,237	ns 0,291
BMI	ns 0,210	ns 0,289	ns 0,211
FM	ns 0,227	<0,05 0,521	ns 0,141
FFM	ns 0,186	ns 0,099	ns 0,215
Fram	<0,001 0,978	0,0616 0,450	<0,05 0,817
% CHD	ns 0,142	ns 0,285	0,0835 0,686
$\dot{V}O_2max$	<0,05 0,858	ns 0,050	ns 0,558
LP	ns 0,208	ns 0,137	ns 0,335
CP	ns 0,543	ns 0,172	ns 0,262
VT	ns 0,155	ns 0,052	ns 0,536
PAR	ns 0,267	ns 0,190	ns 0,600

L'efficacité des programmes a été vérifiée par un Test t de Student pour échantillons appariés et un test de puissance post-hoc. A Δ_1 tous les programmes ont porté des modifications significatives pour le poids, le BMI, la FM et la force. Une variation importante du nombre d'effectifs aurait pu montrer une modification significative de FFM pour les programmes EPP (N=45, power=0,80) et A (N=100, power=0,80). Une variation importante du nombre d'effectifs aurait pu montrer une modification significative de $\dot{V}O_2max$ pour les programmes EPP (N=100, power=0,80) et HI (N=100, power=0,80). A Δ_3 le programme non personnalisé (EPNS) a porté des modifications significatives que pour les paramètres physiologiques. Les programmes personnalisés qui ont porté des modifications significatives sur les paramètres anthropométriques sont : DEPAST, A et HI. La variation du nombre d'effectifs aurait pu montrer une modification significative aussi pour le programme MI (N=35, power=0,8). Les programmes personnalisés qui ont porté des modifications significatives sur les paramètres de santé sont : DEPAST et A. La variation du nombre d'effectifs aurait pu montrer une modification significative aussi pour le programme EPP (N=35, power=0,95). Les programmes personnalisés qui ont porté des modifications significatives sur les paramètres physiologiques cardiovasculaires : DEPAST et AF. En général tous les programmes personnalisés ont porté une modification sur les paramètres de force.

					Δ_1					
PA	BW moyenne p value power	BMI moyenne p value power	FM moyenne p value power	FFM moyenne p value power	Fram moyenne p value power	% CHD moyenne p value power	$\dot{V}O_2max$ moyenne p value power	LP moyenne p value power	CP moyenne p value power	VT moyenne p value power
DEPAST	-5,31	-1,91	-4,1	-0,97	-0,75	-0,31	0,36	89,69	9,24	14,25
	<0,0001	<0,05	0,0001	<0,01	<0,05	<0,05	<0,0001	<0,0001	<0,0001	<0,0001
	1,000	1,000	1,000	0,86	0,71	0,61	0,99	1,000	1,000	1,000
EPNS	-4,85	-1,73	-2,8	-1,6	0,07	-0,73	-0,08	55,01	5,11	7,42
	<0,0001	<0,0001	<0,0001	<0,01	ns	ns	ns	<0,001	<0,05	<0,01
	1,000	1,000	1,000	0,92	0,035	0,22	0,056	0,99	0,75	0,92
EPP	-4,65	1,69	-3,52	-1,42	0,07	-0,27	0,16	107,81	12,43	19,35
	<0,0001	<0,0001	<0,01	ns	ns	ns	ns	<0,0001	<0,001	<0,0001
	1,000	1,000	0,95	0,36	0,051	0,13	0,18	1,000	0,97	1,000
A	-5,65	-2,01	-4,36	-0,78	-0,92	-0,46	0,43	66,07	5,26	8,28
	<0,0001	<0,0001	0,0001	ns	ns	ns	<0,001	<0,0001	<0,01	<0,0001
	1,000	1,000	1,000	0,297	0,44	0,32	0,969	0,999	0,82	0,99
AF	-4,97	-1,8	-3,84	-1,39	-0,85	-0,19	0,24	102,22	11,2	18,7
	<0,0001	<<0,0001	<0,0001	<0,05	ns	ns	<0,05	<0,0001	<0,0001	<0,0001
	1,000	1,000	0,999	0,68	0,33	0,18	0,67	1,000	0,999	1,000
MI	-5,16	-1,86	-3,53	-1,4	-0,81	-0,29	0,27	108,68	13,71	19,51
	<0,0001	<0,0001	<0,001	0,0001	ns	ns	<0,01	<0,0001	<0,0001	<0,0001
	1,000	1,000	1,000	0,95	0,37	0,42	0,81	1,000	1,000	1,000
HI	-5,71	-2,05	-3,47	-0,79	-1,21	-0,27	0,23	111,18	15,59	19,91
	<0,0001	<0,0001	<0,0001	<0,05	<0,01	ns	ns	<0,0001	<0,0001	<0,0001
	1,000	1,000	1,000	0,72	0,99	0,35	0,38	1,000	1,000	1,000

Δ3											
PA	BW moyenne p value power	BMI moyenne p value power	FM moyenne p value power	FFM moyenne p value power	Fram moyenne p value power	% CHD moyenne p value power	$\dot{V}O_2max$ moyenne p value power	LP moyenne p value power	CP moyenne p value power	VT moyenne p value power	PAR moyenne p value power
DEPAST	-5,3	-1,92	-3,1	1,37	-1,14	-0,7	0,25	44,22	9,36	11,24	0,84
	<0,01	<0,01	ns	ns	<0,05	ns	<0,05	<0,001	<0,0001	<0,0001	<0,05
	0,82	0,85	0,42	0,11	0,73	0,07	0,61	0,97	0,999	0,997	0,63
EPNS	-1	-0,49	0,77	-1,58	-0,33	-1,67	-0,55	46,02	0,39	14,91	1,22
	ns	ns	ns	ns	ns	ns	<0,05	ns	0,01	<0,05	ns
	0,058	0,064	0,056	0,18	0,054	0,15	0,55	0,4	0,83	0,69	0,23
EPP	-4,4	-1,7	-5,06	-0,14	2,7	0,2	0,88	63,06	9,45	13,8	2,64
	ns	ns	ns	ns	0,066	ns	ns	<0,001	<0,001	<0,001	<0,05
	0,24	0,26	0,33	0,053	0,51	0,08	0,08	0,99	0,99	0,99	0,69
A	-5,14	-1,95	-5,15	-0,06	-1,5	-0,3	0,15	43,8	11,61	10,81	0,95
	0,069	<0,05	<0,05	ns	<0,01	ns	ns	<0,01	<0,0001	<0,01	ns
	0,449	0,54	0,75	0,05	0,06	0,18	0,23	0,85	0,999	0,93	0,32
AF	-4,8	-1,63	-2,5	-0,83	-0,85	0,1	0,42	31,75	6,38	11,27	0,5
	ns	ns	ns	ns	ns	ns	<0,05	ns	0,01	0,01	ns
	0,35	0,33	0,21	0,23	0,19	0,08	0,57	0,42	0,75	0,76	0,16
MI	-7,3	-2,6	-5,11	-0,78	0,13	0	0,44	49,77	7,55	12,46	1,14
	0,077	0,07	ns	ns	ns		ns	<0,01	<0,05	<0,01	ns
	0,43	0,44	0,38	0,15	0,051	0,050	0,36	0,79	0,67	0,94	0,28
HI	-10,74	-3,7	-7,43	-2,88	2,88	-0,43	0,37	30,61	3,64	14,41	0,44
	<0,05	<0,05	<0,05	ns	ns	ns	ns	ns	ns	<0,05	ns
	0,988	0,58	0,58	0,26	0,28	0,15	0,15	0,18	0,23	0,65	0,06

3 Résultats

3.1 PREMIERE ETUDE_DEPAST

3.1.1 Aspect descriptif

3.1.1.1 Paramètres esthétiques_court terme

Réduction de poids et composition corporelle

La masse et la composition corporelle déterminées avant et après le programme de RMC dans le groupe étudié figurent dans le Tableau 12.

Tableau 12 - Composition et poids corporels moyens (±DS) observés dans le groupe d'étude (N = 71) avant et après le programme à court terme de RMC.

	avant	après	Δ %
Poids (kg)	113,8 ± 2,2	108,7 ± 2,1*	- 4,5
BMI (kg/m^2)	41,3 ± 0,5	39,4 ± 0,5*	- 4,6
FM (%)	48,5 ± 6,8	46,9 ± 6,4*	- 3,6
FFM (%)	51,5 ± 6,8	53,1 ± 6,45*	+ 3,1

* = valeur significativement différente de la valeur correspondante mesurée avant le programme ($p < 0{,}001$, évaluée à l'aide d'un test *t* de Student pour données appariées)

Au terme du programme de 3 semaines, le poids, le BMI et la FM ont significativement diminué. Étant donné qu'aucune variation significative n'a été observée dans la quantité de FFM (FFM, avant : 58,8 ± 1,5 kg ; après : 57,9 ± 1,4 kg), celle-ci a subi une augmentation significative en terme de pourcentage.

3.1.1.2 Paramètres esthétiques_long terme

Réduction de poids et composition corporelle

La masse et la composition corporelle déterminées avant et à 1 an de la fin du programme de RMC dans le groupe étudié figurent dans le Tableau 13.

Tableau 13 - Composition et poids corporels moyens (±DS) observés dans le groupe d'étude (N = 44) avant et à 1 an de la fin du programme de RMC.

	avant	1 an	Δ
Poids (kg)	113,2 ± 19,5	107,9 ± 21,1‡	- 5,3
BMI (kg/m^2)	40,8 ± 3,4	38,9 ± 4,9‡	- 1,9
FM (kg)	52,8 ± 9,7	48,4 ± 12,2	- 4,4
FFM (kg)	59,9 ± 14,1	59,8 ± 14	- 0,1

‡ = valeur significativement différente de la valeur correspondante mesurée avant le programme ($p < 0{,}01$, évaluée à l'aide d'un test *t* de Student pour données appariées)

Conclusions

- perte de poids qui est restée stable à 1 an
- gain de 1 kg de FM après la perte initiale de 3 kg
- perte de 1 kg de FFM à court terme

3.1.1.3 Paramètres de santé_court terme

<u>Facteurs de risque</u>

Le tableau 14 considère les facteurs de risque liés aux maladies cardiovasculaires avant et après le programme de RMC. On y observe une réduction de 17,9% pour le cholestérol total et de 20,1% pour le cholestérol HDL. Les réductions étaient moins élevées pour les valeurs de tension (valeur systolique –SBP- 6,2% ; valeur diastolique –DBP- 4,0%) et du glucose sanguin (8,5%). Au total le score du CHD est diminué de 11,5%. Toute modification observée après le programme de RMC est significative ($p<0,05$).

Tableau 14 : Données moyennes (±DS) du score CHD et à 1 an de la fin du programme de RMC

	avant	après	Δ (%)
Cholestérol total (mg/dl)	187,6 ± 38,2	160,7 ± 31,3°	-26,9 (17,9)
Cholestérol HDL (mg/dl)	42,3 ± 8,4	35,5 ± 7,2°	-6,8 (20,1)
SBP (mmHg)	124,5 ± 8,9	117,5 ± 8,7°	-7,0 (6,2)
DBP (mmHg)	76,5 ± 5,6	73,9 ± 5,9°	-2,7 (4,0)
Glucose sanguin (mg/dl)	80,1 ± 13,1	74,2 ± 7,7°	-5,9 (8,5)
Framingham	-3,3 ± 5,2	-4,0 ± 2,2°	-0,8 (18,5)
CHD score (% risque)	2,2 ± 2,0	1,9 ± 1,4°	-0,3 (11,5)

° = $p < 0,05$

3.1.1.4 Paramètres de santé_long terme

<u>Facteurs de risque</u>

Le CHD score (% risque) et la valeur du Framingham avant et à 1 an de la fin du programme de RMC dans le groupe étudié figurent dans le Tableau 15.

Tableau 15 : Données moyennes (±DS) du score CHD avant à 1 an de la fin du programme de RMC

	avant	1 an	Δ (%)
Cholestérol total (mg/dl)	195,2 ± 38,9	195,6 ± 38,3	0,4 (-1,3)
Cholestérol HDL (mg/dl)	42,4± 8,1	50,4 ± 12,2*	8 (14,1)
SBP (mmHg)	124,8 ± 9,4	129,4 ± 18,4	4,7 (2)
DBP (mmHg)	76,5 ± 5,6	77,3 ± 7,8	0,8 (0,3)
Glucose sanguin (mg/dl)	81,3 ± 8,9	94,1 ± 10,4*	12,8 (12,8)
Framingham	-2,7 ± 4,9	-3,8 ± 6,0°	-1,1 (29,9)
CHD score (% risque)	2,5 ± 2,2	2,4 ± 2,0	-0,1 (-4,2)

,° = valeur significativement différente de la valeur correspondante mesurée avant le programme ($p < 0,001$, °$p < 0,05$ évaluée à l'aide d'un test *t* de Student pour données appariées)

<u>Conclusions</u>

- pas de modification à terme pour les paramètres de santé Framingham et CHD score (% risque)

3.1.1.5 Capacités physiologiques_court terme

<u>Paramètres cardiovasculaires</u> - Le Tableau 16 montre les valeurs moyennes de la

$\dot{V}O_2max$ déterminées avant et après le programme de réduction de la masse corporelle, en termes absolus et en relation avec la masse corporelle.

Tableau 16 - Capacité aérobie maximale ($\dot{V}O_2max$) moyenne (±DS) absolue et relative (par unité de masse corporelle) atteinte avant et après le programme à court terme de RMC par les sujets du groupe d'étude.

	Avant	Après	Δ %
$\dot{V}O_2max$ (l/min)	2,56 ± 0,08	2,93 ± 0,10*	+ 14,5
$\dot{V}O_2max$ (ml/min/kg)	22,8 ± 0,6	27,4 ± 0,9*	+ 20,2

* = valeur significativement différente de la valeur correspondante mesurée avant le programme ($p < 0,001$, évaluée à l'aide d'un test *t* de Student pour données appariées)

Il ressort une augmentation significative pour les deux paramètres.

Le RPE évalué au cours du test de détermination de la $\dot{V}O_2max$ sur la base d'une échelle de Borg à 10 points a diminué significativement après le programme (note avant : 2,6 ± 0,1 ; note après : 0,8 ± 0,1 ; $p < 0,001$) et aucune différence significative entre les sexes n'a été observée dans l'un ou l'autre cas.

Le niveau d'effort atteint en réponse à la charge métabolique constante a augmenté significativement pendant le conditionnement physique préliminaire (1ère semaine) et pendant la période de conditionnement à l'entraînement (2ème et 3ème semaines), comme le montre la figure 4, qui reporte l'effort quotidien en kcal/min pour le pédalage sur cycloergomètre et la marche sur tapis mécanique.

L'effet du conditionnement sur le niveau d'effort atteint a été évalué par test ANOVA à une voie pour mesures répétées (cycloergomètre, 1ère semaine : df = 4, F = 2,311, p = 0,05 ; 2ème et 3ème semaines : df = 9, F = 3,749, p < 0,001 ; marche sur tapis roulant, 1ère semaine : df = 4, F = 24,333, p < 0,001 ; 2ème et 3ème semaines : df = 9, F = 13,643, p < 0,001). Dans tous les cas, les hommes ont développé un effort plus élevé que les femmes pour la charge métabolique constante imposée (p < 0,001). L'IP a montré une tendance similaire, avec une augmentation significative par effet du conditionnement. Les valeurs quotidiennes pour le pédalage sur cycloergomètre et la marche sur tapis roulant ont été testées par test ANOVA à une voie pour mesures répétées (cycloergomètre, 1ère semaine : df = 4, F = 2,916, p < 0,05 ; 2ème et 3ème semaines : df = 9, F = 4,785, p < 0,001 ; marche sur tapis roulant, 1ère semaine : df = 4, F = 30,051, p < 0,001 ; 2ème et 3ème semaines : df = 9, F = 14,438, p < 0,001) ont sont présentées dans la figure 5.

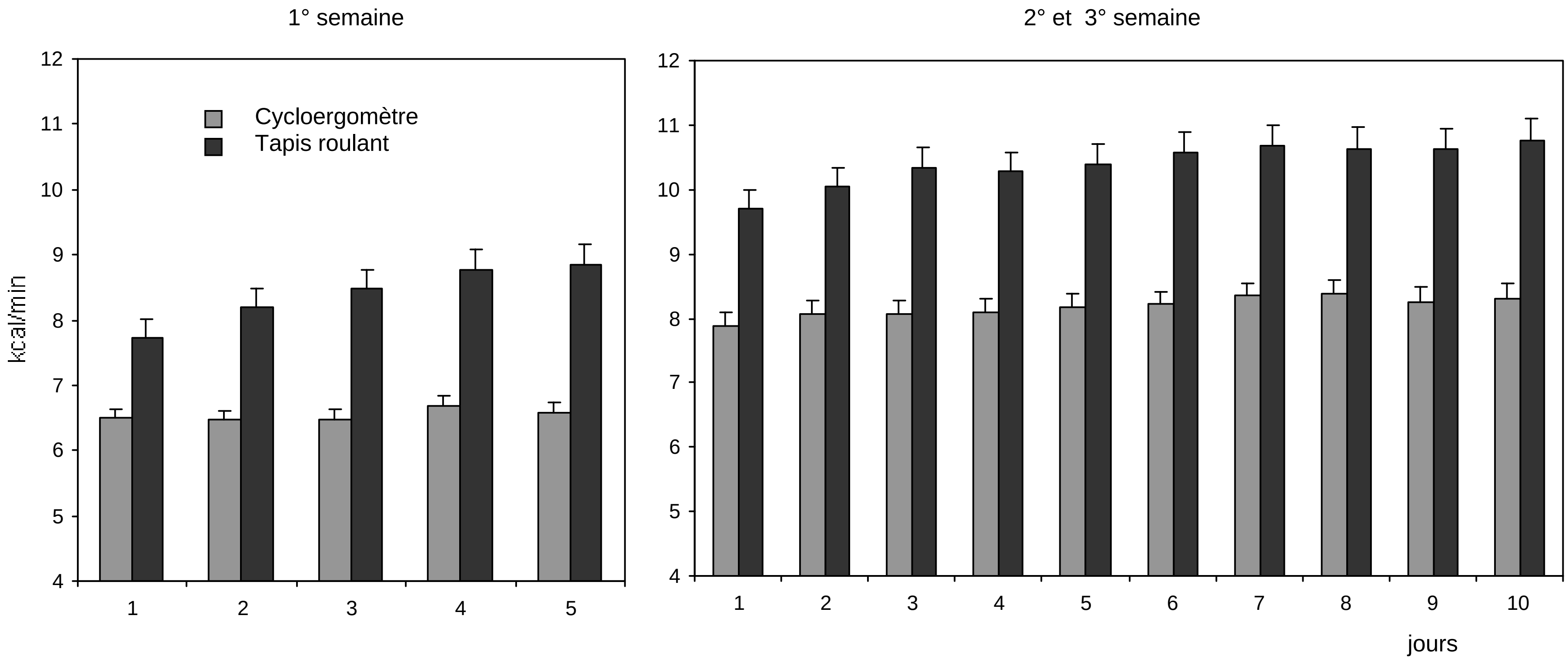


Figure 4 - Niveau d'effort quotidien (kcal/min) atteint en réponse à une charge métabolique constante (50 % de $\dot{V}O_2$max pendant la 1ère semaine de conditionnement physique préliminaire et 60% pendant les 2ème et 3ème semaines de conditionnement à l'entraînement), dans les activités de pédalage sur cycloergomètre et de marche sur tapis roulant, chez 71 patients souffrant d'obésité sévère.

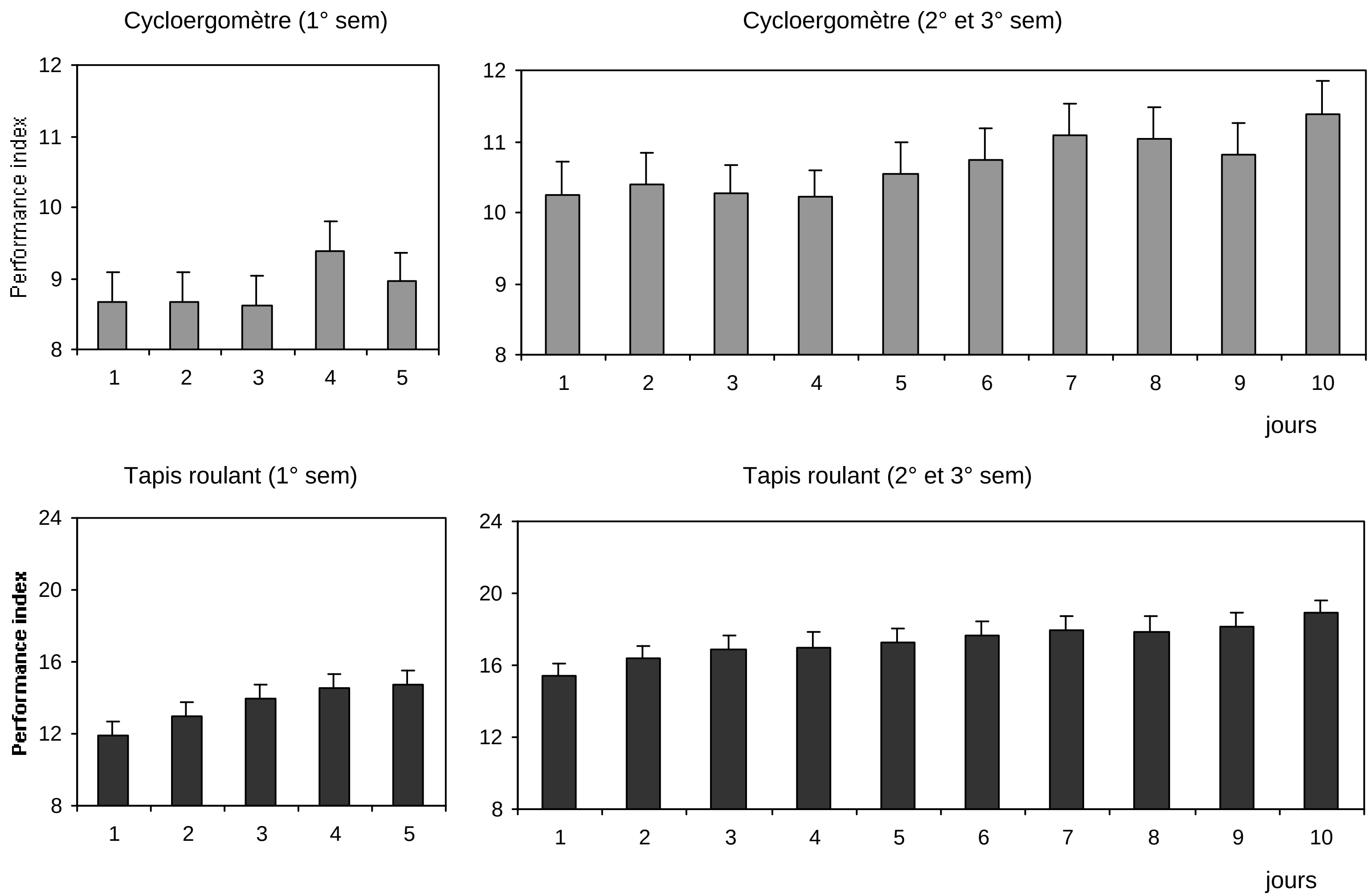


Figure 5 - Valeurs quotidiennes de l'indice de performance atteintes en réponse à une charge métabolique constante (50 % de $\dot{V}O_2max$ pendant la 1ère semaine de conditionnement physique préliminaire et 60% pendant les 2ème et 3ème semaines de conditionnement à l'entraînement), dans les activités de pédalage sur cycloergomètre et de marche sur tapis roulant, chez 71 patients souffrant d'obésité sévère.

Les deux sexes ont présenté une tendance similaire, bien que l'on ait relevé chez les hommes des valeurs de l'IP significativement plus élevées que chez les femmes, et ce pour chaque jour de la période étudiée ($p < 0,001$).

Les résultats obtenus pendant les trois semaines du programme sont résumés sur le Tableau 17, qui montre l'effort total atteint avec le pédalage sur cycloergomètre et la marche sur tapis roulant, et l'IP moyen.

Tableau 17 - Effort et indice de performance (IP) moyens (± DS) et variations hebdomadaires pendant les trois semaines de l'étude pendant un entraînement à charge métabolique constante mesurés sur 71 sujets souffrant d'obésité sévère.

	Charge métabolique (%$\dot{V}O_2$max)	Effort (kcal)	Variation de l'effort (kcal)	IP (-)	Variation de l'IP (%)
lundi		219 ± 7		10,1 ± 0,5	
Conditionnement prélim. (1ère semaine)	50		24 ± 4		38,5 ± 12,4
vendredi		243 ± 7*		11,6 ± 0,5*	
lundi		273 ± 7		12,8 ± 0,5	
Test de conditionnement (2ème semaine)	60		17 ± 3		10,5 ± 2,4
vendredi		290 ± 8*		13,9 ± 0,5*	
lundi		294 ± 7		14,1 ± 0,6	
Test de conditionnement (3ème semaine)	60		4 ± 3		7,7 ± 3,0
vendredi		298 ± 8		15,1 ± 0,5*	

* : valeur significativement différente ($p < 0,001$) de la valeur observée le lundi de la même semaine. Différences évaluées à l'aide d'un test *t* de Student pour données appariées

Il apparaît ainsi que, pendant le programme, l'augmentation totale de la capacité d'effort en réponse à une charge métabolique constante a été en moyenne de 44,6 ± 5,8 kcal. En termes absolus, l'augmentation de la capacité d'effort totale a été significativement plus élevée chez les hommes que chez les femmes (hommes : 68,8 ± 11,9 kcal ; femmes : 36,4 ± 6,5 kcal, $p < 0,05$) ; par contre, pour une amélioration de l'effort exprimée en pourcentage de la capacité d'effort avant le début du programme, on n'a relevé aucune différence entre les sexes (hommes : 34,9 ± 12,7 kcal ; femmes : 21,1 ± 3,2 kcal, p = ns). Enfin, on a relevé une corrélation significative entre l'augmentation individuelle totale de la capacité d'effort et l'augmentation (en %) de l'IP, comme le montre la figure 6, où l'on trouve également l'équation de la droite de régression pour tous les sujets de l'étude.

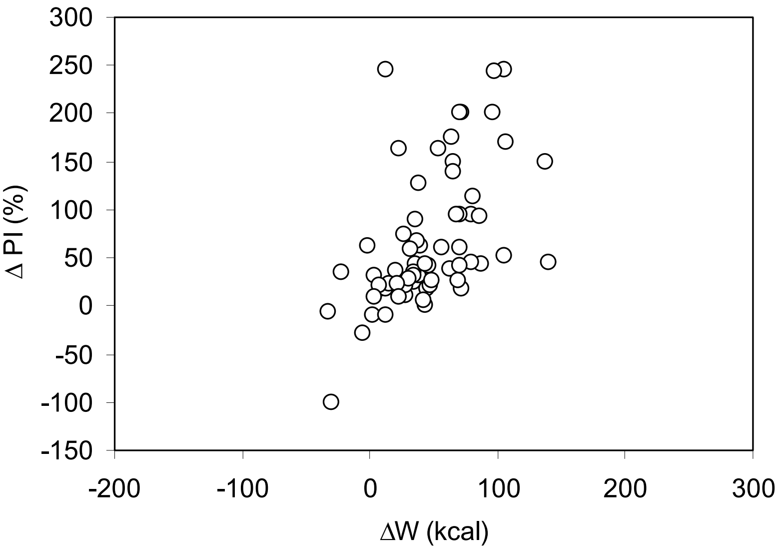


Figure 6 - Augmentation individuelle (en %) de l'indice de performance représentée en fonction de l'augmentation totale de la capacité d'effort (ΔW, kcal), relevée pendant les trois semaines de programme de RMC chez 71 patients souffrant d'obésité sévère. La figure présente également l'équation de la droite de régression.

<u>Force</u> – Les résultats concernant la force maximale atteinte sur les trois machines isotoniques avant et après le programme RMC par les sujets sont présentés sur le tableau 18.

Tableau 18 - Force maximale moyenne (± DS) obtenue sur trois machines isotoniques différentes avant et après le programme RMC. Les différences ont été évaluées à l'aide d'un test *t* de Student pour données appariées.

	avant	après	Δ
Leg Press (kg)	255,0 ± 77,2	344,7 ± 98,0**	89,7
Chest Press (kg)	33,0 ± 15,0	42,3 ± 8,3**	9,2
Vertical Traction (kg)	72,9 ± 18,3	87,1 ± 21,6**	14,3

** = p < 0,0001

<u>Puissance</u> – La figure 7 résume la variation moyenne des prestations relevées pendant le test de saut. Grâce à l'amélioration de la puissance maximale développée (Wj), une réduction significative du temps de contact avec le sol dans le saut (Tc,j) a pu être relevée à la fin du programme. De plus, une augmentation significative du temps de vol (Tf,j) et du déplacement vertical du barycentre (ΔCG) a pu être observée à la fin du programme RMC.

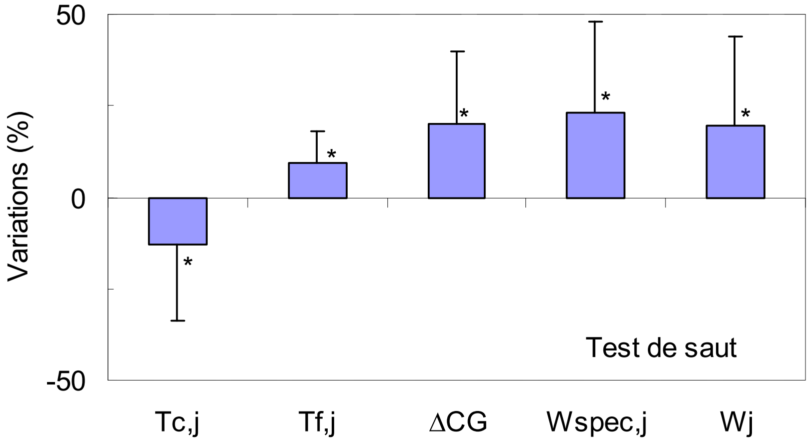


Figure 7 - Variations de plusieurs paramètres, après le programme RMC, mesurées chez 53 sujets obèses par le test de saut. Les différences par rapport à la situation avant le début du programme ont été évaluées par un test *t* de Student pour données appariées (* = p < 0,001).

3.1.1.6 Capacités physiologiques_long terme

L'efficacité du programme à long terme a été vérifiée pour les paramètres principaux : $\dot{V}O_2$max, force (LP, CP, VT).

Paramètres cardiovasculaires - Le tableau 19 montre les valeurs moyennes de la $\dot{V}O_2$max déterminées avant et à 1 an de la fin du programme de réduction de la masse corporelle, en termes absolus et en relation avec la masse corporelle.

Tableau 19 - Capacité aérobie maximale ($\dot{V}O_2$max) moyenne (±DS) absolue et relative (par unité de masse corporelle) atteinte avant et à 1 an de la fin du programme de RMC par les sujets du groupe d'étude.

	avant	1 an	Δ
$\dot{V}O_2$max (l/min)	2,57 ± 0,74	2,82 ± 0,10°	0,25
$\dot{V}O_2$max (ml/min/kg)	22,8 ± 0,6	27,4 ± 1,0‡	3,02

‡,° = valeur significativement différente de la valeur correspondante mesurée avant le programme ($^‡p < 0,01$, $°p < 0,05$ évaluée à l'aide d'un test *t* de Student pour données appariées)

Force – Les résultats concernant la force maximale atteinte sur les trois machines isotoniques avant et à 1 an de la fin du programme RMC par les sujets sont présentés sur le tableau 20.

Tableau 20 - Force maximale moyenne (± DS) obtenue sur trois machines isotoniques différentes avant et à 1 an de la fin du programme RMC. Les différences ont été évaluées à l'aide d'un test *t* de Student pour données appariées.

	avant	1 an	Δ
Leg Press (kg)	249,2 ± 78,6	293,4 ± 85,4*	44,2
Chest Press (kg)	32,1 ± 14,9	41,5 ± 15,5**	9,4
Vertical Traction (kg)	72,3 ± 20,5	83,5 ± 19,5**	11,2

** = p < 0,0001 ; * = p < 0,001

Conclusions

- amélioration des capacités physiologiques à long terme

CONCLUSIONS AU TERME DE L'ETUDE POUR L'ENSEMBLE DE LA POPULATION

- diminution de 5 kg grâce à l'activité physique (les sujets n'ont pas suivi de régime au terme de l'hospitalisation)
- pas de modification évidente des facteurs de risque
- amélioration des capacités physiologiques

3.1.2 Analyse_différence de comportement entre les sexes

3.1.2.1 Différences inter-sexe pour paramètres de départ

Le sexe pourrait être un facteur de confusion. Les différences inter-sexe pour les principaux paramètres de départ ont été étudiées : poids, taille, BMI, Masse grasse, Masse maigre, Framingham, CHD score (% risque), $\dot{V}O_2$max, Force (LP, CP, VT).

Paramètres esthétiques

Données anthropométriques

Tableau 21 - Données anthropométriques moyennes (±DS) observées dans le groupe d'étude divisées par sexe.

	hommes N=18	femmes N=53	p
Taille (cm)	176,8 ± 6,3	162,2 ± 7,1	<0,0001
Poids (kg)	130,3 ± 17,0	107,9 ± 15,3	<0,0001
BMI (kg/m^2)	41,6 ± 3,9	40,9 ± 4,5	ns
FM (kg)	50,4 ± 7,8	56,4 ± 12,1	ns
FFM (kg)	78,6 ± 7,8	51,9 ± 5,1	<0,0001

significativité évaluée à l'aide d'un test pour données appariées

Conclusions

- BMI et Masse grasse n'étant pas différents les hommes et les femmes ont été regroupés pour avoir un échantillon plus grand et donc une puissance de test plus importante

Paramètres de santé

Facteurs de risque

Tableau 22 : Données moyennes (±DS) des facteurs de risque observées dans le groupe d'étude divisées par sexe.

	hommes	femmes	p
Framingham	2,2 ± 2,3	-5,2 ± 5,1	<0,0001
CHD score (% risque)	4,8 ± 2,1	1,4 ± 1,0	<0,0001

Capacités physiologiques

Paramètres cardiovasculaires et Force

Tableau 23 - Capacité aérobie maximale ($\dot{V}O_2max$) et Force (LP, CP, VT) moyennes (±DS) observées dans le groupe d'étude divisées par sexe.

	hommes	femmes	p
$\dot{V}O_2max$ (l/min)	3,1 ± 0,9	2,4 ± 0,4	<0,05
Leg Press (kg)	341,7 ± 85,8	225,5 ± 46,1	<0,0001
Chest Press (kg)	50,9 ± 15,8	26,9 ± 8,5	<0,0001
Vertical Traction (kg)	94,9 ± 16,5	65,4 ± 11,7	<0,0001

3.1.2.2 Différences de comportement entre les sexes pour Δ_1

L'efficacité du programme en fonction du sexe a été donc vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, Framingham, CHD score (% risuqe), $\dot{V}O_2max$, Force (LP, CP, VT).

Paramètres esthétiques_court terme

Le tableau 24 montre les valeurs observées stratifiés par sexe, avant et après le programme intégré. On a relevé une différence significative entre les deux sexes pour la perte de poids, de FM et de FFM.

Tableau 24 - Valeurs moyennes (± DS) des paramètres anthropométriques avant et après le programme de trois semaines.

	hommes		femmes		p
	avant	après	avant	après	entre Δ_1
Poids (kg)	130,3 ± 17	123,6 ± 15,4	107,9 ± 15,3	103 ± 14,6	<0,001
BMI (kg/m^2)	41,6 ± 3,9	39,5 ± 3,5	40,9 ± 4,5	39,1 ± 4,3	ns
FM (kg)	50,4 ± 7,8	47,1 ± 7,1	56,4 ± 12,1	52 ± 12,2	<0,0001
FFM (kg)	78,6 ± 7,8	75,2 ± 7,5	51,9 ± 5,1	51,7 ± 4,5	<0,0001

Les deux sexes ont montré une tendance similaire en termes de variation de BMI, les hommes présentant toutefois une perte de poids et de FFM significativement plus élevées que les femmes.

Paramètres de santé_court terme

Facteurs de risque

Tableau 25 - Valeurs moyennes (± DS) des paramètres de santé avant et après le programme de trois semaines.

	hommes		femmes		p
	avant	après	avant	après	entre Δ_1
Framingham	2,22 ± 2,26	1,11 ± 1,37	-5,17 ± 4,49	-5,79 ± 4,96	ns
CHD score (% risque)	4,83 ± 2,12	3,56 ± 1,2	1,36 ± 1,0	1,38 ± 0,88	<0,01

Les hommes ont une réduction significativement plus élevée du CHD score que les femmes.

Capacités physiologiques_court terme

Tableau 26 - Valeurs moyennes (± DS) des paramètres cardiovasculaire et force avant et après le programme de trois semaines.

	hommes		femmes		p
	avant	après	avant	après	entre Δ_1
$\dot{V}O_2max$ (l/min)	3,1 ± 0,9	3,8 ± 1,1	2,4 ± 0,4	2,6 ± 0,5	<0,05
Leg Press (kg)	341,7 ± 85,8	449,8 ± 82,7	225,5 ± 46,1	309 ± 74,5	ns
Chest Press (kg)	50,9 ± 15,8	65,7 ± 16,5	26,9 ± 8,5	34,3 ± 10,4	<0,05
Vertical Traction (kg)	94,9 ± 16,5	116 ± 14,1	65,4 ± 11,7	77,3 ± 13,2	<0,01

Les hommes ont une amélioration significativement plus élevée de la $\dot{V}O_2max$ (l/min) et de la force pour CP et VT.

3.1.2.3 Différences de comportement entre les sexes pour Δ_3

Les modifications à un 1 an de la fin du programme de RMC sont similaire pour les deux groupes sauf pour la FM, les femmes obtenant une perte plus importante que les hommes (femmes N=30, hommes N=14).

Paramètres esthétiques_long terme

Tableau 27 - Valeurs moyennes (± DS) des paramètres anthropométriques avant et après le programme de trois semaines.

	hommes		femmes		p
	avant	1 an	avant	1 an	entre Δ_3
Poids (kg)	131,4 ± 18	126,7 ± 14	104,7 ± 13,7	99,1 ± 17,9	ns
BMI (kg/m^2)	42,1 ± 3,6	40,6 ± 2,9	40,2 ± 3,2	38 ± 5,4	ns
FM (kg)	51 ± 7,9	49,7 ± 6,9	53,5 ± 10,4	47,8 ± 14,2	<0,05
FFM (kg)	78,6 ± 8,6	77,7 ± 7,8	51,5 ± 4,9	51,2 ± 5,1	ns

Paramètres de santé_long terme

Facteurs de risque

Tableau 28 - Valeurs moyennes (± DS) des paramètres de santé avant et après le programme de trois semaines.

	hommes		femmes		p
	avant	1 an	avant	1 an	entre Δ_3
Framingham	2,4 ± 2,5	1,6 ± 2,4	-5 ± 3,9	-6,3 ± 5,4	ns
CHD score (% risque)	5,1 ± 2,2	4,6 ± 2,1	1,2 ± 0,6	1,3 ± 0,7	ns

Capacités physiologiques_long terme

Tableau 29 - Valeurs moyennes (± DS) des paramètres cardiovasculaire et force avant et après le programme de trois semaines.

	hommes		femmes		p
	avant	1 an	avant	1 an	entre Δ_3
$\dot{V}O_2max$ (l/min)	3,1 ± 1,1	3,6 ± 1,2	2,3 ± 0,3	2,4 ± 0,7	ns
Leg Press (kg)	327,3 ± 77,6	354,3 ± 86,7	212,8 ± 46,3	265 ± 69,5	ns
Chest Press (kg)	47,6 ± 13,0	56,1 ± 14,9	24,9 ± 9,0	34,7 ± 10,2	ns
Vertical Traction (kg)	94 ± 17,7	101,4 ± 19,2	62,1 ± 12,2	75,1 ± 13,2	ns

CONCLUSIONS AU TERME DE L'ETUDE DIFFERENCE DE COMPORTEMENT ENTRE LES SEXES

- Les deux sexes répondent pratiquement de manière identique (surtout à terme)
- Cependant la perte de FM semble importante chez les femmes alors qu'il existe une augmentation de FM à terme chez les hommes

3.1.3 Analyse_discrimination en fonction du niveau d'activité physique

L'étude univariée du niveau d'activité physique maintenu après la fin du programme de RMC(Δ_3 PAR) en fonction du sexe fait apparaître la formation de deux groupes : les sujets actifs Δ_3 PAR > 0 et les sujets inactifs Δ_3 PAR ≤ 0, le niveau initial du PAR pré programme de RMC étant identique pour les deux sexes. En prenant Δ_3 PAR comme critère, les paramètres discriminants entre les deux groupes d'activités sont :

pour les actifs	Δ_3 Poids	$p<0{,}05$
	Δ_3 BMI	$p<0{,}05$
	Δ_3 FM	$p<0{,}05$
pour les non actifs	Δ_3 Framingham	$p<0{,}05$.

<u>Conclusions</u>

- l'activité physique (en plus de la restriction calorique) a un effet positif (en particulier pour la perte de poids et de FM)

3.1.4 Etudes des corrélations

L'étude des corrélations à court terme a permis l'identification des sujets responders par rapport aux sujets non responders. On a observé les suivantes corrélations négatives significatives :

- entre BW et Δ_1 BW (r= -0,65, p<0,0001),
- entre BMI et Δ_1 BW (r=-0,446, p<0,0001),
- entre BMI and Δ_1 BMI (r=-0,482, p<0,0001).

L'études des corrélations sur les PAR a permis de vérifier le rôle du programme de RMC et de l'activité physique à long terme. On a observé les suivantes corrélations négatives significatives :

- entre PAR et Δ_3 PAR (r=-0,394, p<0,01),
- entre Δ_3 PAR and Δ_3 BW (r=-0,440, p<0,01).

<u>Conclusions</u>

- perte de poids à court terme :

  responders » sujets au départ avec BMI plus important

  non responders » sujets au départ avec BMI plus faible
- analyse du PAR à long terme :

» les sujets inactifs ont augmenté leur niveau d'activité physique

» plus le sujet est actif et plus il perd de poids

Tous les autres résultats significatifs de l'étude des corrélations sont présentés en ANNEXE II.

CONCLUSIONS AU TERME DE L'ETUDE DEPAST

- POIDS » maintien du poids après 1 an
- PAR » importance d'une activité physique pour maintenir le poids

QUEL TYPE D'ACTIVITE PHYSIQUE ?

3.2 DEUXIEME ETUDE_EPNS vs EPP

3.2.1 Résultats à court terme : différence entre les méthodologies

AU DEPART, PARAMETRES QUI DIFFERENT POUR LES DEUX GROUPES D'ENTRAINEMENT

La comparaison des paramètres des premiers tests (situation pré programme de réduction de la masse corporelle) entre les différents groupes d'entraînement a permis de détecter les facteurs de confusion suivants : aucun des paramètres évalués ne présentait de différence significative d'un groupe expérimental à l'autre, sauf la force CP (EPNS : 42,2 ± 24 kg ; EPP : 29,3 ± 16,2 kg). Ce paramètre ne sera pas considéré comme important et sera négligé en tant que facteur de confusion, confirmant la comparabilité des populations sélectionnées. Autres facteurs de confusion pourraient être le sexe et le PAR.

DIFFERENCES DE VARIATION (Δ_1) ENTRE LES DEUX GROUPES EN FONCTION DU NIVEAU D'ACTIVITE INITIAL

Aucun paramètre anthropométrique et de facteur de risque n'a montré de différence entre les Δ_1 entre les deux groupes au terme de 3 semaines d'hospitalisation. Pour les paramètres physiologiques on n'observe une différence entre les Δ_1 entre les deux groupes que pour la force.

3.2.1.1 Aspect descriptif

Réduction de poids - Pendant la durée du programme, les deux groupes ont perdu une quantité de poids corporel (EPNS : - 4,27 ± 1,14% ; EPP : - 4,17 ± 1,17%) ayant un degré de significativité comparable.

Composition corporelle – Pendant la durée du programme, les deux groupes ont perdu une quantité de masse grasse (EPNS : - 2,8±1,4kg; EPP : - 3,5±3,5kg) ayant un degré de significativité comparable. Seul le groupe EPP a réussi à maintenir le niveau de départ de masse maigre, ne perdant donc pas la quantité de muscles initiale à cause du régime diététique. Le tableau 30 montre les valeurs de masse grasse et de masse maigre observées, avant et après le programme intégré, dans les deux groupes.

Tableau 30 - Composition corporelle moyenne (±DS) observée chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines.

	avant	après	significativité
FM (kg)			
EPNS (N = 15)	52,17 ± 10,35	48,65 ± 9,41*	$p < 0{,}001$
EPP (N = 15)	50,09 ± 6,91	47,29 ± 6,49*	$p < 0{,}001$
FFM (kg)			
EPNS (N = 15)	60,77 ± 13,23	59,17 ± 12,36*	$p < 0{,}05$
EPP (N = 15)	59,85 ± 13,98	58,43 ± 12,45	p = ns

p = valeur significativement différente de la valeur correspondante mesurée avant le programme

Framingham - Le tableau 31 considère les facteurs de risque liés aux maladies cardiovasculaires avant et après le programme de RMC, analysées séparément pour les sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP). Les modifications après le programme de trois semaines sont significatives pour les deux groupes pour les paramètres suivants: SBP et DBP (EPNS, $p<0,01$; EPP, $p<0,05$), cholestérol total et HDL (EPNS, $p<0,001$; EPP, $p<0,01$). La réduction du glucose sanguin n'est significative que pour les sujets appartenant au groupe EPP ($p<0,05$), tandis que la réduction du CHD score n'est significative pour aucun groupe. Aucune différence significative n'est apparue entre les deux groupes.

Tableau 31 : Données moyennes du score CHD (±DS) observées chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines.

	EPNS (N=15)		EPP (N=15)	
	avant	après	avant	après
Cholestérol total (mg/dl)	187,7 ± 36,8	155,1 ± 26,5	187,8 ± 34,0	166,5 ± 24,7
Cholestérol HDL (mg/dl)	46,7 ± 10,5	37,1 ± 5,4	44,2 ± 9,2	36,1 ± 8,8
SBP (mmHg)	124,0 ± 9,9	115,3 ± 10,6	120,7 ± 5,9	116,0 ± 7,1
DBP (mmHg)	77,0 ± 8,8	73,7 ± 7,4	77,0 ± 5,6	73,3 ± 5,9
Glucose sanguin (mg/dl)	77,7 ± 8,9	78,3 ± 25,9	83,7 ± 10,7	76,8 ± 9,2
Framingham	-0,6 ± 7,6	-0,53 ± 6,8	-1,6 ± 5,8	-1,5 ± 5,9
CHD score (% risque)	4,20 ± 4,5	3,47 ± 3,0	2,80 ± 2,1	2,53 ± 1,3

<u>Paramètres cardiovasculaires</u> - La figure 8 montre la valeur moyenne de $\dot{V}O_2max$ déterminée chez les sujets des groupes expérimentaux avant et après le programme de réduction de la masse corporelle.

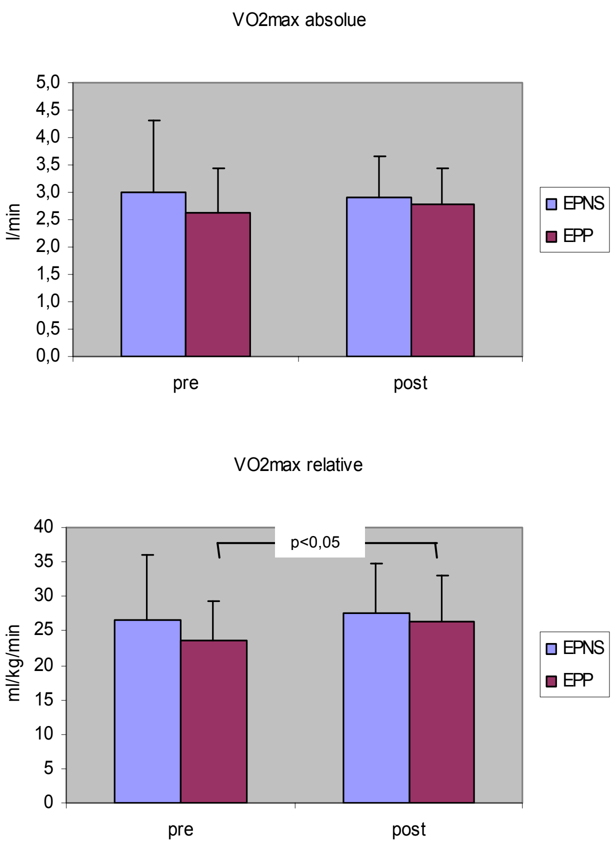


Figure 8 - Capacité aérobie maximale moyenne ($\dot{V}O_2max$) exprimée en termes absolus (panneau A) et en relation avec la masse corporelle (panneau B), déterminée chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines (les valeurs de p sont mentionnées dans la figure).

Aucune différence significative n'a été détectée entre les groupes en terme de valeur absolue ou spécifique (c'est-à-dire par kg de masse corporelle) de $\dot{V}O_2max$. Seuls les sujets EPP ont montré une augmentation significative de la $\dot{V}O_2max$ spécifique. De même, par effet du programme, la valeur moyenne du RPE sur une échelle de Borg à 10 points pendant l'exécution du test a significativement diminué dans les deux groupes (EPP, avant : 2,96 ± 1,30, après : 1,02 ± 0,89, p < 0,001; EPNS, avant : 2,53 ± 1,13 ; après : 2,11 ± 1,31 ; p < 0,001), mais les sujets du groupe EPP ont reporté une réduction significativement plus importante que les sujets de l'autre groupe (EPP: -1,96 ± 1,23 ; EPNS : -0,42 ± 0,80 ; p < 0,001).

<u>Force</u> - Les valeurs moyennes de force isotonique maximale, observées chez les sujets EPP et EPNS avant le début du programme pour les trois groupes de muscles différents testés chacun au moyen d'une machine spécifique, sont reportées dans le tableau 32, tandis que la figure 9 synthétise, exprimées en pourcentage, les variations de force provoquées par le programme.

Tableau 32 - Valeurs moyennes (± DS) de force maximale (1-RM, kg) de trois groupes de muscles différents, testés au moyen des machines isotoniques, observées chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant le programme.

1-RM	EPNS (N = 15)	EPP (N = 15)
Leg Press (kg)	271 ± 87	248 ± 79
Chest Press (kg)	43 ± 23	39 ± 18
Vertical Traction (kg)	85 ± 26	79 ± 16

Aucune différence statistiquement significative n'a été relevée entre les groupes.

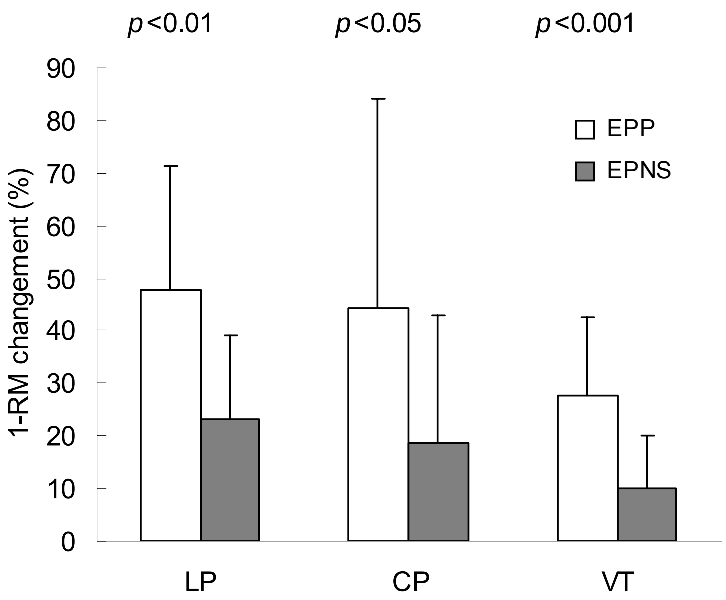


Figure 9 - Variations moyennes de la force isotonique maximale (1-RM) mesurée sur trois machines différentes (leg press, LP; chest press, CP; vertical traction, VT), observées après le programme de 3 semaines chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) (les valeurs de p sont mentionnées dans la figure).

Les deux groupes ont montré, après le programme, une augmentation significative de la force 1-RM des trois groupes musculaires testées (EPNS : LP, $p < 0{,}001$; CP, $p < 0{,}01$; VT, $p < 0{,}01$; EPP : LP, $p < 0{,}001$; CP, $p < 0{,}01$; VT, $p < 0{,}001$). Toutefois, les sujets EPP ont montré une amélioration de la force significativement plus importante que les sujets du groupe EPNS.

Puissance - La figure 10 illustre les résultats de départ comparés aux résultats après 3 semaines de RMC obtenus dans le cadre du test de saut.

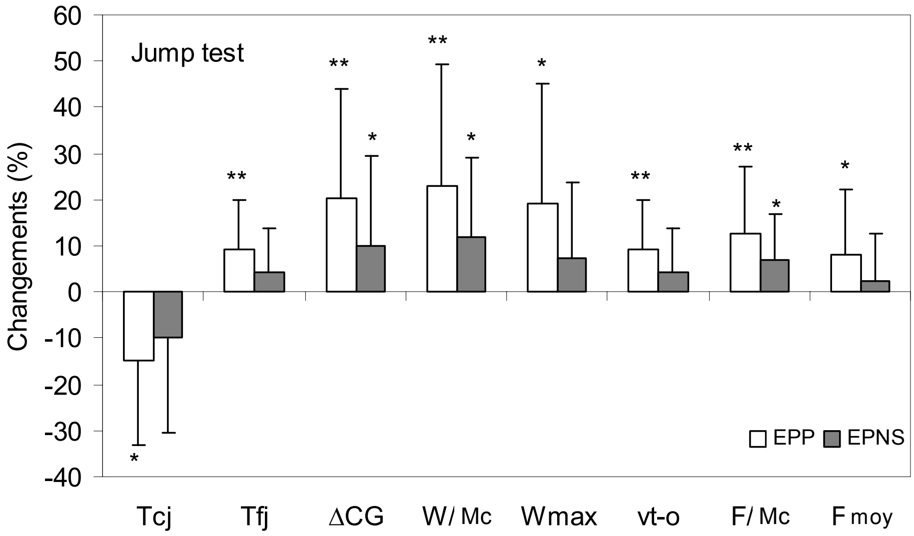


Figure 10 - Variations moyennes des paramètres, déterminées à l'aide du test de saut observée après le programme de 3 semaines chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP). Les astérisques signalent la significativité statistique de la différence entre les résultats obtenus avant et après le programme au sein de chaque groupe (** = $p < 0{,}01$; * = $p < 0{,}05$).

Alors que les sujets du groupe EPP ont montré une amélioration statistiquement significative dans tous les paramètres étudiés, ceux du groupe EPNS n'ont manifesté d'amélioration qu'au niveau des paramètres touchant l'effet de la perte de poids (comme W/Mb et F/Mb) et dans le déplacement du centre de gravité.

3.2.1.2 Efficacite de chaque programme

L'efficacité de chaque programme a été vérifiée pour les paramètres principaux : poids, BMI, Masse grasse (FM), FFM, CHD score, $\dot{V}O_2max$, force (LP, CP, VT). Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative).

Les deux programmes se traduisent par :

paramètres anthropométriques

- une chute du poids

- une baisse du BMI
- une perte de FM
- une modification de FFM (une perte plus qu'un gain)

facteurs de risque

- pas de différence significative pour les deux programmes ni pour Framingham ni pour % risque

paramètres physiologiques

- pas de différence significative pour les deux programmes pour $\dot{V}O_2max$
- efficacité des deux programmes avec une augmentation de force pour LP, CP, VT mais le programme EPP apparaît plus efficace

3.2.1.3 PROGRAMME LE PLUS EFFICACE

Les deux programmes ont un comportement homogène pour :

- les paramètres anthropométriques
- les facteurs de risque

Pour les paramètres physiologiques aucune différence significative n'apparaît pour $\dot{V}O_2max$, par contre une différence significative entre les deux programme subsiste pour la force, le programme EPP entraînant une augmentation de LP, CP, VT de l'ordre du double de celle du programme EPNS.

Tableau 33 - Δ_1 de force maximale (± DS) obtenue sur trois machines isotoniques différentes.

	EPNS	EPP	p
Δ_1 Leg Press	55 ± 44,9	107,8 ± 66	<0,01
Δ_1 Chest Press	5,11 ± 7	12,4 ± 11,6	<0,05
Δ_1 Vertical Traction	7,4 ± 7,9	19,3 ± 10,8	<0,01

3.2.1.4 ANALYSE DESCRIPTIVE DES VARIATIONS DE Δ_1 EN FONCTION DU SEXE ET DANS CHAQUE PROGRAMME

L'efficacité du programme en fonction du sexe a été vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, CHD score, $\dot{V}O_2max$, force (LP, CP, VT).

Les tableaux 34 et 35 montre les valeurs observées, avant et après le programme intégré, dans les deux groupes stratifiés par sexe. On n'a relevé une différence significative entre les groupes et entre les deux sexes que pour le gain en force des différents groupes musculaires.

Tableau 34 - Valeurs moyennes (± DS) des paramètres anthropométriques et liés à la santé observées chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines.

	EPNS (N = 15)		EPP (N = 15)	
	hommes (n = 6)	femmes (n = 9)	hommes (n = 6)	femmes (n = 9)
	POIDS (kg)			
avant	124,3 ± 10,4	102,4 ± 7,0	121 ± 11,7	105,1 ± 13,1
après	117,8 ±9,6	98,6 ± 6,4	115,9 ± 10,7	100,8 ± 13,0
	BMI (kg/m^2)			
avant	40,5 ± 4,3	39,6 ± 5,2	39,7 ± 3,1	40,9 ± 3,5
après	38,4 ± 3,8	38,1 ± 4,9	38 ± 2,6	39,3 ± 3,6
	FM (kg)			
avant	47,8 ± 6,8	51,6 ± 7,0	46,9 ± 5,8	55,7 ± 11,5
après	45,4 ± 5,8	48,6 ± 6,9	44,2 ± 5,3	51,6 ± 10,6
	FFM (kg)			
avant	75,3 ± 6,3	51,1 ± 4,3	75,4 ± 6,5	49,5 ± 3,9
après	72,8 ± 4,5	50,1 ± 4,7	72 ± 6,3	49,4 ± 4,3
	CHD SCORE (% risque)			
avant	4,7 ± 2,8	3,9 ± 5,5	4 ± 2,2	2 ± 1,7
après	3,8 ± 2,5	3,2 ± 3,4	3,3 ± 0,8	2 ± 1,3

Tableau 35 - Valeurs moyennes (± DS) des paramètres physiologiques observées chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines.

	EPNS (N = 15)		EPP (N = 15)	
	hommes (n = 6)	femmes (n = 9)	hommes (n = 6)	femmes (n = 9)
	$\dot{V}O_2$max (l/min)			
avant	3,9 ± 1,5	2,4 ± 0,8	3,3 ± 1,0	2,2 ± 0,3
après	3,4 ±0,4	2,6 ± 0,8	3,4 ± 0,6	2,4 ± 0,3
	LP (kg)			
avant	356,8 ± 68,9	201,3 ± 49,5	288,6 ± 84,5	199,9 ± 37,0
après	416,8 ± 92,3	253 ± 55,9	439,8 ± 91,1	278,8 ± 72,1
	CP (kg)			
avant	67,1 ± 17,3	25,5 ± 6,4	42,3 ± 19,3	20,7 ± 4,4
après	70,7 ± 12,8	31,7 ± 8,6	62,8 ± 22,8	27,8 ± 6,2
	VT (kg)			
avant	114 ± 16,3	62,2 ± 11,8	82,9 ± 15,9	61,1 ± 7,6
après	121 ± 10,8	69,8 ± 14,6	112,7 ± 15,3	73,5 ± 8,8

Ceci indique que les deux programmes ont eu un effet similaire en terme de réduction de poids, de variation de la composition corporelle et du métabolisme aérobic indépendamment du sexe des sujets. En revanche, une différence significative a été relevée entre les hommes des deux groupes quant à l'amélioration de 1-RM ($p<0,05$), les hommes du groupe EPP ayant amélioré plus.

3.2.1.5 DIFFERENCE DE COMPORTEMENT DE CHAQUE SEXE EN FONCTION DU PROGRAMME ET DANS CHAQUE GROUPE

Le Test des signes univariés a permis de déterminer que :

les hommes et les femmes se comportent identiquement en fonction du programme pour

• paramètres anthropométriques	Δ_1 poids Δ_1 BMI
• facteurs de risque	Δ_1 Framingham Δ_1 risque %
• paramètres physiologiques	Δ_1 $\dot{V}O_2max$

les hommes et les femmes ne se comportent pas de façon identique en fonction du programme pour

• paramètres anthropométriques	Δ_1 FFM Δ_1 FM
• paramètres anthropométriques	Δ_1 LP Δ_1 CP Δ_1 VT

Conclusions

- pas de différence entre les programmes d'entraînement sur la perte de poids
- pas de différence entre les programmes d' entraînement sur le % de risque CHD
- pas de différence entre les programmes d' entraînement sur la physical fitness cardiovasculaire
- nécessité d'un entraînement en force pour améliorer la force (différence entre les sexes) et l' entraînement en force semble préserver la perte de FFM
- 30 min d'activité CV est efficace quel que soit le type d'ex

3.2.2 Résultats à long terme : suivi

3.2.2.1 Suivi à 6 mois_aspect desciptif

BMI & PAR : La figure 11 montre l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital, et les changements en termes de poids corporel par rapport aux valeurs post-programme.

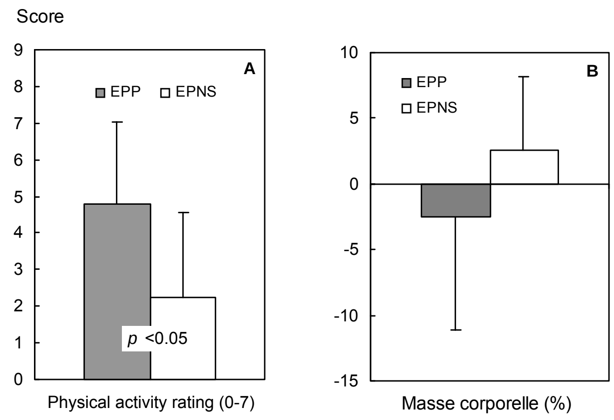


Figure 11 - Auto-évaluation moyenne du niveau maintenu d'activité physique, librement choisie, pendant 6 mois après la fin du programme (panneau A) et variation de la masse corporelle pendant la même période (panneau B), établie par le biais d'entretiens téléphoniques chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP).

L'auto-évaluation du niveau d'activité physique maintenu après la fin du programme s'est révélée significativement plus élevée chez les sujets du groupe EPP. En termes de poids, bien qu'aucune différence statistiquement significative n'ait été relevée entre les deux groupes, les sujets EPP ont montré une nette tendance à perdre encore du poids, alors que les sujets EPNS semblaient avoir tendance à reprendre une partie de la masse corporelle perdue pendant le programme.

3.2.2.2 Suivi à 1 an_aspect descriptif

<u>Variation de poids</u> – Un an après, les deux groupes ont repris une quantité de poids corporel (EPNS : 3,0 ± 9,9% ; EPP : 0,1 ± 9,6%) comparable. Les sujets des deux groupes ont quand même réussi à maintenir un poids corporel inférieur aux valeurs qu'ils avaient avant le début du programme intégré. La figure 12 montre les changements en terme de BMI par rapport aux valeurs pré et post programme.

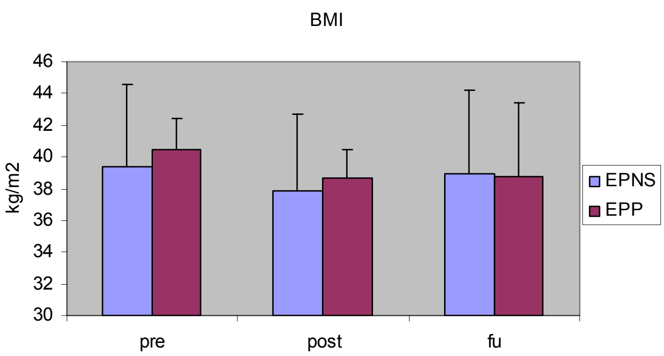


Figure 12 - Variation de la masse corporelle un an après la fin du programme évaluée pendant le day-hospital des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP).

Composition corporelle – Pendant l'année où les sujets étaient libre de suivre le régime alimentaire et le programme d'activité physique, les deux groupes ont maintenu une quantité de masse grasse (EPNS : 3,7±8,9 kg; EPP : - 1,6±7,9 kg) comparable, même si le groupe EPP a continué à en perdre contrairement au groupe EPNS qui a augmenté légèrement sa masse grasse. Au contraire seul le groupe EPP a réussi à augmenter la masse maigre. La figure 13 montre les changements en termes de masse grasse et de masse maigre par rapport aux valeurs pré et post programme.

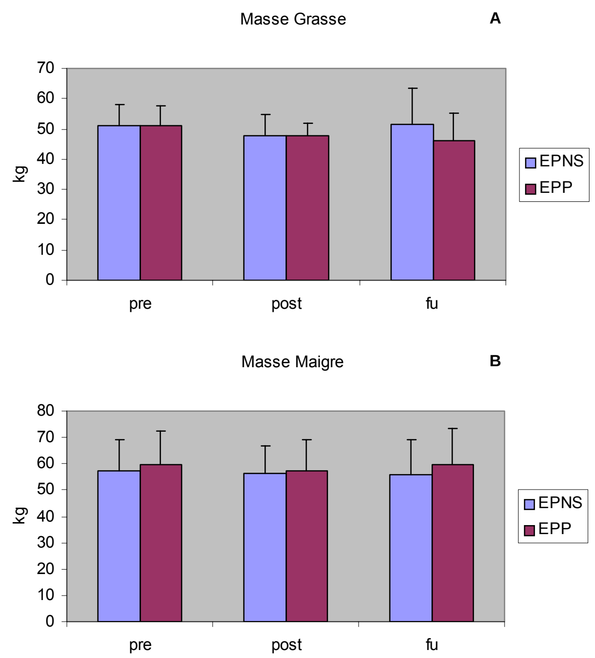


Figure 13 – Masse grasse (panneau A) et masse maigre (panneau B) exprimée en kg, déterminées chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines et un an après. Les valeurs de *p* ne sont significative que pour les valeurs de masse maigre du groupe EPP ($p<0,05$).

PAR – La figure 14 montre l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital et maintenue après 6 mois et un an après la fin du programme intégré.

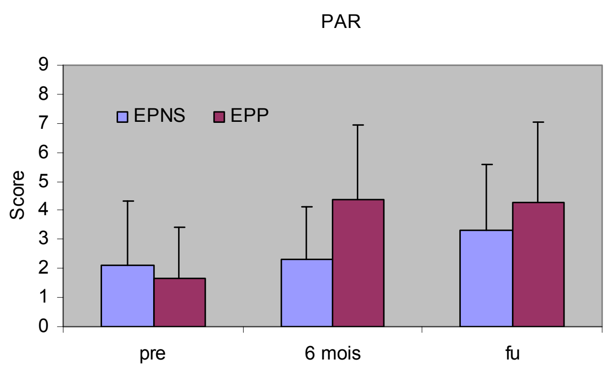


Figure 14 - Auto-évaluation moyenne du niveau maintenu d'activité physique, librement choisie, pendant 1 an après la fin du programme chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP).

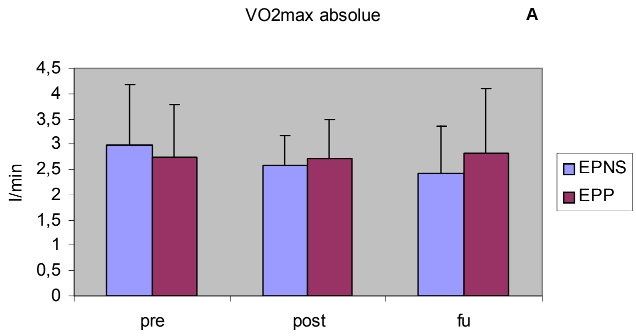
L'auto-évaluation du niveau maintenu d'activité physique après la fin du programme pendant l'année dans les deux groupes s'est révélée plus élevée chez les sujets du groupe EPP.

Framingham - Le tableau 36 considère les facteurs de risque liés aux maladies cardiovasculaires avant et après le programme de RMC et à 1 an après la fin du programme, les deux groupes analysés séparément, sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP). Les modifications un an après la fin du programme de trois semaines sont significatives pour les deux groupes pour les paramètres suivants: SBP (EPNS, $p<0,05$; EPP, $p<0,001$), cholestérol total et HDL (EPNS, $p<0,01$; EPP, $p<0,001$), glucose sanguin (EPNS et EPP, $p<0,01$). Les valeurs de DBP et du score CHD ne sont significatives pour aucun groupe. Seules les modifications du paramètre SBP pour le groupe EPP observées avant et 1 an après la fin du programme de RMC sont significatives ($p<0,01$). Aucune différence significative n'est apparue entre les deux groupes.

Tableau 36 : Variation moyenne du score CHD observée chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant et après le programme de trois semaines et 1 an après la fin du programme de RMC.

	EPNS (N=15)		EPP (N=15)	
	Pré-Post	Post-FU	Pré-Post	Post-FU
Cholestérol total (mg/dl)	-19,6%	+26,7%	-12,4%	+18,3%
Cholestérol HDL (mg/dl)	-20,9%	+38,8%	-25,6%	+39,5%
SBP (mmHg)	-6,3%	+13,3%	-6,2%	+17,0%
DBP (mmHg)	-1,9%	+7,5%	-3,3%	+9,5%
Glucose sanguin (mg/dl)	-9,0%	+24,2%	-8,8%	+22,9%
CHD score (% risque)	-0,67	-1,00	-0,30	+0,88

Paramètres cardiovasculaires - La figure 15 montre la valeur moyenne de $\dot{V}O_2max$ déterminée chez les sujets des groupes expérimentaux avant et après le programme de réduction de la masse corporelle et 1 an après la fin du programme de RMC.



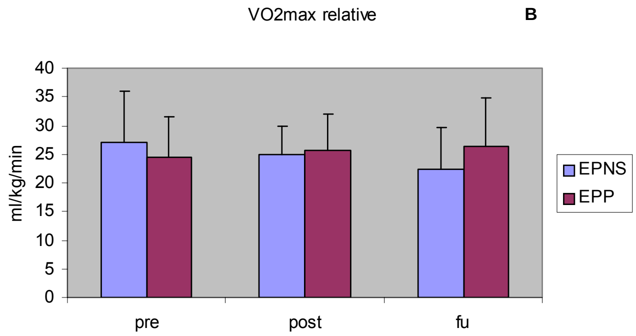


Figure 15 - Capacité aérobie maximale moyenne ($\dot{V}O_2$max) exprimée en termes absolus (panneau A) et en relation avec la masse corporelle (panneau B), déterminée chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) avant, après le programme de trois semaines et 1 an après la fin du programme.

Aucune différence significative n'a été détectée entre les groupes en termes de valeur absolue ou spécifique (c'est-à-dire par kg de masse corporelle) de $\dot{V}O_2$max, même si seuls les sujets EPP ont montré une augmentation de la $\dot{V}O_2$max absolue et relative 1 an après la fin du programme. La réduction de $\dot{V}O_2$max pour le groupe EPNS s'est avérée significative ($p<0,05$).

<u>Force</u> - Les valeurs moyennes de force isotonique maximale, observées chez les sujets EPP et EPNS 1 an après la fin du programme pour les trois groupes de muscles différents testés chacun au moyen d'une machine spécifique, sont reportées dans le tableau 37.

Tableau 37 - Valeurs moyennes (± DS) de force maximale (1-RM, kg) de trois groupes de muscles différents, testés au moyen des machines isotoniques, observées chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP) 1 an après la fin du programme.

1RM	EPNS (N = 15)	EPP (N = 15)
Leg Press (kg)	295,6 ± 97,4	284,2 ± 70,3
Chest Press (kg)	45,3 ± 18,0	39,4 ± 14,6
Vertical Traction (kg)	90,1 ± 28,0	83,6 ± 18,0

Les deux groupes ont montré, 1 an après la fin du programme, une perte de la force 1-RM des groupes musculaires des membres inférieurs. La diminution de force n'est significative que pour le groupe EPP, celui qui s'était amélioré le plus après le programme d'entraînement personnalisé de trois semaines (p < 0,05). Les deux groupes ont montré, au contraire, une tendance différente pour les autres groupes musculaires analysés : le groupe EPNS a augmenté la force de façon non significative, tandis que le groupe EPP a diminué son niveau de force (VT, p < 0,05 ; CP, p < ns). Toutefois, tous les sujets ont réussi a maintenir un niveau de force significativement supérieur par rapport au tout début d'entraînement (EPNS : LP, ns; CP et VT, p < 0,05; EPP : LP, CP et VT, p < 0,001). La figure 16 synthétise les variations de force provoquées par le programme et par l'arrêt du programme.

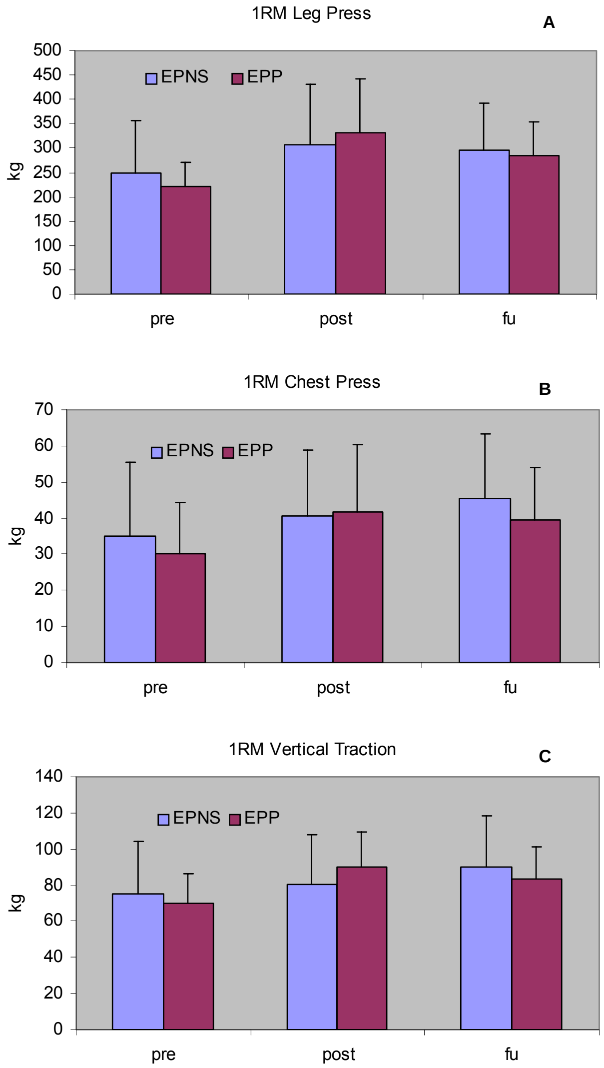
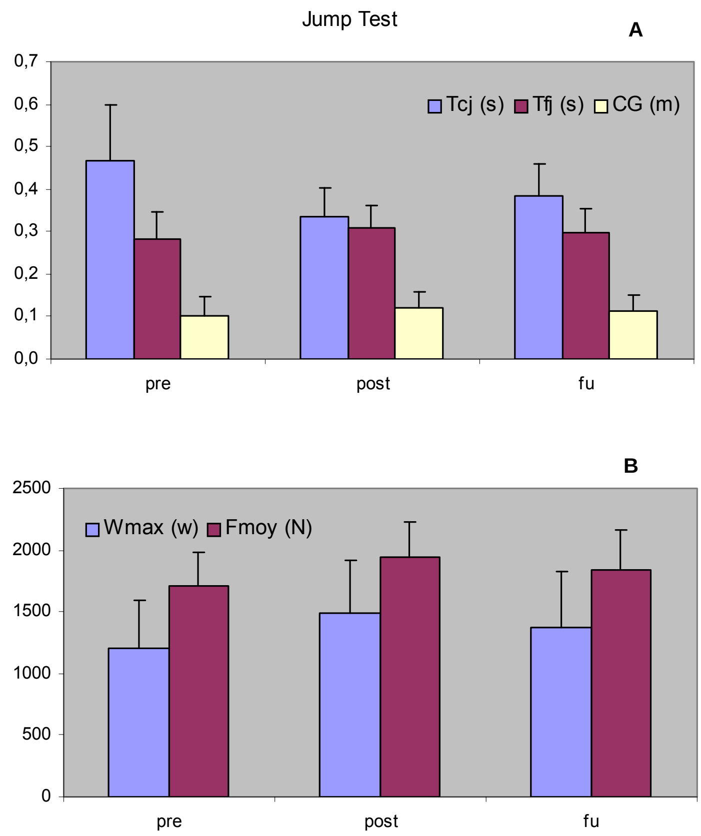


Figure 16 - Variations moyennes de la force isotonique maximale (1-RM) mesurée sur trois machines différentes (leg press, LP; chest press, CP; vertical traction, VT), observée après le programme de 3 semaines et 1 an après la fin du programme chez des sujets soumis à un entraînement non-spécifique (EPNS) et à un entraînement personnalisé (EPP).

Puissance – trend avec N3 EPNS e N7 EPP

Figure EPNS+EPP; aucune différence significative pour les deux groupes analysés ensemble.



3.2.2.3 ANALYSE DESCRIPTIVE DES SUJETS COMPARES A EUX MEMES

Le Test de Wilcoxon pour la comparaison des Δ_1 (3 semaines) et Δ_3 (1 an) n'a montré de différences significatives que pour LP, ce qui signifie que les sujets ont maintenu leur acquis de Δ_1 au terme des 3 semaines d'hospitalisation à la fin de l'année étudiée sauf pour LP qui a diminué (Δ_1 LP = 85,5 ± 69,8 ; Δ_3 LP = 55,4 ± 55,8). Donc pas de modification importante en Δ_3 par rapport à Δ_1.

3.2.2.4 ANALYSE DESCRIPTIVE EN FONCTION DU SEXE

L'efficacité des programmes en fonction du sexe a été vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, CHD score, $\dot{V}O_2$max, force (LP, CP, VT).

Le tableau 38 montre les valeurs observées, avant et 1 an après la fin du programme intégré, stratifiés par sexe.

Tableau 38 - Valeurs moyennes (± DS) des paramètres anthropométriques, physiologiques et liés à la santé observées chez les hommes et chez les femmes les deux programmes mélangés avant et 1 an après la fin du programme de RMC.

	hommes (n = 5)	femmes (n = 15)	hommes (n = 5)	femmes (n = 15)
	Poids (kg)		$\dot{V}O_2$max (l/min)	
avant	121,9 ± 12,7	105,1 ± 9,4	3,7 ± 1,3	2,6 ± 0,9
1 an	127,2 ± 18,1	99,5 ± 10,2	3,5 ± 1,7	2,4 ± 0,8
	BMI (kg/m^2)		LP (kg)	
avant	40,1 ± 3,1	40 ± 4,0	284,8 ± 57,7	217 ± 78,9
1 an	41,6 ± 3,6	37,9 ± 4,9	358,2 ± 67,6	266,4 ± 73,7
	FM (kg)		CP (kg)	
avant	47,8 ± 6,0	52 ± 6,8	43,3 ± 21,3	28,5 ± 14,2
1 an	50,6 ± 8,9	47,8 ± 11,2	53 ± 20,2	38,5 ± 13,3
	FFM (kg)		VT (kg)	
avant	75 ± 7,1	53,1 ± 7,5	85,7 ± 23,2	67,7 ± 21,3
1 an	76,5 ± 9,4	51,6 ±6,8	102,2 ± 17,4	81,3 ± 22,1
	CHD score (% risque)			
avant	3,8 ± 2,8	3,5 ± 4,6		
1 an	4,6 ± 2,2	2,7 ± 1,4		

Le Test de Wilcoxon nous montre que :

Paramètres anthropométriques

- les hommes ont tendance à gagner du poids (p=0,8)
- les hommes ont tendance à augmenter leur BMI (p=0,8)
- les hommes ont tendance à augmenter leur FM (p=0,8)
- les hommes regagnent en FFM ($p<0,05$) après une perte initiale

Facteurs de risque

- pas de différence significative pour les deux sexes

Paramètres physiologiques

- pas de différence significative pour les deux sexes pour $\dot{V}O_2$max
- pour la force les hommes ont tendance à perdre la force pour LP (p=0,07)

L'analyse de ses résultas nous montre que les femmes ont maintenu les bénéfices obtenus après le programme de RMC mais ces résultats pourraient être biaisés en raison de la disparité de l'échantillon.

3.2.2.5 Etude des correlations entre le niveau d'activite maintenu (Δ_3 PAR) et la variation des parametres sur l'echantillon global

Le test de corrélation appliqué au PAR (physical activity rating) maintenu pendant 1 an a établi son influence sur les résultats successifs du follow up de poids, BMI et FM ($p<0,01$). Le test de corrélation a aussi permis de déterminer le sens (négatif) et la force de la liaison (-0,6). Plus le Δ_3 PAR augmente et plus on note une perte de poids, BMI et FM, donc plus le sujet est actif et plus il perd du poids et de la FM.

Le programme d'entraînement suivi en hospitalisation n'a quand même pas influencé le PAR maintenu pendant 1 an.

L'influence du niveau du PAR à un an sur les principaux paramètres à long terme a été contrôlée. Le niveau de PAR influence significativement les deltas poids, BMI ($p<0,05$) à court terme (une tendance à été observée pour FM, $p=0,06$) et poids, BMI et FM à long terme ($p<0,05$).

3.2.2.6 Difference entre le niveau d'activite de depart et le niveau d'activite pendant l'annee

L'augmentation d'activité par rapport au départ est significativement plus importante dans le groupe EPP ($p<0,05$), par contre aucune différence n'a été détectée dans le groupe EPNS. Le niveau du PAR initial des deux programmes a été contrôlé et, ne différenciant pas, les résultats finaux peuvent être comparés.

3.2.2.7 Resultat final : difference a un an entre les programmes

Apparemment après un an aucune différence significative apparaît pour aucun paramètre analysé, alors que le niveau d'activité est significativement différent pour le groupe EPP. Le problème vient du fait que le nombre de femmes est plus important (ce qui rejoint ce que nous avions trouvé en $\Delta 1$ où les différences de LP, CP et VT s'observaient chez les hommes). Donc les deux groupes ne sont pas comparables et il serait hasardeux d'en tirer des conclusions définitives quant à la différence d'efficacité des deux programmes.

<u>Conclusions</u>

- plus le PAR est élevée plus la perte de poids est importante
- le type d'activité physique ne joue pas un rôle significatif dans les variations de poids mais le niveau d'activité physique oui

Conclusions au terme de l'etude EPP vs EPNS

- AVANTAGE DU PROGRAMME EPP

» augmentation de force chez les hommes

» maintien d'un niveau supérieur d'activité physique après hospitalisation

Mais pourquoi le niveau supérieur d'activité physique ne se reflète pas sur les résultats à un an ?

L'intérêt supérieur du programme EPP est surtout donné par un entraînement mieux encadré et donc plus facilement comparable.

Quel avantage porte un entrainement de force ?

1 Introduction

1.1 Problem statement

1.2 Statement of research objectives

2 Matériel & Méthode

2.1 Populations non morbides

2.2 Protocoles

2.3 Analyse statistique

3 Résultats

3.1 PREMIERE ETUDE_DEPAST

3.2 DEUXIEME ETUDE_EPNS vs EPP

3.3 TROISIEME ETUDE_A vs AF

3.4 QUATRIEME ETUDE_MI vs HI

4 Discussion

4.1 Materials and Methods discussion

4.2 Results Discussion

4.3 Conclusion

5 Bibliographie

3.3 TROISIEME ETUDE_A vs AF

3.3.1 Résultats à court terme : différence entre les méthodologies

3.3.1.1 Aspect descriptif

Réduction de poids - Comme le montre le tableau 39, le programme RMC a provoqué une réduction significative du BMI tant dans le groupe A que dans le groupe AF, mais sans différence statistiquement significative entre les deux groupes.

Tableau 39 - Valeurs moyennes (± DS) de l'indice de masse corporelle (BMI) avant et après 3 semaines de programme de RMC par des sujets effectuant un entraînement aérobie (A) et un entraînement aérobie + entraînement de force (AF).

BMI (kg/m^2)	A (N = 26)	AF (N = 26)
Avant	41,7 ± 5,3	41,1 ± 4,1
Après	39,7 ± 4,8*	39,3 ± 3,8*

* = significativement différente de la valeur correspondante établie avant le programme ($p < 0{,}001$, évaluée à l'aide du test *t* de Student pour données appariées).

Composition corporelle – Pendant la durée du programme, les deux groupes ont perdu une quantité de masse grasse (avant 48,33% ; après 46,74%) ayant un degré de significativité comparable et ont aussi augmenté le niveau de départ de masse maigre (avant 51,67% ; après 53,26%), ne perdant donc pas la quantité de muscles initiale à cause du régime diététique. Le tableau 40 montre les valeurs de masse grasse et de masse maigre observées, avant et après le programme intégré, dans les deux groupes.

Tableau 40 - Composition corporelle moyenne (±DS) observée chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie + entraînement de force (AF) avant et après le programme de trois semaines.

	Avant	Après	significativité
Masse grasse (kg)			
A (N = 25)	56,1 ± 12,7	51,8 ± 12,1	p < 0,0001
AF (N = 26)	54,7 ± 11,0	50,8 ± 11,0	p < 0,0001
Masse grasse (%)			
A (N = 25)	48,3 ± 7,2	46,5 ± 6,7	p < 0,001
AF (N = 26)	48,4 ± 7,3	47 ± 7,0	p < 0,05
Masse maigre (kg)			
A (N = 25)	60,5 ± 15,1	59,7 ± 13,4	p = ns
AF (N = 26)	58,7 ± 12,9	57,3 ± 11,5	p < 0,05
Masse maigre (%)			
A (N = 25)	51,7 ± 7,2	53,5 ± 6,7	p < 0,001
AF (N = 26)	51,7 ± 7,3	53 ± 7,0	p < 0,05

p = valeur significativement différente de la valeur correspondante mesurée avant le programme évaluée à l'aide d'un test *t* de Student pour données appariées

Framingham - Le tableau 41 considère les facteurs de risque liés aux maladies cardiovasculaires avant et après le programme de RMC, analysées séparément pour les sujets soumis à un entraînement personnalisé aérobie (A) et à un entraînement personnalisé aérobie+force (AF). Les modifications après le programme de trois semaines sont significatives pour les deux groupes pour les paramètres suivants : tension (SBP : A et AF, p<0,001 ; DBP : A, p<0,001, AF, p<0,05), cholestérol total et HDL (A et AF, p<0,001), glucose sanguin (A, p<0,001 et AF, p<0,01), tandis que la réduction du CHD score (Framingham et % risque) n'est significative pour aucun groupe. Aucune différence significative n'est apparue entre les deux groupes.

Tableau 41 : Données moyennes du score CHD (±DS) observées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF) avant et après le programme de trois semaines.

	A (N=25)		AF (N=26)	
	avant	après	avant	après
Cholestérol total (mg/dl)	189,8 ± 38,1	163,9 ± 32,6	185,9 ± 36,1	159,8 ± 27,9
Cholestérol HDL (mg/dl)	40,4 ± 7,2	34,6 ± 6,8	43,4 ± 8,6	36,3 ± 7,6
SBP (mmHg)	126,7 ± 10,5	119,0 ± 8,8	122,9 ± 7,8	116,9 ± 6,5
DBP (mmHg)	78,1 ± 5,7	74,8 ± 5,9	76,1 ± 5,5	73,5 ± 5,1
Glucose sanguin (mg/dl)	79,4 ± 8,8	71,1 ± 8,0	81,6 ± 10,0	75,9 ± 8,5
Framingham	-2,5 ± 5,3	-3,4 ± 5,0	-3,2 ± 5,4	-4,1 ± 6,2
CHD score (% risque)	2,5 ± 2,2	2 ± 1,3	2,2 ± 1,8	2 ± 1,3

Paramètres cardiovasculaires - Toujours après le programme, les prestations aérobies (établies par détermination indirecte de $\dot{V}O_2$max) ont subi une augmentation significative et comparable dans les deux groupes, tant en termes absolus qu'en termes relatifs, comme on le voit sur la figure 17.

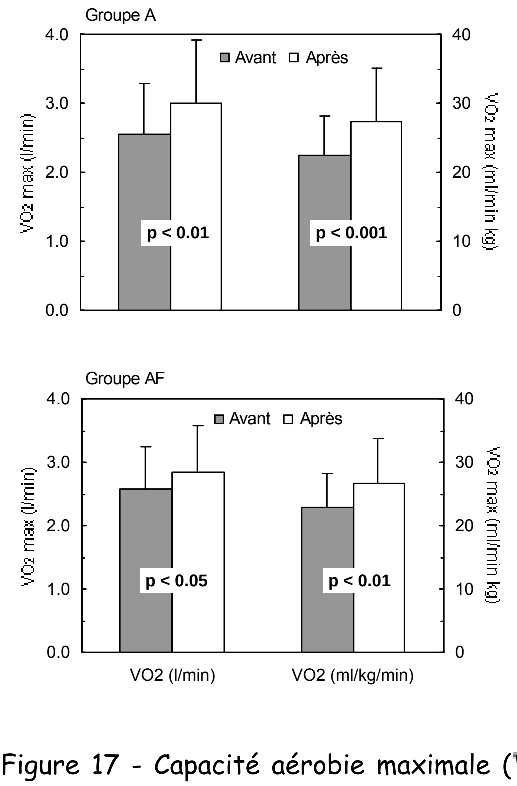


Figure 17 - Capacité aérobie maximale ($\dot{V}O_2$max) moyenne (± DS) en termes absolus (l/min) et par unité de masse corporelle (ml/min/kg) déterminée avant (barres sombres) et après (barres claires) le programme de RMC chez des sujets effectuant un entraînement aérobie (groupe A, panneau du haut) et un entraînement aérobie + entraînement de force (groupe AF, panneau du bas). Au sein de chaque groupe, les différences (illustrées sur la figure) ont été évaluées à l'aide d'un test *t* de Student pour données appariées. Aucune différence significative n'a été relevée entre les groupes.

La figure 18 montre le RPE observé en fonction de la fréquence cardiaque (FC) aux quatre niveaux du test pour la détermination de $\dot{V}O_2$max, avant et après le programme.

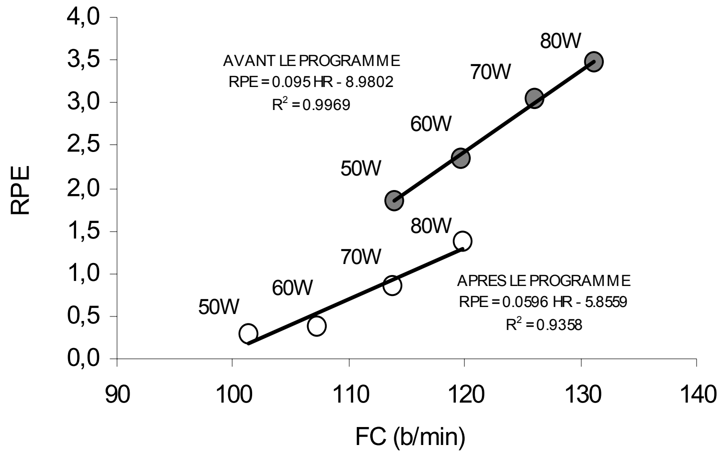


Figure 18 - Le taux d'effort perçu (RPE) moyen, exprimé en unités arbitraires se rapportant à l'échelle de Borg, est indiqué en fonction de la fréquence cardiaque (FC) moyenne observée chez tous les sujets aux quatre niveaux (50, 60, 70 et 80 W) du test incrémental pour la détermination de $\dot{V}O_2$max avant (cercles foncés) et après (cercles clairs) le programme.

S'il existe une forte corrélation linéaire entre RPE et FC tant avant qu'après le programme, le rapport entre ces deux éléments, après ce même programme, montre des régressions significativement différentes, ce qui indique un impact différent de l'entraînement.

Force - Les résultats concernant la force maximale atteinte sur les trois machines isotoniques avant et après le programme de RMC par les sujets des groupes A et AF sont présentés sur le tableau 42.

Tableau 42 - Force maximale moyenne (± DS) obtenue sur trois machines isotoniques différentes avant et après le programme de RMC par des sujets effectuant un entraînement aérobie (A) et un entraînement aérobie + entraînement de force (AF).

Test de force	A		AF	
	avant	après	avant	après
Leg press (kg)	259,9 ± 91,5	326,0 ± 108,7*	244,8 ± 73,7	347,1 ± 99,7*
Chest press (kg)	32,1 ± 16,9	37,4 ± 17,3‡	30,9 ± 13,8	42,1 ± 18,4*
Vertical traction (kg)	72,6 ± 21,3	80,9 ± 22,1*	70,1 ± 15,7	88,8 ± 21,2*

‡ = $p < 0,01$; * = $p < 0,001$

Bien que l'on ait relevé dans les deux groupes une augmentation significative de la valeur de 1-RM développée sur toutes les machines, les améliorations du groupe AF ont été significativement supérieures, comme le montre la figure 19, qui illustre les changements relatifs déterminés par le programme.

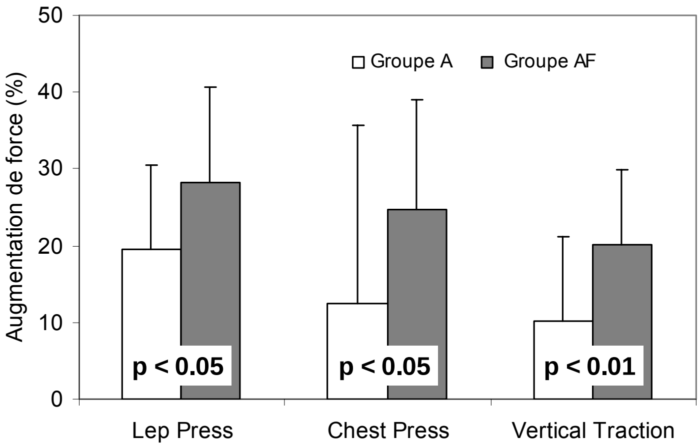


Figure 19 – Augmentation de force moyenne (± DS) sur les trois machines isotoniques observée après le programme de RMC chez les sujets effectuant un entraînement aérobie (groupe A, barres claires) et un entraînement aérobie + entraînement de force (groupe AF, barres foncées).

Puissance - Le tableau 43 synthétise les prestations anaérobies des membres inférieurs exprimées pendant le test de saut dans le groupe A et le groupe AF. Après le programme de RMC, les deux groupes ont montré une augmentation similaire (et sans différence systématique entre les résultats respectivement obtenus) au niveau des prestations anaérobies.

Tableau 43 - Résultats obtenus pendant les tests de saut avant et après 3 semaines de programme de RMC par des sujets effectuant un entraînement aérobie (A) et un entraînement aérobie + entraînement de force (AF). Au sein de chaque groupe, les différences (illustrées sur la figure) ont été évaluées à l'aide d'un test *t* de Student pour données appariées : ° = p < 0,05 ; * = p < 0,01 ; ** = p < 0,001

Test de saut	A (N=26)		AF (N=26)	
	avant	après	avant	après
Tcj (s)	0,487 ± 0,110	0,430 ± 0,120°	0,435 ± 0,110	0,361 ± 0,090*
Tfj (s)	0,297 ± 0,061	0,323 ± 0,068**	0,300 ± 0,069	0,323 ± 0,059**
ΔCG (m)	0,113 ± 0,049	0,133 ± 0,043**	0,116 ± 0,048	0,132 ± 0,047**
W/Mc (W/kg)	11,99 ± 4,01	14,12 ± 4,09**	13,03 ± 4,81	15,62 ± 5,07**
Wmax (W)	1368 ± 550	1556 ± 527*	1424 ± 527	1682 ± 610**

Tcj, Tfj : temps de contact et temps de vol du pied par rapport au sol pendant chaque saut de la série ; ΔCG : déplacement total du centre de gravité pendant chaque saut ; W/Mc : puissance spécifique par unité de masse corporelle ; Wmax : puissance totale pendant chaque saut.

3.3.1.2 Parametres sur lesquels les programmes presentent ou non une efficacite

L'efficacité de chaque programme a été vérifiée pour les paramètres principaux : poids, BMI, FM (kg), FFM (kg), CHD score, $\dot{V}O_2$max (l/min), force (LP, CP, VT). Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative).

Les deux programmes sont efficaces pour :

paramètres anthropométriques

- Δ_1 Poids (p<0,0001)
- Δ_1 BMI (p<0,0001)

paramètres physiologiques

- Δ_1 LP (p<0,0001)
- Δ_1 CP (p<0,0001)

- Δ_1 FM ($p<0{,}0001$)
- Δ_1 VT ($p<0{,}0001$)

Les deux programmes divergent pour :

<u>paramètres anthropométriques</u>

- Δ_1 FFM (significatif pour AF, $p<0{,}01$)

<u>paramètres physiologiques</u>

- Δ_1 $\dot{V}O_2max$ (significatif pour A, $p<0{,}01$)

L'entraînement en force semblerait ne pas préserver la FFM.

Les deux programmes sont inefficaces pour :

<u>facteurs de risque</u>

- Δ_1 Framingham
- Δ_1 % risque

3.3.1.3 EFFICACITE DE CHAQUE PROGRAMME EN TENANT COMPTE DU SEXE

L'efficacité du programme en fonction du sexe a été vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, CHD score, $\dot{V}O_2max$, force (LP, CP, VT).

Les tableaux 44 et 45 montre les valeurs observées, avant et après le programme intégré, dans les deux groupes stratifiés par sexe.

Tableau 44 - Valeurs moyennes (± DS) des paramètres anthropométriques et liés à la santé observées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie + entraînement de force (AF) avant et après le programme de trois semaines.

	A (N = 26)		AF (N = 26)	
	hommes (n = 7)	femmes (n = 19)	hommes (n = 7)	femmes (n = 19)
	POIDS (kg)			
avant	136 ± 16,8	108,4 ± 16,7	124,9 ± 14,8	108,4 ± 13,9
après	128,1 ± 15,6	103,5 ± 15,6	118,9 ± 12,6	103,8 ± 13,6
	BMI (kg/m^2)			
avant	42,1 ± 4,9	41,6 ± 5,5	40,5 ± 3,5	41,3 ± 4,3
après	39,7 ± 4,5	39,7 ± 5,1	38,6 ± 2,8	39,5 ± 4,3
	FM (kg)			
avant	53,8 ± 9,2	57 ± 13,9	48,7 ± 7,0	56,9 ± 11,2
après	49,9 ± 8,7	52,5 ± 13,4	45,5 ± 6,1	52,8 ± 11,7
	FFM (kg)			
avant	82,4 ± 7,7	51,9 ± 5,2	77,3 ± 7,9	51,9 ± 5,1
après	79,0 ± 7,5	52,2 ± 4,4	73,7 ± 7,4	51,3 ± 4,5
	Framingham			
avant	2,7 ± 1,7	-4,4 ± 4,9	1,4 ± 2,8	-4,8 ± 5,0
après	1 ± 1,5	-5 ± 4,8	0,9 ± 1,1	-5,9 ± 6,2
	CHD SCORE (% risque)			
avant	5,1 ± 2,2	1,5 ± 1,1	4 ± 2,0	1,5 ± 1,2
après	3,4 ± 1,1	1,5 ± 1,0	3,3 ± 0,8	1,5 ± 1,0

Tableau 45 - Valeurs moyennes (± DS) des paramètres physiologiques observées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie + entraînement de force (AF) avant et après le programme de trois semaines.

	A (N = 26)		AF (N = 26)	
	hommes (n = 7)	femmes (n = 19)	hommes (n = 7)	femmes (n = 19)
		$\dot{V}O_2max$ (l/min)		
avant	3,1 ± 1,2	2,3 ± 0,3	3,3 ± 1,0	2,2 ± 0,3
après	4 ± 1,0	2,6 ± 0,5	3,4 ± 0,6	2,4 ± 0,3
		LP (kg)		
avant	387,6 ± 70,3	212,9 ± 36,2	312,4 ± 99,7	219,9 ± 42,3
après	463,3 ± 66,7	275,4 ± 69,9	455,7 ± 93,2	307 ± 68,1
		CP (kg)		
avant	55,3 ± 14,3	23,6 ± 6,7	44,6 ± 18,6	25,9 ± 7,1
après	61,4 ± 8,4	28,6 ± 9,3	63,6 ± 20,9	34,2 ± 8,9
		VT (kg)		
avant	101,5 ± 10,8	62 ± 12,3	87,7 ± 19,3	63,5 ± 7,1
après	113,2 ± 9,5	69 ± 9,7	116,2 ± 16,9	78,6 ± 11,5

Le Test des signes univariés a permis de déterminer que :

Les deux programmes sont efficaces pour (quelque soit le sexe) :

paramètres anthropométriques

- Δ_1 Poids (p<0,01)
- Δ_1 BMI (p<0,01)
- Δ_1 FM (p<0,01)

paramètres physiologiques

- Δ_1 LP (p<0,01)
- Δ_1 CP (p<0,05)
- Δ_1 VT (p<0,01)

Les deux programmes divergent pour :

paramètres anthropométriques

- Δ_1 FFM (les hommes ont une perte significative quelque soit le programme, p<0,01)

facteurs de risque

- Δ_1 Framingham (les hommes ont une baisse significative avec entraînement aérobie, p<0,05)

paramètres physiologiques

- Δ_1 $\dot{V}O_2max$ (significatif que pour les hommes qui suivent un entraînement aérobie, p<0,05)

Les deux programmes sont inefficaces pour :

facteurs de risque

- Δ_1 % risque

Ceci indique que les deux programmes ont eu un effet similaire en terme de réduction de poids et de FM et d'amélioration de la force indépendamment du sexe des sujets. En revanche, l'entraînement en force semblerait ne pas préserver la FFM pour les hommes et l'entraînement aérobie semblerait être efficace que pour les hommes.

3.3.1.4 REPONSE AU SEIN DE CHAQUE SEXE EN FONCTION DU PROGRAMME

Quelque soit le programme aucune différence significative existe pour les réponses à l'entraînement quelque soit le sexe.

<u>Conclusions</u>

- pas de différence entre les programmes d'entraînement sur la perte de poids et de FM
- les hommes perdent aussi de la FFM
- les hommes qui suivent le programme A améliorent le plus leur physical fitness cardiovasculaire
- l'amélioration de la $\dot{V}O_2max$ semblerait être liée à la perte de FM et de FFM

3.3.2 Résultats à long terme : suivi

3.3.2.1 Suivi à 6 mois_aspect descriptif

<u>PAR</u> : La figure 20 montre l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital.

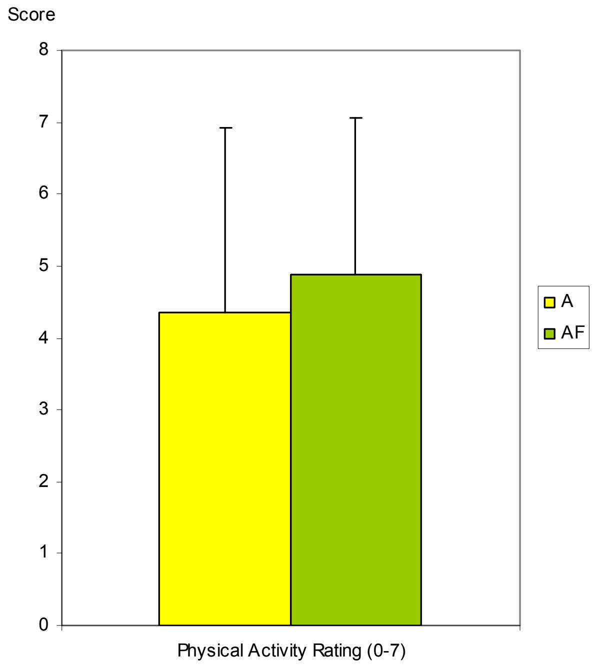


Figure 20 - Auto-évaluation moyenne du niveau maintenu d'activité physique, librement choisie, pendant 6 mois après la fin du programme établie par le biais d'entretiens téléphoniques chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF).

L'auto-évaluation du niveau d'activité physique maintenu après la fin du programme s'est révélée similaire et significativement plus élevé par rapport aux valeurs pré-hospitalisation pour les deux groupes (A, $p<0,01$; AF, $p<0,001$). Tous les sujets ont attesté de continuer à pratiquer une activité aérobie intense (course à pieds, natation, bicyclette) régulièrement toutes les semaines (entre 30 et 60 minutes par semaine).

3.3.2.2 Suivi à 1 an_aspect descriptif

Variation de poids – Un an après, les deux groupes ont maintenu le poids corporel qu'ils avaient au moment de la fin du programme intégré (A : 0,1% ; AF : 0,9%). Les sujets des deux groupes ont donc réussi à maintenir le même poids corporel pendant un an entier. La figure 21 montre les changements en termes de BMI par rapport aux valeurs pré programme (la baisse est significative pour A, p<0,05).

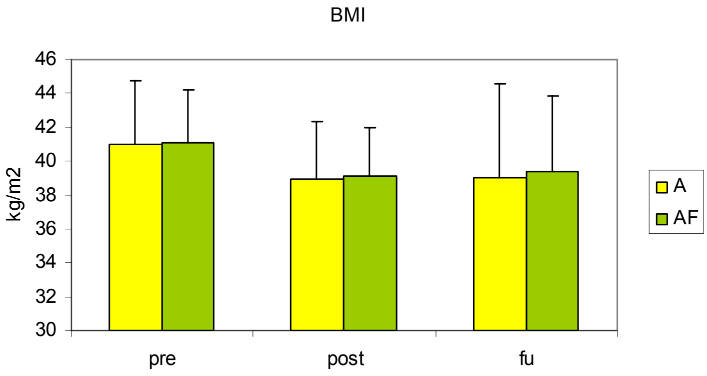


Figure 21 - Variation de la masse corporelle pendant un an après la fin du programme évaluée pendant le day-hospital des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF).

Composition corporelle – Pendant l'année où les sujets étaient libres de suivre le régime alimentaire et le programme d'activité physique, les deux groupes ont maintenu une quantité de masse grasse (A : N=19, -0,7±8,1 kg; AF : N=19, 0,6±9,3 kg) comparable. Au sein des deux groupes la masse maigre a augmenté légèrement (A : N=19, 1±5,1 kg; AF : N=19, 0,9±2,7 kg). La figure 22 montre les changements en termes de masse grasse et de masse maigre par rapport aux valeurs pré et post programme.

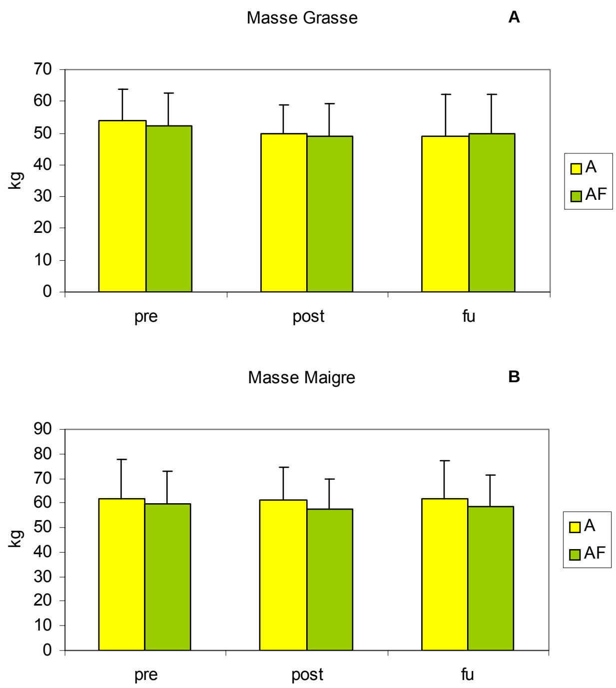


Figure 22 – Masse grasse (panneau A) et masse maigre (panneau B) exprimées en kg, déterminées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF) avant et après le programme de trois semaines et un an après.

PAR – La figure 23 montre l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital et maintenue après 6 mois et un an de la fin du programme intégré.

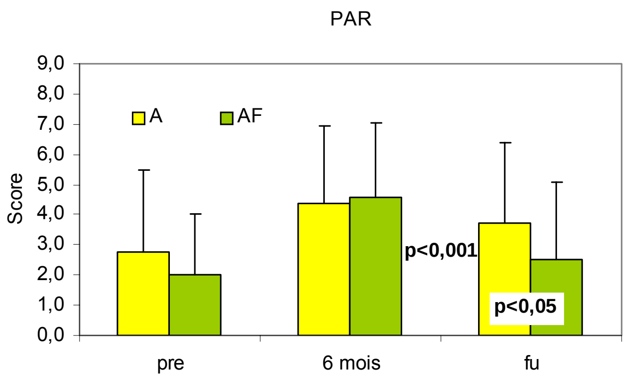


Figure 23 - Auto-évaluation moyenne du niveau maintenu d'activité physique, librement choisie, pendant 1 an après la fin du programme chez des sujets soumis à un entraînement aérobie (A : N=19) et à un entraînement aérobie+force (AF : N=20).

L'auto-évaluation du niveau d'activité physique maintenu après la fin du programme a significativement baissé pendant l'année analysée dans les deux groupes et s'est révélée plus élevée chez les sujets du groupe AF. Elle a été quand même maintenue à un niveau plus élevé que celui du pré programme.

Framingham - Le tableau 46 considère les facteurs de risque liés aux maladies cardiovasculaires avant et après le programme de RMC et 1 an après la fin du programme, analysées séparément pour les sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF). Les modifications un an après la fin du programme de trois semaines sont significatives pour les deux groupes pour les paramètres suivants : SBP (A, p<0,05 ; AF, p<0,01), cholestérol total et HDL (A et AF, p<0,001), glucose sanguin (A, p< 0,001 ; AF, p<0,01). La valeur de DBP n'est significative que pour le groupe AF (p<0,05). Seules les modifications du glucose sanguin pour le groupe A (p<0,001) et du cholestérol HDL pour les deux groupes (A, p< 0,001 ; AF, p<0,01), observées avant et 1 an après la fin du programme de RMC, sont significatives (p<0,01). Une seule différence significative est apparue entre les deux groupes (Glucose sanguin, p<0,05).

Tableau 46 : Variation moyenne du score CHD observée chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF) avant et après le programme de trois semaines et 1 an après la fin du programme de RMC.

	A (N=20)		AF (N=20)	
	Pré-Post	Post-FU	Pré-Post	Post-FU
Cholestérol total (mg/dl)	-16%	+18%	-15,5%	+22,1%
Cholestérol HDL (mg/dl)	-15,8%	+43,3%	-18,9%	+45,7%
SBP (mmHg)	-5,6%	+9,17%	-3,5%	+11,5%
DBP (mmHg)	-4,6%	+3,3%	-2,3%	+6,1%
Glucose sanguin (mg/dl)	-8,7%	+35,2%	-8,5%	+19,5%
Framingham	-0,7	-0,8	-0,6	-0,3
CHD score (% risque)	-0,6	+0,3	-0,3	+0,4

Paramètres cardiovasculaires - La figure 24 montre la valeur moyenne de $\dot{V}O_2max$ déterminée chez les sujets des groupes expérimentaux avant et après le programme de réduction de la masse corporelle et 1 an après la fin du programme de RMC.

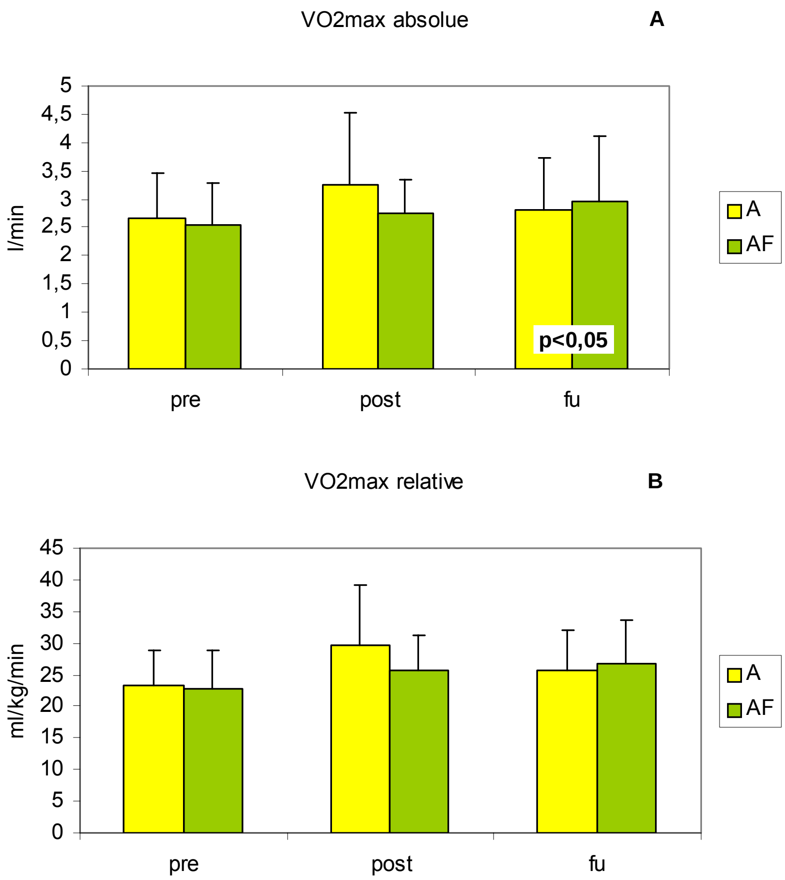


Figure 24 - Capacité aérobie maximale moyenne ($\dot{V}O_2max$) exprimée en termes absolus (panneau A) et en relation avec la masse corporelle (panneau B), déterminée chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF) avant, après le programme de trois semaines et après 1 an la fin du programme.

Aucune différence significative n'a été détectée pour les groupes analysés ensemble entre les valeurs de $\dot{V}O_2max$ du FU et de la fin du programme de RMC. Seuls les sujets AF ont montré une augmentation non significative de la $\dot{V}O_2max$ après 1 an la fin du programme (AvsAF, $p<0,05$).

Force - Les valeurs moyennes de force isotonique maximale, observées chez les sujets A et AF après 1 an la fin du programme pour les trois groupes différents de muscles testés, chacun au moyen d'une machine spécifique, sont reportées dans le tableau 47.

Tableau 47 - Valeurs moyennes (± DS) de force maximale (1-RM, kg) de trois groupes de muscles différents, testés au moyen des machines isotoniques, observées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF) 1 an après la fin du programme.

1-RM	A (N = 15)	AF (N = 15)
Leg Press (kg)	294,8 ± 93,8	285,1 ± 67,0
Chest Press (kg)	43,5 ± 17,1	40,3 ± 15,0
Vertical Traction (kg)	84,3 ± 21,8	83,9 ± 18,8

Les deux groupes ont montré, 1 an après la fin du programme, une perte de la force 1RM des groupes musculaires des membres inférieurs. La diminution de force n'est significative que pour le groupe AF, le groupe qui s'était amélioré le plus après le programme d'entraînement personnalisé de trois semaines ($p < 0{,}001$). Les deux groupes ont montré, au contraire, une tendance différente pour les autres groupes musculaires analysés : le groupe A a augmenté la force, de façon non significative, pour les groupes musculaires en poussé du tronc et a maintenu la force des groupes musculaires en traction du tronc ; tandis que le groupe AF a diminué son niveau de force (VT, $p < 0{,}01$; CP, $p < 0{,}05$). Toutefois, tous les sujets ont réussi a maintenir un niveau de force significativement supérieur par rapport au tout début d'entraînement (A : LP et VT, 0,01; CP, $p < 0{,}001$; AF : LP, ns ; CP et VT, $p < 0{,}05$). La figure 25 synthétise les variations de force provoquées par le programme et par l'arrêt du programme.

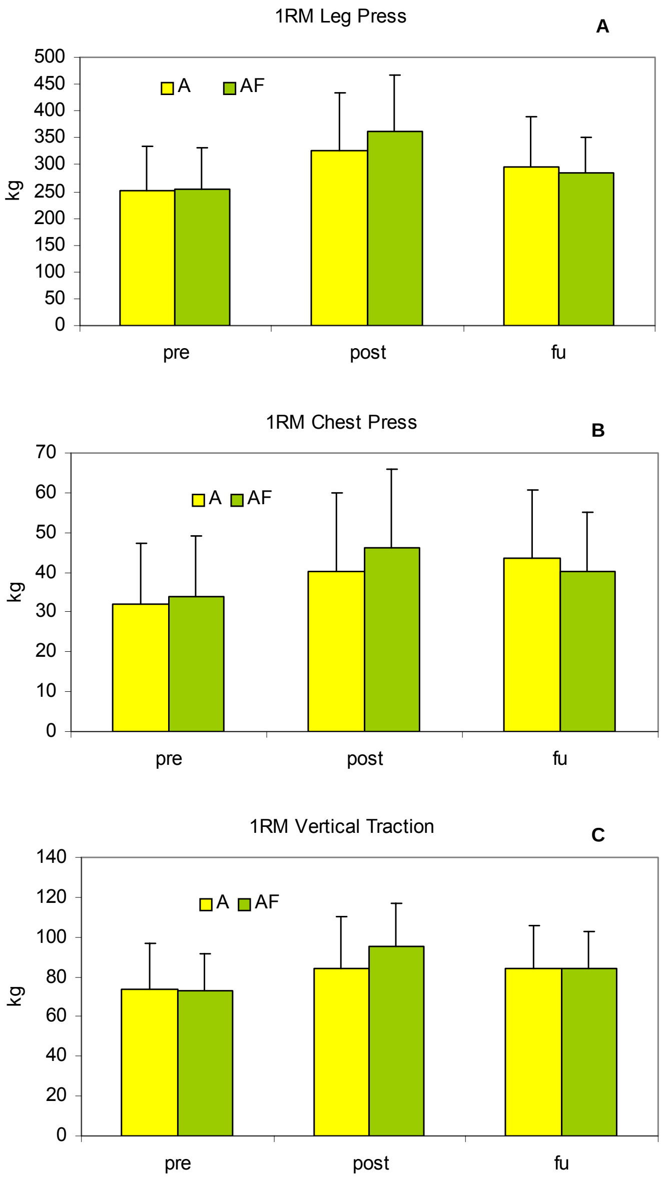
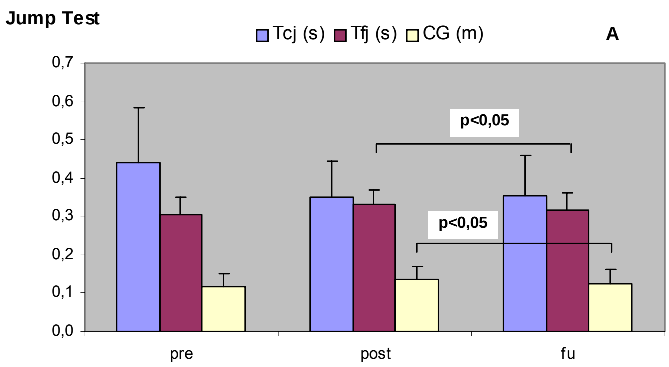
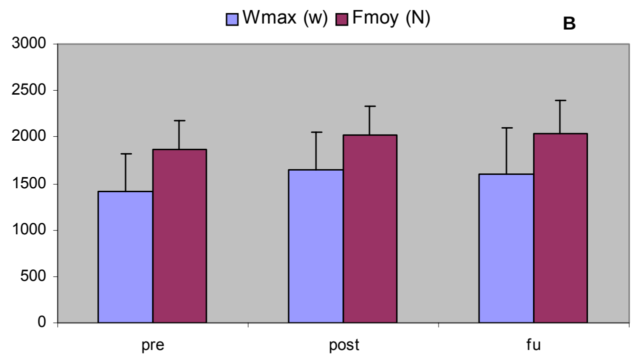


Figure 25 - Variations moyennes de la force isotonique maximale (1-RM) mesurée sur trois machines différentes (leg press, LP; chest press, CP; vertical traction, VT), observées après le programme de 3 semaines et un an après la fin du programme chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie+force (AF).

Puissance – trend N5 A et N9 AF

Figure A+AF; différence significative les deux groupes analysés ensemble pourTcj et CG.





3.3.2.3 Parametres sur lesquels les programmes presentent ou non une efficacite

L'efficacité de chaque programme a été vérifiée pour les paramètres principaux : poids, BMI, FM (kg), FFM (kg), CHD score, $\dot{V}O_2$max (l/min), force (LP, CP, VT). Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative).

Les deux programmes sont efficaces pour :

paramètres physiologiques

- Δ_3 CP ($p<0,05$)
- Δ_3 VT ($p<0,05$)

Les deux programmes divergent pour :

paramètres anthropométriques

- Δ_3 BMI (significatif pour A, $p<0,05$)
- Δ_3 FM (significatif pour A, $p<0,05$)

facteurs de risque

- Δ_3 Framingham (significatif pour A, $p<0,01$)

paramètres physiologiques

- Δ_3 LP (significatif pour A, $p<0,01$)

- Δ_3 $\dot{V}O_2max$ (significatif pour AF, $p<0,05$)

Les deux programmes sont inefficaces pour :

paramètres anthropométriques

- Δ_3 Poids
- Δ_3 FFM

facteurs de risque

- Δ_3 % risque

paramètres physiologiques

- Δ_3 PAR

3.3.2.4 EFFICACITE DE CHAQUE PROGRAMME EN FONCTION DU SEXE

L'efficacité du programme en fonction du sexe a été vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, CHD score, $\dot{V}O_2max$, force (LP, CP, VT).

Les tableaux 48 et 49 montre les valeurs observées, observées avant le programme de 3 semaines et 1 an après la fin du programme, dans les deux groupes stratifiés par sexe.

Tableau 48 - Valeurs moyennes (± DS) des paramètres anthropométriques et liés à la santé observées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie + entraînement de force (AF) avant et 1 an après le programme de trois semaines.

	A (N = 20)		AF (N = 20)	
	hommes (n = 7)	femmes (n = 13)	hommes (n = 7)	femmes (n = 13)
		POIDS (kg)		
avant	133,4 ± 15,9	105,2 ± 12,7	129,4 ± 20,9	105,6 ± 15,8
1 an	130,3 ± 10,9	99 ± 20,5	123,2 ± 16,7	101,6 ± 17,9
		BMI (kg/m^2)		
avant	41,9 ± 4,3	40,5 ± 3,6	42,2 ± 3,2	40,4 ± 3,0
1 an	40,9 ± 2,1	38 ± 6,5	40,4 ± 3,8	38,9 ± 4,8
		FM (kg)		
avant	52,8 ± 8,3	54,8 ± 10,7	48,9 ± 7,7	54 ± 10,8
1 an	51 ± 4,8	47,7 ± 16,3	49 ± 9,3	50,1 ± 14,1
		FFM (kg)		
avant	80,9 ± 7,8	51 ± 4,3	75,9 ± 9,3	51,9 ± 5,8
1 an	80,1 ± 6,3	51,4 ± 5,8	74,6 ± 9,5	51,2 ± 5,0
		Framingham		
avant	2,7 ± 1,7	-5,5 ± 4,6	2,0 ± 3,2	-5,1 ± 3,4
1 an	1,6 ± 2,4	-7,2 ± 4,8	1,7 ± 2,6	-6,2 ± 6,1
		CHD SCORE (% risque)		
avant	5,1 ± 2,2	1,3 ± 0,9	5 ± 2,3	1,2 ± 0,4
1 an	4,6 ± 2,1	1,2 ± 0,4	4,7 ± 2,1	1,5 ± 0,9

Tableau 49 - Valeurs moyennes (± DS) des paramètres physiologiques observées chez des sujets soumis à un entraînement aérobie (A) et à un entraînement aérobie + entraînement de force (AF) avant et 1 an après le programme de trois semaines.

	A (N = 20)		AF (N = 20)	
	hommes (n = 7)	femmes (n = 13)	hommes (n = 7)	femmes (n = 13)
		PAR		
avant	2,1 ± 2,4	3,2 ± 2,9	2 ± 2,2	2 ± 2,0
1 an	2,7 ± 2,4	4,3 ± 2,7	2,6 ± 2,2	2,5 ± 2,8
		$\dot{V}O_2$max (l/min)		
avant	3,2 ± 1,2	2,4 ± 0,3	3,1 ± 1,0	2,3 ± 0,4
1 an	3,7 ± 0,9	2,3 ± 0,4	3,5 ± 1,4	2,7 ± 0,9
		LP (kg)		
avant	343,6 ± 73,1	201,1 ± 30,9	310,9 ± 84,0	222,3 ± 59,0
1 an	372,4 ± 107,0	252,9 ± 53,0	336,1 ± 63,8	257,6 ± 52,3
		CP (kg)		
avant	50 ± 9,6	22,2 ± 6,3	45,3 ± 16,2	27,7 ± 11,1
1 an	63,6 ± 9,2	32,7 ± 7,8	48,6 ± 16,2	35,8 ± 12,7
		VT (kg)		
avant	99,9 ± 13,1	59,2 ± 12,8	88 ± 20,6	64,4 ± 11,4
1 an	106 ± 18,6	72,6 ± 12,5	96,8 ± 20,0	77,1 ± 14,6

Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative) en fonction du sexe.

Quelque soit le sexe les deux programmes sont efficaces pour :

aucun paramètre

Les deux programmes divergent pour :

<u>paramètres anthropométriques</u>

- Δ_3 Poids (significatif pour femmes du programme A, p<0,05)
- Δ_3 BMI (significatif pour femmes du programme A, p<0,05)
- Δ_3 FM (significatif pour femmes du programme A, p<0,01)

<u>facteurs de risque</u>

- Δ_3 Framingham (significatif significatif pour femmes du programme A, p<0,05)

<u>paramètres physiologiques</u>

- Δ_3 LP (significatif pour femmes du programme A, p<0,05)
- Δ_3 CP (significatif pour femmes du programme A et AF et pour hommes du programme A, p<0,05)
- Δ_3 VT (significatif pour femmes du programme A et AF, p<0,01)

Les deux programmes sont inefficaces pour :

<u>paramètres anthropométriques</u>

- Δ_3 FFM

<u>facteurs de risque</u>

- Δ_3 % risque

paramètres physiologiques

- Δ_3 $\dot{V}O_2max$
- Δ_3 PAR

3.3.2.5 REPONSE AU SEIN DE CHAQUE SEXE EN FONCTION DU PROGRAMME

Quelque soit le programme aucune différence de réponse à long terme n'existe entre les deux sexes en fonction du programme sauf pour Δ_3 $\dot{V}O_2max$ pour le quel le programme AF est plus efficace significativement chez les femmes ($p<0,05$).

Conclusions

- un an après, les deux groupes ont maintenu le poids corporel, la FM et la FFM qu'ils avaient au moment de la fin du programme intégré
- le niveau d'activité physique maintenu pendant 1 an (PAR), plus d'une heure par semaine d'activité physique à une intensité légère et modérée, n'a pas permis une perte de poids et de FM supplémentaire ni une amélioration des paramètres physiologiques et lié à la santé

CONCLUSIONS AU TERME DE L'ETUDE A VS AF

» les deux programmes sont efficaces mais il n'y on a pas un supérieur à l'autre (sauf pour le femmes où le programme AF a permis une plus importante augmentation du $\dot{V}O_2max$ à long terme)

» les deux programmes sont quand même très semblables

Mais pourquoi l'entraînement en force ne permet pas une amélioration de la FFM au moins à court terme ? Peut être l'intensité n'été pas suffisamment élevée ?

- MAINTIEN DE L'ENTRAINEMENT EN FORCE

QUEL AVANTAGE PORTE UNE AUGMENTATION D'INTENSITE ?

1 Introduction

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1.2 Statement of research objectives

2 Matériel & Méthode

2.1 Populations non morbides

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2.3 Analyse statistique

3 Résultats

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3.2 DEUXIEME ETUDE_EPNS vs EPP

3.3 TROISIEME ETUDE_A vs AF

3.4 QUATRIEME ETUDE_MI vs HI

4 Discussion

4.1 Materials and Methods discussion

4.2 Results Discussion

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3.4 QUATRIEME ETUDE_MI vs HI

3.4.1 Résultats à court terme : différence entre les méthodologies

3.4.1.1 Aspect descriptif

Réduction de poids - Comme le montre le tableau 50, le programme de RMC a provoqué une réduction significative du BMI tant dans le groupe MI que dans le groupe HI, mais sans différence statistiquement significative entre les deux.

Tableau 50 - Valeurs moyennes (± DS) de l'indice de masse corporelle (BMI) avant et après 3 semaines de programme RMC par des sujets effectuant un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI).

BMI	MI (N = 32)	HI (N = 35)
Avant	41,3 ± 4,6	42,6 ± 5,8
Après	39,5 ± 4,3*	40,6 ± 5,6*

* = significativement différente de la valeur correspondante établie avant le programme ($p < 0,001$, évaluée à l'aide du test *t* de Student pour données appariées).

Composition corporelle – Pendant la durée du programme, les deux groupes ont perdu une quantité de masse grasse (avant 48,06% ; après 46,72%) ayant un degré de significativité comparable et ont aussi augmenté le niveau de départ de masse maigre (avant 51,94% ; après 53,28%), ne perdant donc pas la quantité de muscles initiale à cause du régime diététique. Le tableau 51 montre les valeurs de masse grasse et de masse maigre observées, avant et après le programme intégré, dans les deux groupes.

Tableau 51 - Composition corporelle moyenne (±DS) observée chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant et après le programme de trois semaines.

	Avant	Après	significativité
Masse grasse (kg)			
MI (N = 31)	54,4 ± 12,1	50,84 ± 12,8*	p < 0,001
HI (N = 35)	56,8 ± 12,1	53,32 ± 12,2*	p < 0,001
Masse grasse (%)			
MI (N = 31)	47,8 ± 6,9	46,52 ± 7,1*	p < 0,001
HI (N = 35)	48,3 ± 6,5	46,90 ± 6,7*	p < 0,001
Masse maigre (kg)			
MI (N = 31)	59,2 ± 12,0	57,83 ± 10,6*	p < 0,001
HI (N = 35)	61,3 ± 15,8	60,55 ± 14,8*	p < 0,001
Masse maigre (%)			
MI (N = 31)	52,2 ± 6,9	53,48 ± 7,1*	p < 0,001
HI (N = 35)	51,7 ± 6,5	53,10 ± 6,7*	p < 0,001

* = valeur significativement différente de la valeur correspondante mesurée avant le programme évaluée à l'aide d'un test *t* de Student pour données appariées

Framingham - Le tableau 52 considère les facteurs de risque liés aux maladies cardiovasculaires avant et après le programme de RMC analysées séparément pour les sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI). Les modifications après le programme de trois semaines sont significatives pour les deux groupes pour les paramètres suivants: cholestérol total et HDL (MI et HI, p<0,001), glucose sanguin (MI et HI, p<0,001). La réduction de tension n'est significative, pour les valeurs diastoliques, que pour les sujets appartenant au groupe MI (SBP : MI, p<0,05 et HI, p<0,01 ; DBP : MI, p<0,01, HI, p=ns), tandis que le Framingham score n'est significatif que pour le groupe HI (p<0,01). La réduction du CHD score (% de risque) n'est significative pour aucun groupe. Aucune différence significative n'est apparue entre les deux groupes.

Tableau 52 : Données moyennes du score CHD (±DS) observées chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant et après le programme de trois semaines.

	MI		HI	
	avant	après	avant	après
Cholestérol total (mg/dl)	179,4 ± 40,8	154,3 ± 30,0	173,5 ± 34,4	146,7 ± 29,8
Cholestérol HDL (mg/dl)	42,4 ± 10,5	35,9 ± 9,3	46,7 ± 9,3	40,6 ± 11,1
SBP (mmHg)	125,3 ± 10,0	119,8 ± 10,7	131,4 ± 11,3	124,2 ± 10,3
DBP (mmHg)	75,2 ± 5,9	72,0 ± 6,3	76,7 ± 6,8	75,9 ± 8,0
Glucose sanguin (mg/dl)	79,1 ± 8,7	73,8 ± 6,7	79,7 ± 8,7	74,1 ± 6,3
Framingham	-4,8 ± 5,1	-5,6 ± 5,3	-4,1 ± 4,9	-5,5 ± 5,1
CHD score (% risque)	2,06 ± 2,0	1,77 ± 1,4	2,09 ± 1,5	1,82 ± 1,0

Paramètres cardiovasculaires - Toujours après le programme, les prestations aérobies (établies par détermination indirecte de $\dot{V}O_2max$) ont subi en termes relatifs une augmentation significative et comparable dans les deux groupes, tandis qu'en termes absolus seul le groupe qui s'est entraîné à moyenne intensité a obtenu des résultats significatifs, comme on le voit sur la figure 26.

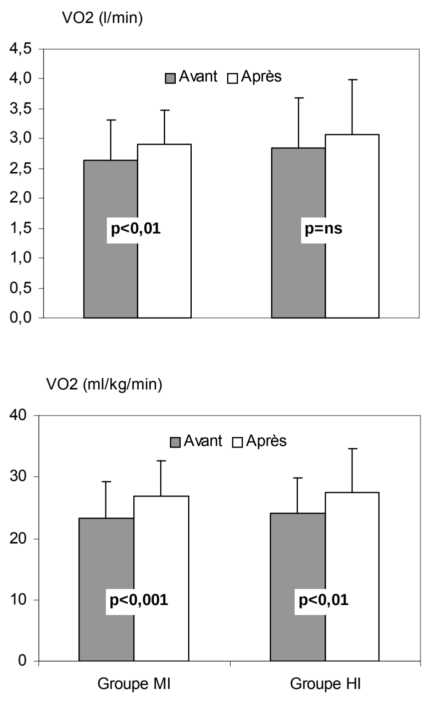


Figure 26 - Capacité aérobie maximale ($\dot{V}O_2max$) moyenne (± DS) en termes absolus (l/min) et par unité de masse corporelle (ml/min/kg) déterminée avant (barres sombres) et après (barres claires) le programme de RMC chez des sujets effectuant un entraînement à moyenne intensité (groupe MI) et un entraînement à haute intensité (groupe HI). Au sein de chaque groupe, les différences (illustrées sur la figure) ont été évaluées à l'aide d'un test *t* de Student pour données appariées. Aucune différence significative n'a été relevée entre les groupes.

Force - Les résultats concernant la force maximale atteinte sur les trois machines isotoniques avant et après le programme de RMC par les sujets des groupes MI et HI sont présentés sur le tableau 53.

Tableau 53 - Force maximale moyenne (± DS) obtenue sur trois machines isotoniques différentes avant et après le programme de RMC par des sujets effectuant un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI). Au sein de chaque groupe, les différences (illustrées sur la figure) ont été évaluées à l'aide d'un test *t* de Student pour données appariées : * = p < 0,001

Test de force	MI		HI	
	avant	après	avant	après
Leg press (kg)	269,1 ± 76,1	377,8 ± 96,2*	293,3 ± 67,8	404,5 ± 86,5*
Chest press (kg)	38,9 ± 16,7	52,6 ± 20,8*	43,2 ± 17,1	58,7 ± 22,4*
Vertical traction (kg)	77,5 ± 18,9	97,0 ± 23,8*	87,1 ± 27,4	107,0 ± 31,3*

Aucune différence significative n'a été relevée entre les groupes, comme le montre la figure 27, qui illustre les changements relatifs déterminés par le programme.

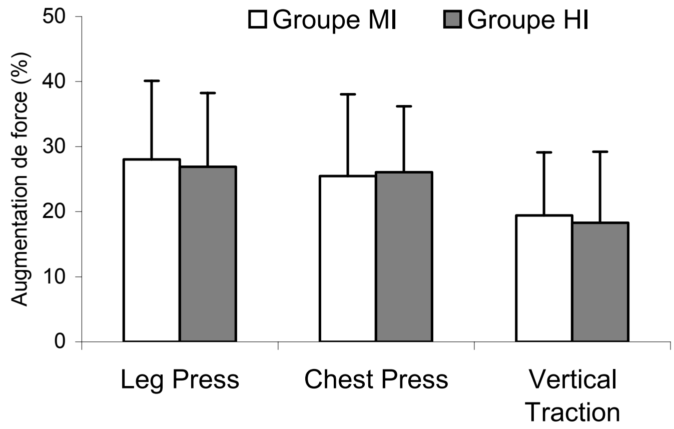
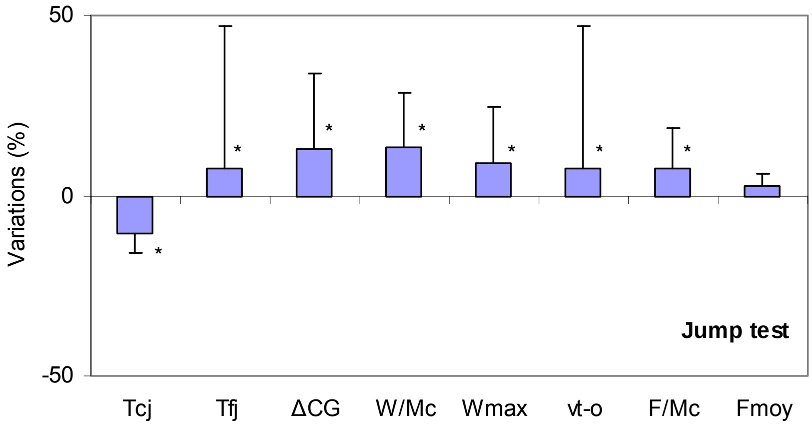


Figure 27 - Augmentation de force moyenne (± DS) sur les trois machines isotoniques observée après le programme de RMC chez les sujets effectuant un entraînement à moyenne intensité (groupe MI, barres claires) et un entraînement à haute intensité (groupe HI, barres foncées).

Puissance – trend N19 MI et N5 HI

Figure MI+HI; différence significative les deux groupes analysés ensemble pourTcj, Tfj, ΔCG, W/Mc, Wmax, vt-o, F/Mc.



3.4.1.2 PARAMETRES SUR LESQUELS LES PROGRAMMES PRESENTENT OU NON UNE EFFICACITE

L'efficacité de chaque programme a été vérifiée pour les paramètres principaux : poids, BMI, FM (kg), FFM (kg), CHD score, $\dot{V}O_2max$ (l/min), force (LP, CP, VT). Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative).

Les deux programmes sont efficaces sur l'ensemble des paramètres :

paramètres anthropométriques

- Δ_1 Poids ($p<0{,}0001$)
- Δ_1 BMI ($p<0{,}0001$)
- Δ_1 FM ($p<0{,}0001$)
- Δ_1 FFM ($p<0{,}05$)

paramètres physiologiques

- Δ_1 LP ($p<0{,}0001$)
- Δ_1 CP ($p<0{,}0001$)
- Δ_1 VT ($p<0{,}0001$)

Les deux programmes divergent pour :

paramètres physiologiques

- Δ_1 $\dot{V}O_2max$ (significatif pour MI, $p<0{,}01$)

facteurs de risque

- Δ_1 Framingham (significatif pour HI, $p<0{,}01$)

Les deux programmes sont inefficaces pour :

facteurs de risque

- Δ_1 % risque

3.4.1.3 EFFICACITE DE CHAQUE PROGRAMME EN TENANT COMPTE DU SEXE

L'efficacité du programme en fonction du sexe a été vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, CHD score, $\dot{V}O_2max$, force (LP, CP, VT).

Les tableaux 54 et 55 montre les valeurs observées, avant et après le programme intégré, dans les deux groupes stratifiés par sexe.

Tableau 54 - Valeurs moyennes (± DS) des paramètres anthropométriques et liés à la santé observées chez des sujets soumis à un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI) avant et après le programme de trois semaines.

	MI (N = 32)		HI (N = 35)	
	hommes (N = 10)	femmes (N = 22)	hommes (N = 10)	femmes (N = 25)
		POIDS (kg)		
avant	126,4 ± 19,3	109,5 ± 16,7	137,7 ± 23,8	111 ± 15,8
après	120 ± 18,0	104,9 ± 16,1	130,8 ± 22,4	105,8 ± 15,4
		BMI (kg/m^2)		
avant	41,7 ± 3,8	41,2 ± 5,0	43,7 ± 6,9	42,2 ± 5,4
après	39,6 ± 3,5	39,4 ± 4,7	41,5 ± 6,5	40,2 ± 5,3
		FM (kg)		
avant	47,8 ± 7,6	57 ± 12,6	55,4 ± 9,8	57,3 ± 13,1
après	44,7 ± 6,9	53,3 ± 13,8	52,1 ± 9,3	53,8 ± 13,3
		FFM (kg)		
avant	75 ± 8,4	52,8 ± 5,2	82,1 ± 14,8	53,1 ± 4,6
après	71,9 ± 7,6	52,1 ± 4,5	79,8 ± 14,2	52,8 ± 4,1
		Framingham		
avant	1,4 ± 3,0	-7,6 ± 3,0	-0,6 ± 3,7	-5,4 ± 4,6
après	0,4 ± 2,2	-8,3 ± 3,8	-1,1 ± 3,4	-6,9 ± 4,7
		CHD SCORE (% risque)		
avant	4,3 ± 2,3	1 ± 0,0	3 ± 1,4	1,8 ± 1,4
après	3,3 ± 1,6	1 ± 0,2	2,6 ± 1,1	1,5 ± 0,8

Tableau 55 - Valeurs moyennes (± DS) des paramètres physiologiques observées chez des sujets soumis à un entraînement à moyenne intensité (MI) et un entraînement à haute intensité (HI) avant et après le programme de trois semaines.

	MI (N = 32)		HI (N = 35)	
	hommes (N = 10)	femmes (N = 22)	hommes (N = 10)	femmes (N = 25)
		$\dot{V}O_2max$ (l/min)		
avant	3,1 ± 0,9	2,4 ± 0,5	3,5 ± 0,9	2,6 ± 0,7
après	3,4 ± 0,5	2,7 ± 0,5	3,7 ± 0,8	2,8 ± 0,8
		LP (kg)		
avant	338 ± 79,1	237,7 ± 50,8	331,7 ± 79,5	278 ± 57,4
après	478 ± 77,2	332,2 ± 64,4	449,4 ± 115	386,6 ± 66,8
		CP (kg)		
avant	55,1 ± 19,4	31,5 ± 8,2	63,6 ± 17,5	35 ± 7,3
après	74,2 ± 23,1	42,7 ± 9,3	86,9 ± 20,9	47,5 ± 9,1
		VT (kg)		
avant	96,5 ± 19,0	68,9 ± 11,0	117,1 ± 27,6	75,1 ± 15,9
après	125,1 ± 16,4	84,3 ± 13,3	144,8 ± 28,0	91,9 ± 16,3

Le Test des signes univariés a permis de déterminer que :

Les deux programmes sont efficaces pour (quelque soit le sexe) :

paramètres anthropométriques

- Δ_1 Poids ($p<0,0001$)
- Δ_1 BMI ($p<0,0001$)
- Δ_1 FM ($p<0,0001$)

paramètres physiologiques

- Δ_1 LP ($p<0,0001$)
- Δ_1 CP ($p<0,0001$)
- Δ_1 VT ($p<0,0001$)

Les deux sexes divergent sur la variation de :

paramètres anthropométriques

- Δ_1 FFM (les hommes perdent plus de FFM quelque soit le programme, p<0,01, alors qu'il n'y a pas de différence significative pour les femmes)

Les deux programmes divergent en fonction du programme et en fonction du sexe pour :

facteurs de risque

- Δ_1 Framingham (les femmes ont une baisse significative avec entraînement HI, p<0,01)
- Δ_1 %risque (les hommes ont une baisse significative avec entraînement MI, p<0,05)

paramètres physiologiques

- Δ_1 $\dot{V}O_2max$ (significatif que pour les femmes qui suivent un entraînement MI, p<0,05)

Ceci indique que les deux programmes ont eu un effet similaire en terme de réduction de poids et de FM et d'amélioration de la force indépendamment du sexe des sujets. En revanche, l'entraînement semblerait ne pas préserver la FFM pour les hommes et l'entraînement aérobie semblerait être efficace que pour les femmes qui suivent un entraînement moyenne intensité.

3.4.1.4 REPONSE AU SEIN DE CHAQUE SEXE EN FONCTION DU PROGRAMME

Quelque soit le programme aucune différence significative existe pour les réponses à l'entraînement quelque soit le sexe. Pour chaque sexe il n'y a pas de programme qui se révèle supérieur (bien que tous les deux soient efficaces).

Conclusions

- pas de différence entre les programmes d'entraînement sur la perte de poids et de FM et pour l'amélioration de la force
- les hommes perdent aussi de la FFM
- les femmes qui suivent le programme MI améliorent le plus leur physical fitness cardiovasculaire

3.4.2 Résultats à long terme : suivi

3.4.2.1 Suivi à 6 mois_aspect descriptif

PAR_La figure 28 montre l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital.

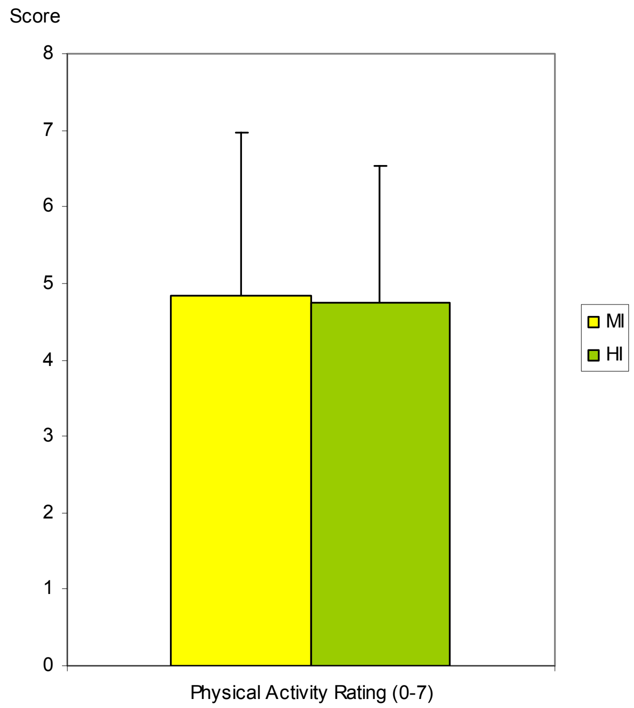


Figure 28 - Auto-évaluation moyenne du niveau maintenu d'activité physique, librement choisie, pendant 6 mois après la fin du programme établie par le biais d'entretiens téléphoniques chez des sujets soumis à moyenne intensité (MI) et à un entraînement à haute intensité (HI).

L'auto-évaluation du niveau d'activité physique maintenu après la fin du programme s'est révélée similaire et significativement plus élevé par rapport aux valeurs pré-hospitalisation pour les deux groupes (MI et HI, $p<0,001$). Tous les sujets ont attesté de continuer à pratiquer une activité aérobie intense (course à pieds, natation, bicyclette) régulièrement toutes les semaines (entre 30 et 60 minutes par semaine).

La figure 29 montre les changements en termes de BMI par rapport aux valeurs post-programme pour le groupe HI.

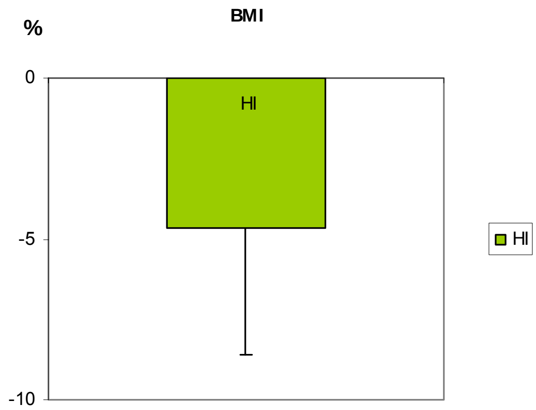


Figure 29 - Variation de la masse corporelle pendant 6 mois après la fin du programme, établie en fonction d'entretiens téléphoniques, chez des sujets soumis à un entraînement à haute intensité (HI).

En termes de poids, les sujets HI ont montré une nette tendance à perdre encore du poids.

3.4.2.2 Suivi à 1 an_aspect descriptif

Variation de poids – Un an après, les deux groupes ont réduit en partie leur poids corporel, même si la perte n'est significative que pour le groupe HI (MI : -1,8% ; HI : -2,8% , $p<0{,}05$). Aucune différence statistiquement significative n'est apparue entre les deux groupes. La figure 30 montre les changements en termes de BMI par rapport aux valeurs pré et post programme.

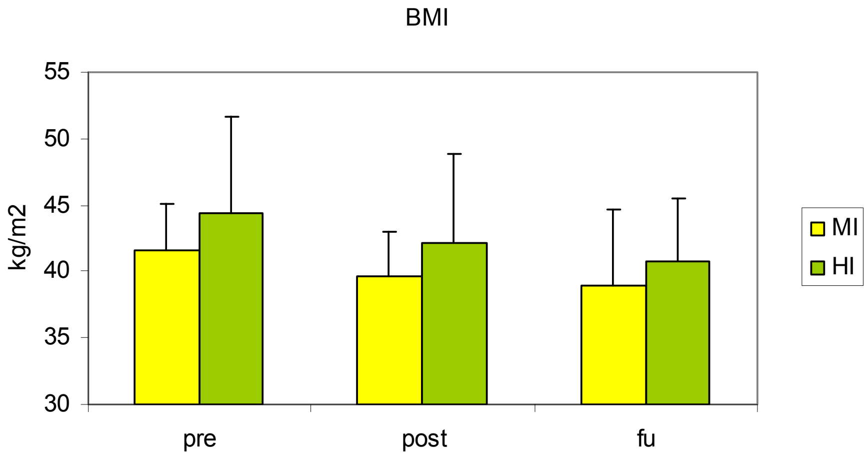
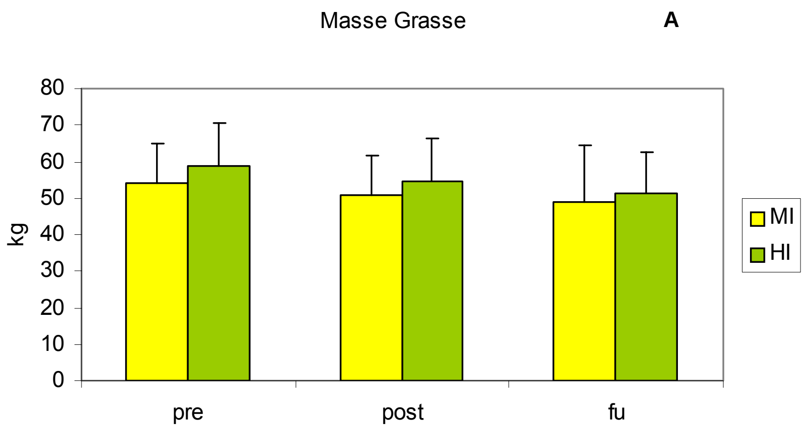


Figure 30 - Variation de la masse corporelle un an après la fin du programme évaluée pendant le day-hospital des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI).

Composition corporelle – Pendant l'année où les sujets étaient libres de suivre le régime alimentaire et le programme d'activité physique, les deux groupes ont perdu une quantité de masse grasse (MI : N=14, -1,97±11,2 kg; HI : N=9, -3,4±8,8 kg) comparable mais non significative. Au sein du groupe MI la masse maigre a augmenté légèrement, tandis qu'une tendance inverse s'est produite au sein du groupe HI (MI : N=14, 0,84±2,7 kg; HI : N=9, -1,92±5,2 kg). La figure 31 montre les changements en termes de masse grasse et de masse maigre par rapport aux valeurs pré et post programme.



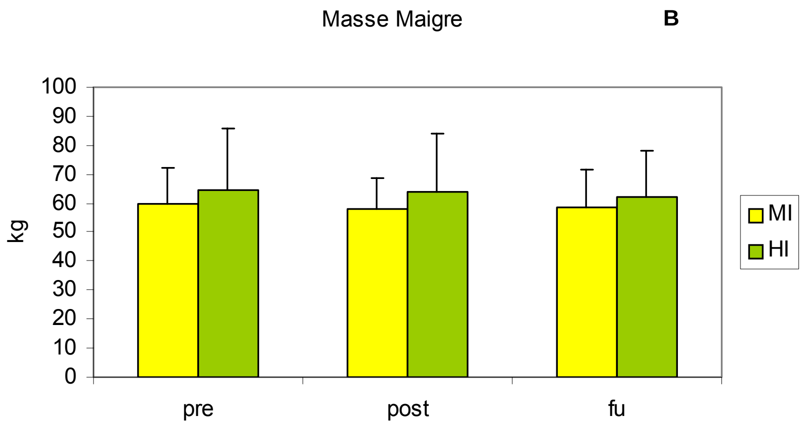


Figure 31 – Masse grasse (panneau A) et masse maigre (panneau B) exprimée en kg, déterminées chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant et après le programme de trois semaines et un an après.

PAR – La figure 32 montre l'intensité de la routine personnelle d'activité physique librement choisie par le patient après la sortie de l'hôpital et maintenue après 6 mois et un an après la fin du programme intégré.

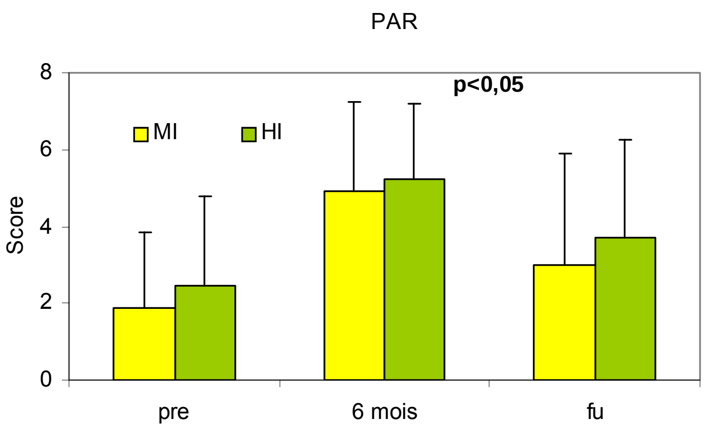


Figure 32 - Auto-évaluation moyenne du niveau maintenu d'activité physique, librement choisie, pendant 1 an après la fin du programme chez des sujets soumis à un entraînement à moyenne intensité (MI : N=14) et à un entraînement à haute intensité (HI : N=9).

L'auto-évaluation du niveau d'activité physique maintenu après la fin du programme a significativement baissé pendant l'année examinée, les deux groupes analysés ensemble. Il a été quand même maintenu à un niveau plus élevé que celui du pré programme.

Framingham - Le tableau 56 considère les facteurs de risques liés aux maladies cardiovasculaires avant, après le programme de RMC et 1 an après la fin du programme, analysées séparément pour les sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI). Les modifications un an après la fin du programme de trois semaines sont significatives pour les deux groupes pour les paramètres suivants : SBP (MI et HI, $p<0,05$), cholestérol total et glucose sanguin (MI, $p< 0,001$; HI, $p<0,05$) et HDL (MI, $p< 0,001$; HI, $p<0,01$). Les valeurs de DBP et de SBP ne sont significatives que pour le groupe MI ($p<0,05$). Seules les modifications du glucose sanguin ($p<0,05$) et du cholestérol HDL pour le groupe MI ($p<0,01$), observées avant et 1 an après la fin du programme de RMC, sont significatives. Aucune différence significative n'est apparue entre les deux groupes.

Tableau 56 : Variation moyenne du score CHD observée chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant et après le programme de trois semaines et 1 an après la fin du programme de RMC.

	MI (N=15)		HI (N=9)	
	Pré-Post	Post-FU	Pré-Post	Post-FU
Cholestérol total (mg/dl)	-15,8%	+21,1%	-24,2%	+26,9%
Cholestérol HDL (mg/dl)	-17,6%	+44,5%	-20,3%	+29,0%
SBP (mmHg)	-2,2%	+10,7%	-4,0%	+4,0%
DBP (mmHg)	-4,0%	+6,0%	-2,0%	-1,5%
Glucose sanguin (mg/dl)	-9,9%	+23,8%	-8,8%	+26,6%
Framingham	-0,6	+0,38	-2,4	+0,43
CHD score (% risque)	-0,38	+0,38	-1,0	+0,50

Paramètres cardiovasculaires - La figure 33 montre la valeur moyenne de $\dot{V}O_2max$ déterminée chez les sujets des groupes expérimentaux avant et après le programme de réduction de la masse corporelle et 1 an après la fin du programme de RMC.

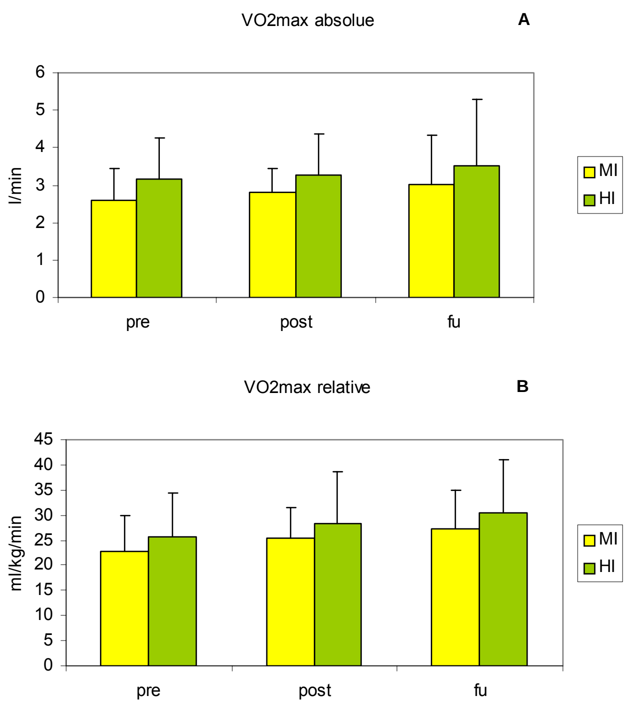


Figure 33 - Capacité aérobie maximale moyenne ($\dot{V}O_2max$) exprimée en termes absolus (panneau A) et en relation avec la masse corporelle (panneau B), déterminée chez des sujets soumis à un à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant, après le programme de trois semaines et 1 an après la fin du programme.

Les deux groupes ont augmenté leur capacité aérobie maximale 1 an après la fin du programme de façon non significative. Aucune différence significative n'a été détectée entre les groupes.

Force - Les valeurs moyennes de force isotonique maximale, observées chez les sujets MI et HI 1 an après la fin du programme pour les trois groupes différents de muscles testés, chacun au moyen d'une machine spécifique, sont reportées dans le tableau 57.

Tableau 57 - Valeurs moyennes (± DS) de force maximale (1-RM, kg) de trois groupes différents de muscles, testés au moyen des machines isotoniques, observées chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) après 1 an la fin du programme.

1-RM	MI (N = 15)	HI (N = 9)
Leg Press	305,2 ± 63,0	347,3 ± 96,5
Chest Press	44,2 ± 14,5	56,6 ± 25,7
Vertical Traction	88,0 ± 20,2	108,4 ± 38,9

Les deux groupes ont montré, 1 an après la fin du programme, une perte significative de la force 1-RM des trois groupes musculaires analysés (LP, $p<0,01$; CP, $p<0,01$; VT, $p<0,001$). La diminution de force est significative pour les trois groupes musculaires pour le groupe HI (LP, $p<0,01$; CP, $p<0,01$; VT, $p<0,001$), tandis que le groupe MI n'a une diminution significative que pour l'exercice VT ($p<0,05$). Toutefois, tous les sujets ont réussi a maintenir un niveau de force supérieur par rapport au tout début d'entraînement (MI : LP et VT, $p<0,01$; CP, $p<0,05$; HI : LP et CP, ns ; VT, $p<0,05$). La figure 34 synthétise les variations de force provoquées par le programme et par l'arrêt du programme.

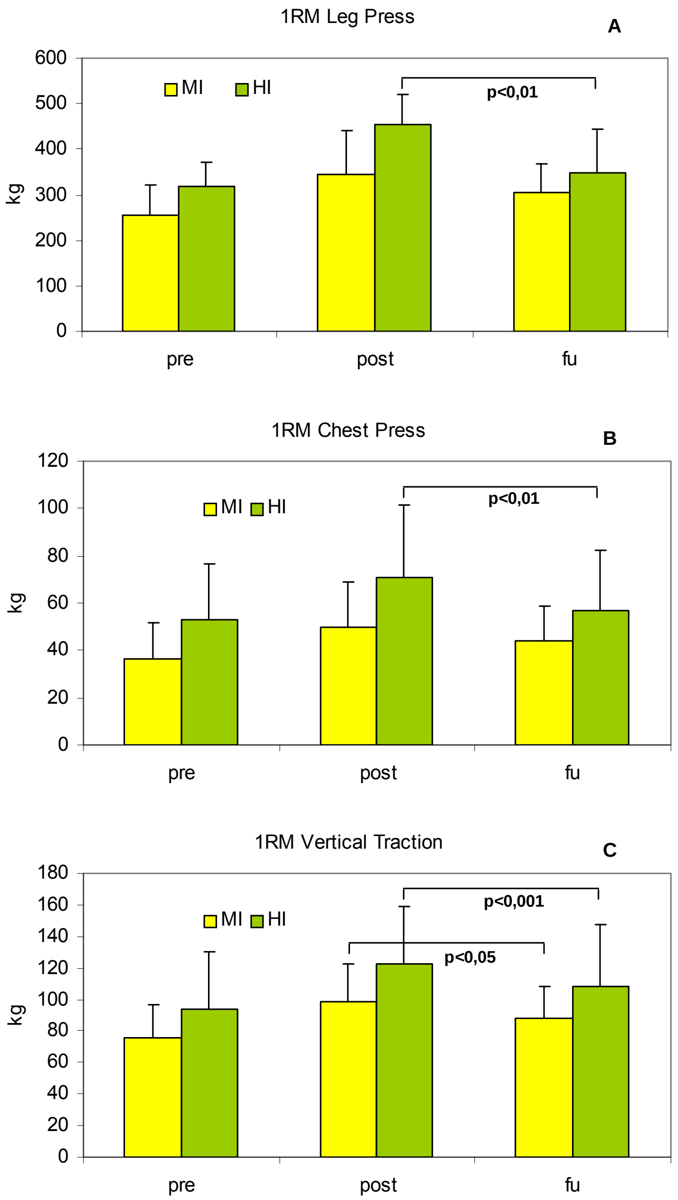
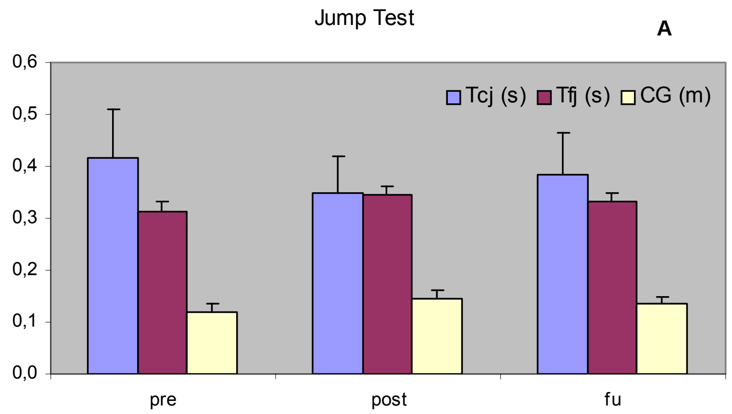
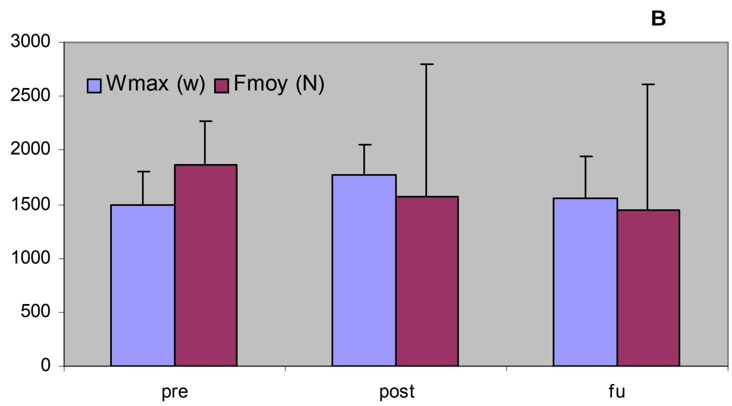


Figure 34 - Variations moyennes de la force isotonique maximale (1-RM) mesurée sur trois machines différentes, observées après le programme de 3 semaines et 1 an après la fin du programme chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI).

Puissance – trend N4 MI





3.4.2.3 Parametres sur lesquels les programmes presentent ou non une efficacite

L'efficacité de chaque programme a été vérifiée pour les paramètres principaux : poids, BMI, FM (kg), FFM (kg), CHD score, $\dot{V}O_2$max (l/min), force (LP, CP, VT). Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative).

Les deux programmes sont efficaces pour :

paramètres physiologiques

- Δ_3 VT ($p<0{,}05$)

Les deux programmes divergent pour :

paramètres anthropométriques

- Δ_3 Poids (significatif pour HI, $p<0{,}05$)
- Δ_3 BMI (significatif pour HI, $p<0{,}05$)
- Δ_3 FM (significatif pour HI, $p<0{,}05$)

paramètres physiologiques

- Δ_3 LP (significatif pour MI, $p<0{,}01$)
- Δ_3 CP (significatif pour MI, $p<0{,}05$)

Les deux programmes sont inefficaces pour :

paramètres anthropométriques

- Δ_3 FFM

facteurs de risque

- Δ_3 Framingham
- Δ_3 % risque

paramètres physiologiques

- Δ_3 $\dot{V}O_2max$
- Δ_3 PAR

3.4.2.4 EFFICACITE DE CHAQUE PROGRAMME EN FONCTION DU SEXE

L'efficacité du programme en fonction du sexe a été vérifiée pour les paramètres principaux : poids, BMI, FM, FFM, CHD score, $\dot{V}O_2max$, force (LP, CP, VT).

Les tableaux 58 et 59 montre les valeurs observées, avant et 1 an après le programme intégré, dans les deux groupes stratifiés par sexe.

Tableau 58 - Valeurs moyennes (± DS) des paramètres anthropométriques et liés à la santé observées chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant et 1 an après le programme de trois semaines.

	MI (N = 15)		HI (N = 9)	
	hommes (n = 5)	femmes (n = 10)	hommes (n = 3)	femmes (n = 6)
		POIDS (kg)		
avant	132,9 ± 20,5	108,5 ± 16,5	151,9 ± 30,7	109,4 ± 13,4
1 an	126,2 ± 16,8	100,9 ± 21,6	129,3 ± 14,5	104,5 ± 14,9
		BMI (kg/m^2)		
avant	43,5 ± 3,8	40,5 ± 3,2	48,4 ± 11,2	42,5 ± 4,2
1 an	41,5 ± 4,8	37,7 ± 5,9	41,2 ± 6,4	40,5 ± 4,4
		FM (kg)		
avant	50,4 ± 7,4	55,7 ± 11,7	60,8 ± 14,7	57,7 ± 11,4
1 an	50,5 ± 9,9	48,5 ± 17,4	47,6 ± 6,4	53,2 ± 13,4
		FFM (kg)		
avant	76,1 ± 7,9	53 ± 5,5	90,2 ± 16,3	52 ± 5,4
1 an	75,8 ± 9,8	52 ± 5,2	82,2 ± 8,1	51,7 ± 4,5
		Framingham		
avant	1,4 ± 4,2	-7,1 ± 2,6	-2 ± 0,0	-2,4 ± 6,1
1 an	1,8 ± 2,9	-8,9 ± 4,3	0,0 ± 1,4	1,8 ± 1,9
		CHD SCORE (% risque)		
avant	5 ± 3,0	1 ± 0,0	2 ± 0,0	3,5 ± 2,6
1 an	5 ± 2,4	1 ± 0,0	1,5 ± 0,7	3 ± 2,7

Tableau 59 - Valeurs moyennes (± DS) des paramètres physiologiques observées chez des sujets soumis à un entraînement à moyenne intensité (MI) et à un entraînement à haute intensité (HI) avant et 1 an après le programme de trois semaines.

	MI (N = 15)		HI (N = 9)	
	hommes (n = 5)	femmes (n = 10)	hommes (n = 3)	femmes (n = 6)
		PAR		
avant	0,6 ± 0,5	2,6 ± 2,2	1,3 ± 0,6	3 ± 2,8
1 an	1,2 ± 1,1	4 ± 3,1	6,3 ± 1,2	1,8 ± 0,5
		$\dot{V}O_2max$ (l/min)		
avant	3,1 ± 1,2	2,4 ± 0,5	3,8 ± 1,0	2,8 ± 1,1
1 an	3,7 ± 1,7	2,7 ± 1,0	5 ± 2,5	2,7 ± 0,7
		LP (kg)		
avant	309,4 ± 57,8	228,4 ± 54,8	378 ± 16,2	286,1 ± 34,2
1 an	343,3 ± 69,3	286,1 ± 53,1	455,1 ± 106,1	298,5 ± 42,6
		CP (kg)		
avant	45,6 ± 20,4	32,1 ± 10,3	81,3 ± 15,3	38,9 ± 8,0
1 an	45,6 ± 14,3	43,5 ± 15,4	86,9 ± 15,9	41,5 ± 11,3
		VT (kg)		
avant	94,1 ± 24,1	66,3 ± 12,0	134,3 ± 17,0	73,9 ± 23,6
1 an	103,9 ± 17,4	80 ± 17,0	159,1 ± 9,4	83 ± 8,0

Le Test des signes univariés a permis de déterminer sur quels paramètres chaque programme s'est-il montré déterminant (différence significative) en fonction du sexe.

Quelque soit le sexe les deux programmes sont efficaces pour :

aucun paramètre

Les deux programmes divergent pour :

<u>paramètres physiologiques</u>

- Δ_3 PAR (significatif pour hommes du programme HI, $p<0,05$)
- Δ_3 LP (significatif pour femmes du programme MI, $p<0,05$)
- Δ_3 CP (significatif pour femmes du programme MI, $p<0,01$)
- Δ_3 VT (significatif pour femmes du programme MI et pour hommes du programme HI, $p<0,05$)

Les deux programmes sont inefficaces pour :

<u>paramètres anthropométriques</u>

- Δ_3 Poids
- Δ_3 BMI
- Δ_3 FM
- Δ_3 FFM

<u>facteurs de risque</u>

- Δ_3 Framingham (significatif significatif pour femmes du programme A, $p<0,05$)
- Δ_3 % risque

<u>paramètres physiologiques</u>

- Δ_3 $\dot{V}O_2max$

Par ces résultats il sembleraient que le maintien d'un PAR plus élevé ne se reflète pas par une augmentation plus importante des paramètres physiologiques et par une diminution di poids, mais attention car la taille de l'échantillonnage pourrait biaiser les résultats.

3.4.2.5 Reponse au sein de chaque sexe en fonction du programme

Quelque soit le programme aucune différence de réponse à long terme n'existe entre les deux sexes en fonction du programme sauf pour Δ_3 FM ($p<0{,}05$) pour le quel les hommes ont eu une réduction plus significative que les femmes sans différence entre les programmes.

<u>Conclusions</u>

- Quelque soit le niveau d'intensité aucune différence significative de réponse n'existe quelque soit le sexe
- un an après, les deux groupes ont maintenu le poids corporel et la FFM qu'ils avaient au moment de la fin du programme intégré, tandis que les hommes ont eu une perte plus importante de FM que les femmes

Conclusions au terme de l'etude MI vs HI

» les deux programmes sont efficaces mais il n'y on a pas un supérieur à l'autre

Résultats à court terme

BMI & COMPOSITION CORPORELLE

Population	Poids (Δ_1) kg	BMI (Δ_1) kg/m^2	Masse grasse (Δ_1) kg	Masse maigre (Δ_1) kg
DEPAST	-5,31^{s}	-1,91^{s}	-4,1^{s}	-0,97^{s}
EPNS vs EPP	-4,85^{s} vs -4,65^{s}	-1,73^{s} vs -1,69^{s}	-2,8^{s} vs –3,52^{s}	-1,6^{s} vs –1,42^{ns}
A vs AF	-5,65^{s} vs -4,97^{s}	-2,01^{s} vs -1,8^{s}	-4,36^{s} vs -3,83^{s}	-0,78^{ns} vs -1,38^{s}
MI vs HI	-5,16^{s} vs -5,71^{s}	-1,85^{s} vs -2,05^{s}	-3,53^{s} vs -3,47^{s}	-1,4^{s} vs -0,79^{s}

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Perte de poids et de FM significative pour tous les groupes.
Perte de FFM plus ou moins importante pour tous les groupes.

FRAMINGHAM

Population	Framingham (Δ_1)	CHD % de risque (Δ_1)
DEPAST	-0,75^{s}	-0,31^{s}
EPNS vs EPP	+0,07^{ns} vs +0,07^{ns}	-0,73^{ns} vs -0,27^{ns}
A vs AF	-0,92^{ns} vs -0,85^{ns}	-0,46^{ns} vs -0,19^{ns}
MI vs HI	-0,81^{ns} vs -1,21^{s}	-0,29^{ns} vs -0,27^{ns}

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Tous les groupes ont obtenu une baisse non significative des paramètres de santé.

PARAMETRES CARDIOVASCULAIRES

Population	$\dot{V}O_2max$ (Δ_1) l/min
DEPAST	+0,36^{s}
EPNS vs EPP	-0,08^{ns} vs +0,15^{ns}
A vs AF	+0,43^{s} vs +0,24^{s}
MI vs HI	+0,27^{s} vs +0,23^{ns}

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Gain de $\dot{V}O_2max$ plus ou moins important pour tous les groupes qui ont suivi un entraînement personnalisé.
Seul le groupe EPNS n'a obtenu aucune amélioration des paramètres cardiovasculaires.

FORCE

Population	LP (Δ_1) kg	CP (Δ_1) kg	VT (Δ_1) kg
DEPAST	$+89{,}69^s$	$+9{,}24^s$	$+14{,}25^s$
EPNS vs EPP	$+55{,}01^s$ vs $+107{,}81^s$	$+5{,}11^s$ vs $+12{,}43^s$	$+7{,}42^s$ vs $+19{,}35^s$
A vs AF	$+66{,}07^s$ vs $+102{,}22^s$	$+5{,}26^s$ vs $+11{,}2^s$	$+8{,}28^s$ vs $+18{,}7^s$
MI vs HI	$+108{,}68^s$ vs $+111{,}18^s$	$+13{,}71^s$ vs $+15{,}59^s$	$+19{,}51^s$ vs $+19{,}91^s$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Différences significatives entre EPNS et EPP ($p<0{,}05$; power=1,000).
Différences significatives entre A et AF ($p<0{,}05$; power=1,00).
Tous les groupes ont obtenu une amélioration de la force mais le programme qui semblerait être le plus efficace est HI.

Résultats à long terme

Suivi à 6 mois

Population	PAR (Δ_2)
DEPAST	$2{,}15^{s}$
EPNS vs EPP	$-0{,}33^{ns}$ vs $+2{,}6^{s}$
A vs AF	$+2^{s}$ vs $+2{,}19^{s}$
MI vs HI	$+2{,}5^{s}$ vs $2{,}79^{s}$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Différences significatives entre EPNS et EPP (p<0,01).
Tous les groupes avec un programme d'entraînement personnalisé ont maintenu un niveau élevé d'activité physique.

Suivi à 1an
BMI & COMPOSITION CORPORELLE

Population	Poids (Δ_3) kg	BMI (Δ_3) kg/m^2	Masse grasse (Δ_3) kg	Masse maigre (Δ_3) kg
DEPAST	$-5{,}3^{s}$	$-1{,}92^{s}$	$-3{,}1^{ns}$	$+1{,}37^{ns}$
EPNS vs EPP	-1^{ns} vs $-4{,}4^{ns}$	$-0{,}49^{ns}$ vs $-1{,}7^{ns}$	$+0{,}77^{ns}$ vs $-5{,}06^{ns}$	$-1{,}58^{ns}$ vs $-0{,}14^{ns}$
A vs AF	$-5{,}14^{ns}$ vs $-4{,}8^{ns}$	$-1{,}95^{s}$ vs $-1{,}63^{ns}$	$-5{,}15^{s}$ vs $-2{,}5^{ns}$	$-0{,}06^{ns}$ vs $-0{,}82^{ns}$
MI vs HI	$-7{,}3^{ns}$ vs $-10{,}74^{s}$	$-2{,}6^{ns}$ vs $-3{,}7^{s}$	$-5{,}11^{ns}$ vs $-7{,}43^{s}$	$-0{,}78^{ns}$ vs $-2{,}88^{ns}$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Tous les sujets ont réussi à maintenir un poids corporel inférieur aux valeurs qu'ils avaient avant le début du programme intégré. Le groupe qui au contraire a réduit encore en partie son poids corporel est HI.
Le seul groupe qui a perdu masse grasse et augmenté la masse maigre est DEPAST.

PAR

Population	PAR (Δ_3)
DEPAST	$+0{,}84^{s}$
EPNS vs EPP	$+1{,}22^{ns}$ vs $+2{,}64^{s}$
A vs AF	$+0{,}95^{ns}$ vs $+0{,}5^{ns}$
MI vs HI	$+1{,}14^{ns}$ vs $+0{,}44^{ns}$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

L'auto-évaluation du niveau d'activité physique maintenu après la fin du programme a été maintenue à un niveau plus élevé que celui du pré programme pendant l'année analysée.

FRAMINGHAM

Population	Framingham (Δ_3)	CHD % de risque (Δ_3)
DEPAST	$-1{,}14^{s}$	$-0{,}07^{ns}$
EPNS vs EPP	$-0{,}33^{ns}$ vs $+2{,}7^{ns}$	$-1{,}67^{ns}$ vs $+0{,}2^{ns}$
A vs AF	$-1{,}5^{s}$ vs $-0{,}85^{ns}$	$-0{,}3^{ns}$ vs $+0{,}1^{ns}$
MI vs HI	$+0{,}13^{ns}$ vs $+2{,}88^{ns}$	$0{,}0^{ns}$ vs $-0{,}43^{ns}$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Les valeurs du score CHD ne sont significatives pour aucun groupe.
Les deux protocoles qui ont eu une plus grande efficacité sur les paramètres de santé sont A et DEPAST.

PARAMETRES CARDIOVASCULAIRES

Population	$\dot{V}O_2max$ (Δ_3) l/min
DEPAST	$+0{,}24^{s}$
EPNS vs EPP	$-0{,}54^{s}$ vs $+0{,}09^{ns}$
A vs AF	$+0{,}15^{ns}$ vs $+0{,}42^{s}$
MI vs HI	$+0{,}44^{ns}$ vs $+0{,}37^{ns}$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Différence significative entre EPNS et EPP ($p<0{,}05$; power=0,76). La variation du nombre d'effectifs aurait pu montrer une modification plus puissante (N=25, power=0,8).
Les deux protocoles qui ont eu une plus grande efficacité sur les paramètres cardiovasculaires sont AF et MI.
Celui qui n'a pas eu d'efficacité est EPNS.

FORCE

Population	LP (Δ_3) kg	CP (Δ_3) kg	VT (Δ_3) kg
DEPAST	$+44{,}22^{s}$	$+9{,}35^{s}$	$+11{,}24^{s}$
EPNS vs EPP	$+46{,}02^{ns}$ vs $+63{,}05^{s}$	$+10{,}39^{s}$ vs $+9{,}45^{s}$	$+14{,}91^{s}$ vs $+13{,}8^{s}$
A vs AF	$+43{,}8^{s}$ vs $+31{,}75^{ns}$	$+11{,}61^{s}$ vs $+6{,}39^{s}$	$+10{,}81^{s}$ vs $+11{,}27^{s}$
MI vs HI	$+49{,}77^{s}$ vs $+30{,}61^{ns}$	$+7{,}55^{s}$ vs $+3{,}64^{ns}$	$+12{,}46^{s}$ vs $+14{,}41^{s}$

valeur significativement différente de la valeur correspondante mesurée avant le programme :
^{s}différence significative ; ^{ns}aucune différence significative

Tous les sujets ont réussi a maintenir un niveau de force supérieur par rapport au tout début d'entraînement.

CONCLUSIONS AU TERME DES ETUDES

» population globale ➷ on a observé une amélioration des capacités physiologiques à court terme et à long terme qui s'accompagne d'une perte de poids

» une différence de comportement entre les sexes est remarquée ➷ une perte de FM chez les femmes et une augmentation chez les hommes qui ne se remarque pour le poids (on pourrait envisager un même apport de calories mais une distribution différente des nutriments_même quantité mais qualité différente des aliments)

» à court terme quelque soit le programme les hommes perdent plus de FFM que les femmes ➷ c'est induit par le régime (nécessité d'utiliser une diète iperprotéique ?)

» tous les programmes d'activité physique se sont révélés positifs à court terme pour tous les paramètres analysés ; tous se sont prouvés positifs à long terme pour le maintien du poids ➷ ce qui nous porte à conclure qu'il est nécessaire d'introduire l'activité physique comme élément indispensable dans la vie quotidienne (lifestyle)

» sans contrôle stricte du régime diététique il est nécessaire maintenir un niveau d'activité physique ➷ la seule analyse du PAR grâce au questionnaire peut apparaître peut fiable mais les test physiologiques permettent d'étayer les réponses individuelles du PAR

» il est difficile de déterminer qu'elle est le programme le plus efficace ➷ c'est à cause de l'échantillonnage

» étude des corrélation : la corrélation PAR - Δ_3 PAR montre que le programme intégré de RMC a fonctionné ➷ les sujets inactifs ont augmenté leur niveau d'activité physique

» comparaison des signes univariés nous montre que ➷ plus le Δ_3 PAR augmente et plus on note une perte de poids (plus le sujet est actif et plus il perd de poids)

- PERSPECTIVES D'AVENIR

➷

PROGRAMME D'ENTRAINEMENT ISOCALORIQUE PAR RAPPORT A MI MAIS ADAPTE EN INTENSITE POUR POUVOIR ETRE SOUMIS A UNE POPULATION DE SUJETS OBESES MORBIDES

OBSERVATIONS AU TERME DES ETUDES

» cette étude clinique s'est déroulé dans un hôpital, avec toutes les limitations d'appareillage ou de déroulement des tests et des entraînements ; les données des tests pourraient avoir un certain nombre d'erreurs, mais chaque groupe a été soumis aux mêmes tests.

» l'étude a porté sur les résultats d'une prise en charge thérapeutique par un hôpital, soumis à des contraintes du point de vue éthique ; le projet n'a pas pu inclure un groupe de contrôle, car il n'était pas possible d'hospitaliser des sujets obèses sans leur donner un traitement et les sujets qui ne faisaient pas d'activité physique (mais que la diète) n'étaient pas comparable avec les sujets étudiés ni comme âge, ni comme niveau de physical fitness de départ.

» il serait nécessaire rajouter un profil psychologique pour un meilleur encadrement et un follow up plus organisé pour une prise en charge meilleure des sujets obèses, pour éviter le drop out élevé à terme.

1 Introduction

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3 Résultats

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4 Discussion

4.1 Materials and Methods discussion

4.1.1 Behavioral intervention

Obesity may be the most significant medical problem that health care providers will face over the coming decades. The aim of our intervention was to create a protocol which could be easily apply to hospital clinical protocols and easily understood and used by primary care. In fact, physicians must aggressively address this chronic disease, providing both preventive and therapeutic care. Because this topic traditionally has not been taught in medical schools, physicians need to acquire the knowledge, skills, and attitudes necessary to be effective obesity care providers (Kushner, 2003).

We have tried to conceive a therapy as suggested since 1984 by Weinsier et al., including three components (diet, exercise, and behavioral/psychological support) together, since they are closely interrelated, interdependent and mutually supportive. Hills in 1988 suggested to add appropriate guidance and follow up. Besides, performing a detailed initial assessment, including an obesity-focused history, physical examination, and selected laboratory and diagnostic tests, is fundamental to the process of care (Kushner, 2003).

The main difference with literature is that our intervention protocol has a very short duration (3 weeks) if compared with the other weight loss intervention; in fact the duration of weight reduction varied between 8 weeks and 12 months (Fogelholm, 2000b). Our idea was to create a stratified intervention conducted year after year, requiring repeat episodes of weight loss in order to set goals that are optimistic, but realistic as suggested by Dixon in 2006. We aimed to repeat the short-term protocol several times obtaining sustained modest weight loss and avoiding weight regain during the 1y interval. During the passive follow up we asked subjects to maintain treatment focusing on healthful eating and exercise behaviors, to maintain weight loss and prevent weight regain long-term as suggested by Perri in 1995. We have contacted patients through telephone 6 months from baseline, according to Jakicic (2003c) suggestions. After 1y subjects were convened again to assess the long-term maintenance of the benefits obtained in the short-term thanks to exercise combined with dietary interventions; the length of the follow up was established according with Miller et al. (1997) and validated by the analysis of different reviews (Curioni, 2005; Douketis, 2005; Franz, 2007).

4.1.2 Diet

It is common for weight loss programs to reduce energy intake to 1000–1500 kcal/d to induce weight loss in obese adults. There may be some advantage to directly measuring energy expenditure; the absolute energy intake should be adjusted based on body weight to elicit an energy deficit of 500–1000 kcal/d (Wadden, 1994; Jeffery, 1995; Wing, 1996; Jakicic, 1999). For this reason we have performed for each subject an evaluation of the resting metabolic rate (RMR) with indirect calorimetry, in order to be the more accurate we can. This methodology to calculate caloric intake has been effective for both people with obesity of grade II and III as demonstrated by correlation analysis. Besides, subjects with morbid obesity has been the better responders for weight loss. On the contrary, the choice of macronutrient composition of the LCD has not followed any particular rules because, according to literature, the optimal macronutrient composition of the diet for weight loss has not been determined (ACSM, 2001; Volek, 2005).

4.1.3 Tests

4.1.3.1 Esthetics aim

Our tests in order to assess weight loss and body composition evaluation included the analysis of body weight, BMI, fat mass and fat free mass. One of the more accurate methodology to analyze body composition and fat content is the Dual energy X-ray absorptiometry (DEXA), but this apparatus is not widespread in hospital environment because it is very expensive. For this reason, in order to detect body composition variation we utilized the impedance method (BIA) which has been validated by numerous studies in obese subjects, confirming that BIA is a useful clinical method for measuring change in body composition (Heitmann, 1990; Kushner, 1990), especially for evaluating body-composition changes induced by diet and exercise interventions (Evans, 1999a). Some precautions has to be taken in order to have reliable data: population-specific BIA regression equations should be used because general BIA equations lead to consistent underprediction of percentage body fat compared with hydrostatic weighing (Heath, 1998; Newton, 2006) and a 3- or 4-compartmental analysis is necessary to accurately estimate body composition and its changes during weight loss (Ritz, 2007).

4.1.3.2 Health aim

Overweight and obesity now dominate the standard risk factors of coronary heart disease (CHD) and should be the focus of national policies for prevention (Nanchahal, 2005), obesity being an independent risk factor for CHD (Rashid, 2003) and CVD (Wilson, 2002). For this reason, a global assessment of cardiovascular risk should be made. The suggested method is to apply the Framingham Score (FPSS) (Hancu, 2004). The FPSS is comprised of summative scores assigned to age, total cholesterol, HDL-C, systolic blood pressure, treatment for hypertension, and cigarette smoking (Patt, 2003). In our study we have focused our attention on parameters linked to health in order to detect if our study allowed some health benefits. The scale we have used included sex, age, weight, height, BMI, diabetes, cigarette smoking, hypertension, total cholesterol, HDL-C (Wilson, 1998).

4.1.3.3 Physiological aim

In order to assess maximal oxygen uptake ($\dot{V}O_2max$) we have chosen to develop a test on cycle ergometer because we have judged it would be the more simple ergometer, involving easily movement to perform without any problem of coordination and balance. This choice has been dictated by different previous experiences (Andersen, 1995; Engelhart, 1996; Mattsson, 1997; Lear, 1999; Hulens, 2001) and confirmed by others (Larsson, 2003; Vsetulova, 2004). We have accomplished a submaximal test because our obese subjects had no training sessions before the test to enhance CV parameters to be able to sustain a real maximal test. Because in primary care and in wellness center no metabolic chart are available, we have also chosen to perform indirect estimation of oxygen consumption, even if this submaximal indirect test could lead measuring (calculation) error. This methodology has been utilized by previous research with reliable results (Mattsson, 1997; Larsson, 2003). Different formulas to estimate oxygen consumption are available: two ACSM formulas and the Latin equation. In 1995, Andersen demonstrated that Latin equation was more accurate than the first ACSM formula for estimating oxygen consumption of loaded cycling in obese women. For this reason we have used the second ACSM formula (ACSM, 2000): $\dot{V}O_2$ = (kgm/min x 1,8ml/kgm) / BW(kg) + 7ml/kg/min. We were aware that the energy expenditure of the obese would be overestimated during non-weight-bearing activities, because energy expenditure expressed per kilogram body mass during these activities is much lower in the obese than in the lean (Saris, 2003), with an error ranging from 8,4 to 31,9% (Lafortuna, 2006). Another error in the estimation of $\dot{V}O_2max$ could depend on the choice of HRmax formula. Even in this case more formulas are available (Cooper formula; Miller, 1993; Tanaka, 2001). We have decided to use the more common (Cooper formula = 220-age). Even if our interest was to control variation in aerobic qualities not to give the actual $\dot{V}O_2max$ of the subject, our values were very closed with the average of the literature, 25 ml/kg/min. In order to understand subjective effort we have controlled the rating of perceived exertion (RPE) during tests and training sessions as carried out by previous (Petroiu, 1984; Sakamoto, 2001) and following (Hulens, 2003; Lotti, 2005; Matoulek, 2007) studies.

For the evaluation of maximal strength we have used the same procedure, choosing an indirect test to estimate 1RM. Instead of using the Wathan equation as Karelis did in 2007, we have chosen the Brzycki formula which we have already used with normal weight people in different wellness centers. The preference for Closed Kinetic Chain Exercises (CKCE), that are physical exercises performed where the hand (for arm movement) or foot (for leg movement) is fixed and cannot move, has been driven by the idea that these multi-joint movements would be more easily to perform, because they simulate everyday movements such as lifting up something from the floor, pulling or pushing something. This choice has been accomplished by another researcher with obese subjects (Fett, 2005).

4.1.4 Training protocols

During the short-term intervention, tailored training protocols were designed in agreement with the guidelines dictated by the American College of Sport Medicine (ACSM, 2000), trying to chose a volume (intensity x time or intensity x series and repetitions) of PA that obese subjects could perform, without any previous conditioning training sessions. In 2001 the ACSM published a position stand on weight loss management where it was underlined that a sufficient amount of moderate-intensity (55–69% of maximal heart rate) exercise could be beneficial for management of body weight, with limited published scientific evidence from randomized trials supporting the necessity of more vigorous (70% of maximal heart rate) forms of exercise (ACSM, 2001), confirming the validity of our training protocols. Since cardiovascular responses to exercise are directly proportional to oxygen demands of skeletal musculature, with oxygen uptake ($\dot{V}O_2$) and heart rate (HR) increasing linearly with work rate, we have used HR for monitoring exercise at specific intensities. In fact, our CV training exercises were guided by the CPR (Constant Pulse Rate) system (Technogym, Italy), which monitors continuously individual HR and in real time redefines the workload based on the heart rate selected for training (the workload varies automatically according to the users reaction to the exercise). This makes it possible to exercise in a safe, effective manner, even if this procedure requires the choice of the more correct relationship between $\dot{V}O_2$ and HR in obese subjects. Different regression equations examined the relationship between $\dot{V}O_2$ and HR in normal weights (Swain, 1994; ACSM, 2000) and in obese (Miller, 1993; Byrne, 2002). Our study have used ACSM relationship because it is the more frequently used in constant workload. At the time we have decided our study protocol, Byrne research on obese people had not been published. According to Byrne results (the %HRpeak-%$\dot{V}O_2$peak relationship was significantly greater than the ACSM recommendations), in our study we have underestimated training workload. In the obese population, the magnitude of discrepancy in %HRpeak at 40%$\dot{V}O_2$peak was 9%. In order to be more precise, because the precision of the HR–$\dot{V}O_2$ relationship may vary from subject to subject as a function of the metabolic stress or physical training level, we should also have individually determined it (Skinner, 2003). However, exercise intensity, controlled during each training session over the 3-wk program through HR, has avoided any further over or underestimation of the workload. It was decided that exercise intensity would increase from 50 or 60 to 60 or 70%$\dot{V}O_2$max and that exercise prescription would be based on the HR associated with 50, 60, and 70% of each subject's initial $\dot{V}O_2$max. One of the most common changes with training is a reduction in HR at the same absolute power output. In this study, the CPR system controlled the resistance of the different ergometers to maintain HR at the programmed level. Over the course of the 3-wk training program, it was assumed that the fitness level of the participants would improve and this was controlled thanks to the performance index (IP) downloaded automatically at the end of each training session.

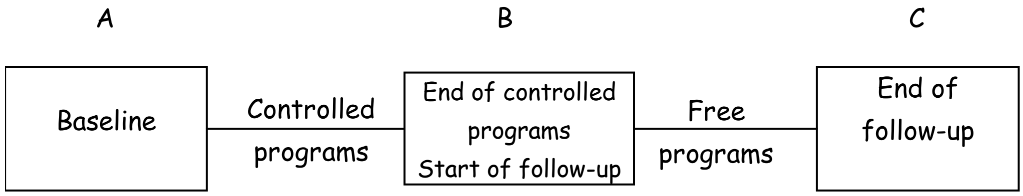
The decision to introduce also strength training has been dictated by the fact that resistance training is recognized to be a potent stimulus to increase fat-free mass (FFM), muscular strength, and power and thus may be an important component of a successful weight loss program by helping to preserve FFM while maximizing fat loss (Ballor, 1988; Pavlou, 1989; Garrow, 1995; Marks, 1995; Ross, 1995 a and b; Geliebter, 1997; Kraemer, 1999).

More difficult has been the choice of the recommended amount of PA to perform by the subjects during the 1y of free living. If it is well recognized that the maintenance of exercise may be one of the best predictors of long-term weight maintenance (Pronk, 1994; Miller, 1997; NHLBI, 1998), no agreement has been reached on the amount of PA necessary to weight loss and to maintain weight lost. Different studies recommend for obese people to participate in at least 30 min of moderate intensity physical activity on most, preferably all, days of the week (Barlow, 1995; Lee, 1998; Wei, 1999). Another study suggests levels of exercise that are greater than the minimal public health for obese people (Schoeller, 1997), Jakicic in 1999 specifying to progress to 200–300 min of exercise per week or 2000 kcal/wk. More recently, a consensus meeting was held in Bangkok (Saris, 2003), where experts in the field of physical activity, energy expenditure and body weight regulation discussed the different aspects of physical activity in relation to the emerging problem of obesity worldwide. The following consensus statement was accepted unanimously: 'The current physical activity guideline for adults of 30 minutes of moderate intensity activity daily, preferably all days of the week, is of importance for limiting health risks for a number of chronic diseases including coronary heart disease and diabetes. However for preventing weight gain or regain this guideline is likely to be insufficient for many individuals in the current environment. There is compelling evidence that prevention of weight regain in formerly obese individuals requires 60–90 minutes of moderate intensity activity or lesser amounts of vigorous intensity activity. Although definitive data are lacking, it seems likely that moderate intensity activity of approximately 45 to 60 minutes per day, or 1.7 PAL is required to prevent the transition to overweight or obesity. For children, even more activity time is recommended. A good approach for many individuals to obtain the recommended level of physical activity is to reduce sedentary behavior by incorporating more incidental and leisure-time activity into the daily routine. Political action is imperative to effect physical and social environmental changes to enable and encourage physical activity. Settings in which these environmental changes can be implemented include the urban and transportation infrastructure, schools, and workplaces.' Our choice to ask subjects to accumulate 30min of PA 5 days/week has been dictated by its feasibility and by the fact that this was the amount of exercise they used to practice during the short-term intervention. We hope to find the physical activity level (PAL) necessary to maintain energy balance and keep body weight stable in weight-reduced/obesity-prone individuals. 30min of exercise are sufficient to obtain an increase of

$\dot{V}O_2max$ and thereby enable the reduced-obese individual to expend sufficient amounts of energy with a reasonable time in order to prevent weight regain (Saris, 2003). The evaluation that the optimal PAL was around 60 min, but most probably it is closer to 80–90 min, of moderate levels of activities such as walking or cycling, has not met our favor.

4.1.5 Statistical analysis

Because of the study design,



statistical analysis has been centred on AB, during which period all training programs were standardised and controlled. Our interest in C has been dictated to objectively define if subjects have maintained a sufficient physical activity level at least to save the results previously obtained. The aim was not to know the global effect from A to C (controlled programs + free programs) because of the possibility to bias results due to the fact that free and uncontrolled programs could enhance or miss all acquired benefits. For this reason a repeated measure ANOVA is not a relevant test. Parametric or nonparametric (t-Student paired and unpaired or Wilcoxon or Mann-Whitney tests) tests were used, according to normal distribution or not.

The 'intention to treat' model has not been performed, even if a large number of dropouts occurred. ITT analysis is intended to avoid various misleading artifacts that can arise in intervention research. For the purposes of ITT analysis, everyone who begins the treatment is considered to be part of the trial, whether they finish it or not. Normally, the last available value of subjects is computed, even if inappropriate handling of missing response can produce misleading conclusions. For example, body weight has decreased from the end of the integrated program till 6-month follow-up and increased again from the first follow-up till the end of the study (FU 1yr). Dropouts occurred at 1 yr. If we had used available data at 6-month to estimate body weight at 1 year we could alter the efficacy of the integrated program.

4.2 Results Discussion

All results on body composition and physiological parameters (maximal oxygen consumption and maximal strength) has to be considered with caution because they have been estimated with indirect tests.

4.2.1 Short-term results

In the first study (DEPAST) our main findings have been:

- a significant enhancement of all studied parameters;
- no differences in the behavior between sex were detected;
- an identification of responders for weight loss (subjects at baseline with a higher BMI) and for FM decrease (subjects at baseline with the lower BW) has been studied.

Some results from this thesis have been included in one of the published contributions included in these articles: Sartorio, 2003a; Sartorio, 2003c, Sartorio, 2005b.

The present study reveals that a short-term individualized and supervised aerobic and strength exercise regimen in combination with energy-restricted diet, nutritional education and psychological counseling significantly reduces body mass, improves body composition and enables the achievement of a significant improvement in both aerobic, strength and lower limb anaerobic performance in a group of morbidly obese patients (grade II and III).

The exercise protocol employed in the study was in line with the recommendations of the American College of Sport Medicine (ACSM, 2000), suggesting a regular program of moderate-to-vigorous intensity aerobic exercise for an accrued time of at least 30 minutes a day to reverse obesity-related risk factors. Moreover, in the present study an individualized program was devised on the basis of the individual maximal aerobic power and maximal strength estimated before the beginning of the training phase.

From the present data it appears that the weight loss induced in both males and females by the body weight reduction (BWR) program is obtained mainly through a reduction in fat mass, with a modest change in fat-free mass. Previous investigations substantiated the favorable role of exercise training in the prevention of skeletal mass loss resulting from prolonged dietary restriction alone in moderately obese or overweight subjects (Pavlou, 1985; Ross,1996). The present study confirms these findings and extends the observations to severely obese patients, which, markedly reduced their body weight and fat mass without any markedly change in fat-free mass.

Concomitant with the changes in body weight and composition, a significant increase was observed in $\dot{V}O_2max$, both in relative and absolute terms and independent from genders, reflecting thus not only the decrease in body fat mass, but likely being the expression of an improvement in cardio-respiratory and metabolic capabilities. This was achieved through an exercise intensity equivalent to 50% of the individual maximum capacity (during the 1st week) with a progression to 60% during the 2nd and 3rd

conditioning. Although the training threshold is not known for obese patients, it has been suggested that, for people in relatively poor physical condition, the training threshold may correspond to about 45% of $\dot{V}O_2max$ (Gaesser, 1984). So the patients of the present study have likely exercised well above the threshold, in the so called 'training-sensitive zone', thus optimizing the conditioning improvement (Shephard, 1968) in spite of a moderate volume of exercise. The improvement of absolute maximum oxygen consumption obtained in this study is consistent with previous results obtained in overweight individuals (Kraemer, 1999) and also in obese patients (grade II and III) of both genders after a different aspecific aerobic exercise training (Sartorio, 2001a). Although physical training is well known to induce metabolic adaptations improving a variety of functional capacity related to oxygen transport and use, the improvement presently reported appear to be a relatively high figure for a training program of a moderate intensity. Nevertheless, the notably poor degree of physical fitness of our subjects before starting the protocol could justify these results. In fact, it has been previously evidenced that the magnitude of improvement in aerobic performance after a training program is inversely related to the initial level of fitness (Pollok, 1973) and that these improvements are attained mostly within the first 3 weeks of training (Hickson, 1981).

Maximum strength, as determined by 1-RM testing in the Leg Press, Chest Press and Vertical Traction exercise was significantly increased in all muscle groups.

Consistent with the increase in maximum aerobic performance was the rate of perceived exertion during the $\dot{V}O_2max$ test, which, for effect of the program, was significantly and markedly reduced without any difference between the subjects of the two genders. As a consequence of such an improvement in $\dot{V}O_2max$, a significant increase was observed in the work capacity developed during both bicycle ergometer pedaling and treadmill walking in terms of both caloric equivalent of work performed at a constant metabolic load and performance index, which can be therefore considered a reliable indicator of the subject's work capacity. Such an improvement corresponded in mean to a total increase of about 45 kcal between the first and the last day of the program in the caloric output attained during the 30-min period of a single conditioning session.

In spite of the specific aerobic exercise training used in this study, an improvement in the performance based mainly on maximal jumping power was also observed. These changes have to be considered independent from the increase in the specific power output (e.g. the power calculated per kg body mass) attained as consequence of the weight loss. In fact, changes in lower limb power observed during jumping test do not match the decrease in body mass attained after the DEPAST program. Thus a part of the improvement has to be ascribed to different factors. One of these might be related to the positive effect of even moderate aerobic exercise in maintaining fat-free mass during weight reduction, as observed in moderately obese or overweight individuals of both genders (Ross, 1996). So, a relative increase in muscle mass may in part contribute to the observed improvement in anaerobic performance described in the present study, although detailed measurement of lower limb mass is required to assess quantitatively the importance of this factor. Further, the acquisition of a certain degree of motor skillness for the training effect of the exercise program could not be excluded in explaining the results observed during maximal jumping power as, in general, the subjects were notably sedentary at the beginning of the program and possibly limited in movements by their unfamiliarity with physical exercise. In line with present findings, Sartorio et al. (2001b) recently found that an aspecific and mainly aerobic exercise conditioning in morbidly obese subjects significantly increased motor coordination in balance test as well as in anaerobic tasks. Finally, an improvement in general well-being and self-esteem after the program, determining on turn a higher level of motivation during the motor task should be considered, since Nieman et al. (2000) recently demonstrated in a group of obese women that the combination of energy restriction and low intensity exercise training significantly improves psychological general well-being scores.

In line with the report of Kraemer et al. (1999) in moderately obese subjects, the combination of aerobic and strength exercise enabled in both genders a significant change in body composition with a definite improvement in FFM.

In conclusion, the present investigation indicates that a short-term body mass reduction program, combining restricted diet, nutritional education, psychological counseling and individualized and supervised aerobic exercise improves aerobic, strength and anaerobic alactic performance in severely obese patients.

In the second study (EPNSvsEPP) our main findings have been:

- no significant differences have been detected between the two training protocols in the enhancement of all the studied parameters;
- 30min of CV training per day are effective independently of the type of exercise and are well tolerated during a LCD;
- only the tailored strength program has enhanced maximum strength, preserving fat free mass;
- a difference in the increase of maximum strength between sex has been detected.

This article is a portion of the present thesis: Lafortuna et al. (2003).

In spite of the different volume of aerobic and strength exercises entailed in the two protocols (consisting in total of about 45 min of exercise per day for the EPP group and ranging from 60 to 100 min per day for EPNS group) it can be calculated that the weekly energy expenditure did not change as a consequence of the difference in exercise intensity, and the effects could be adequately compared. In fact, the weekly caloric output, determined by means of the HR values observed during the aerobic and strength exercise training, was on average for the EPNS group 1517±200 kcal, as referred to the initial evaluation of

$\dot{V}O_2$max, while the EPP subjects developed a weekly energy expenditure of 1344±354 kcal during the first week of the exercise program which rose up to 1661±399 kcal during the third week, with an average expenditure of 1529±305 kcal over the entire period. Thus, the two protocols can be considered as isocaloric and are respectively definable as low volume moderate intensity individualized (EPP) and high volume low intensity non-individualized (EPNS) exercise. Different factors are known to influence the effect of training as initial fitness level and intensity, volume, frequency and type of exercise (Shephard, 1968) but, at present, no detailed study is available in obesity, in general and in morbid obesity (grade II and III), in particular. Therefore, it is of relevant interest to contrast the physiological effects of these two exercise protocols, as complement of dieting, with inherent different practical features in a population of extremely obese patients. These patients are in fact characterized by a very poor initial fitness level due to either a notably sedentary lifestyle and intrinsically reduced muscular performance (Lafortuna, 2002; Sartorio, 2001b). In this short-term investigation we provide evidence that EPP and EPNS protocols achieve comparable results in terms of body mass reduction. However, maximum oxygen uptake and maximal jumping power expressed in absolute terms increased significantly only in EPP, although significant changes were observed in both study groups when oxygen uptake and jumping power were expressed relative to body mass. On the contrary, maximum isotonic strength in all investigated muscle groups significantly improved in both EPP and EPNS, although the changes were significantly greater in EPP.

So the individualized low-volume moderate-intensity schedule of exercise conditioning in EPP protocol appears to enable the achievement of a better absolute aerobic performance and we can speculate that this reflects a true functional improvement of muscular oxidative capacity and whole body cardiorespiratory adaptation. This was possibly due to the intensity of exercise equivalent to 50% of individual maximum aerobic capacity with a progression to 60%, aimed to match the training improvements. On the opposite, the more simple and more easily attainable prescription of a constant load exercise (60W) of the EPNS protocol may have entailed an exercise intensity below the training threshold for most patients and possibly approaching a suboptimal overtraining for some others, although the ceiling for training intensity is unknown also for non-obese subjects. In fact, the constant load of EPNS protocol represented an exercise intensity equivalent to fractions of initial individual maximum aerobic capacity ranging from 19% to 67%, therefore enabling an irrelevant average improvement in this group.

Both EPP and EPNS groups experienced a significant increase in 1RM strength in the Leg Press, Chest Press and Vertical Traction machines, although the specific resistance training performed by patients in the EPP group determined strength improvements significantly greater than those attained by subjects in the EPNS group which performed calisthenics oriented to arm and leg strength exercises. It thus appears that also the relatively non-specific dynamic standing and floor exercise performed by

EPNS subjects is sufficient to attain improvements in muscular strength. It may be argued that a change in fat-free mass could be hardly responsible of the observed strength improvements in a so short time course. In fact, Staron et al. (1994) could not detect significant changes in muscle cross-sectional area during a 8 week period of progressive resistance training in spite of a significant increase in maximum dynamic strength already apparent after 2-4 weeks. On the contrary these authors observed a significant muscle fiber type conversion from type IIb to type IIa with increases in anaerobic sources and enzymes. Therefore it might be speculated that most of strength improvements observed also in the present study are mainly due to changes in neural mechanism of motor units recruitment (Enoka, 1988). Independent from the responsible adaptive mechanism these results further confirm the positive impact of the implementation of a strength training in body mass reduction programs focused on exercise conditioning (Kraemer, 1999; Sartorio, 2003b).

In contrast with the effect of the protocols on maximum strength, only in EPP group significant changes were observed in maximal jumping power. Coherent with this finding were the results concerning the flight and contact time of feet with ground as well as the vertical velocity during the take-off and the average force calculated during the push phase of the jump. Significant changes were observed also in EPNS group for the specific power output and specific average force during the push phase (e.g. relative to body mass) and the vertical displacement of the center of gravity during the jump (which is strictly correlated with the specific power output), indicating that these changes likely reflect the decrease in body mass in this group, though they entail a real improvement in the motor capability in every-day life. The discrepancy between improvements in strength and power output observed in the EPNS group rises the possibility that processes sustaining power generation during fast-velocity contractions and those sustaining strength generation during slow-velocity contractions may be influenced differently by the relatively non-specific kind of training as standing and floor dynamic exercises performed by EPNS subjects. A similar finding was reported by Kraemer et al. (1999) in overweight and moderately obese subjects.

The difference in the increase of maximum strength between sex detected in this study has not been confirmed by another study that have used our same protocol (Sartorio, 2005b).

In conclusion, the present investigation reveals that a simple, non-specific and well-tolerated exercise protocol as EPNS may have a consistent role in a body mass reduction program, enabling the attainment of significant weight loss and improvement of motor capabilities. This is in agreement with previous results obtained with the same exercise training protocol, demonstrating also an improvement in motor control (Sartorio, 2001b), a favorable shift in the balance between parasympathetic and sympathetic neural activity (Sartorio, 2001a) and a significant reduction of cardiovascular risk factors (Sartorio, 2001c). Nonetheless, an individualized and more structured exercise protocol as EPNS, offers similar results in terms of weight loss but better overall results in terms of muscle performance and physical fitness, and may sustain a stronger motivation to subsequent exercise activity.

In the third study (AvsAF) our main findings have been:

- no significant differences have been detected between the two training protocols in the enhancement of health related parameters and in weight loss;
- differences between sex have been detected: male loose both fat mass and fat free mass and men participating to A protocol have increased more their $\dot{V}O_2$max;
- $\dot{V}O_2$max enhancement seems to be due to both fat mass and fat free mass loss.

This article is a portion of the present thesis: Sartorio et al. (2003b).

The present investigation reveals that a body weight reduction program entailing a moderate volume of aerobic exercise training enables the attainment in the short term of significant reduction in BMI, significant improvements in aerobic capacity as well as significant improvements in muscle performance. If also a moderate strength training is added, a further significant improvement in force in the involved muscle groups can be attained.

Training protocols showed similar results for body weight decrease and CV improvement, even if subjects of group A had a significant greater AEE.

A significant improvement also in the performance based mainly on maximal jumping power was observed in both A and AF patients. In patients performing also strength training, in addition to aerobic exercise (AF group) it was detected an increase in maximal force significantly higher than that found in patients undergoing aerobic training only (A group). This is in spite of the fact that no significant difference between A and AF group was actually detected in the performance in the jumping tests, although several variables ranked numerically higher in AF group. This finding of a significantly increased maximal force without a correspondent increase of maximal jumping power observed in group AF in respect of group A, is not completely surprising. In fact, force generation on isotonic machines and jumping test imply very different velocity and duration of the action. So, the longer duration of the muscular contraction during exercise on isotonic machines may not correspond to the optimal velocity of shortening for maximal power production during jumping.

The different impact of the same training protocol in males and females has been demonstrated by Sartorio et al. (2005b), showing that in men the BW loss was composed by a similar amount of fat mass (FM) and fat-free mass (FFM), whereas women lost FM almost entirely. We can hypothesize that this different response is due to the type of diet administered during our intervention program, suggesting the necessity for men of a diet increasing lean protein, in order to preserve FFM, to enhance satiety, to promote a low glycemic index and to increase thermogenesis (ACSM, 2001). The Clinical Practice Guidelines for the Management of Overweight and Obesity in Adults (NHMRC, 2003) showed that individual variations between genders existed for other parameters, for example in the weight loss response to exercise. Males with more gynoid-pattern fat stores and pre-menopausal females, for example, are known to typically lose less weight in response to a set amount of exercise compared with android-shaped males (Ballor, 1995).

Our data were not able to confirm all previous results obtained by Kraemer et al. (1999) indicating that a weight loss dietary regimen in conjunction with aerobic and resistance exercise prevents the normal decline in fat-free mass and muscular power and augments body composition, maximal strength, and maximum oxygen consumption compared with weight loss induced by diet alone.

In conclusion, the present investigation demonstrates that a body weight reduction program entailing a simple exercise conditioning of moderate intensity significantly improves, also in the short-term, the performance of motor tasks based on both aerobic and anaerobic capabilities in severely (grade II and III) obese patients. The adjunction of strength training to systematic aerobic conditioning also improves the capability of force generation in these patients. In view of the considerable degree of deconditioning and poor physical fitness of these patients at the beginning of the study, it is likely that the motor changes attained with the present program well contribute in enhancing life quality by improving patients' capabilities in executing every-day tasks related to even simple motor performances.

In the fourth study (MIvsHI) our main findings have been:

- no significant differences have been detected between the two training protocols in weight loss, in the decrease of fat mass and in the improvement of maximal strength;
- this study confirms the fact that men loose both fat mass and fat free mass during the short-term intervention;
- women participating to MI protocol have increased more their $\dot{V}O_2$max.

Our study showed that for obese sedentary subjects an increase in PA intensity is not necessary in the first 3 weeks of training. Normally it has been demonstrated (Di Pietro, 1999) that the rate of weight loss is positively related to the frequency and duration of the exercise session, as well as the duration of the exercise program, thereby suggesting a dose-response relationship. The lack of difference between our two groups is probably due to the length of the intervention, that should be increased to at least 8 weeks to see any differences, even if this trend has been confirmed by Duncan et al. (1991) and more recently by Jakicic et al. (2003b) and Chambliss (2005) reporting no effect of exercise duration or exercise intensity on changes in body weight or in BMI. These data suggest that weight loss interventions should initially target adequate levels of energy expenditure, with the intensity of the activity adjusted to the individual based on fitness level and preference. So that energy expenditure rather than exercise intensity is important for enhancing weight loss outcomes

(Jakicic, 2006). Moreover, our results in a lack of difference between training protocols fat mass decrease has been confirmed by Grediagin et al. (1995), Leutholtz et al. (1995), Okura et al. (2003) studies whose results indicate that, independent of diet, exercise intensity does not influence FM changes.

We can also hypothesize that the increased intensity has not been well accepted by obese sedentary subjects from a motivational point of view, confirming Fogelholm et al. (2000a) observation that more subjects requested a reduction, rather than an increase, of walking intensity. From a physiological point of view, we can suppose that the increased aerobic intensity (60-70% $\dot{V}O_2max$) for women has not produced the attended results because women were not able to sustain the intensity level. With the CPR system when subjects are not able to maintain the assigned workload, in order to avoid an increase of heart rate, the ergometer automatically decrease the workload. We can assume that HI women have not obtained effectively a greater PA volume than MI women.

Beside the improvements observed in general physical performance and motor capabilities, these protocols entailed also interesting advantages in metabolic and cardiovascular parameters. For all studies, the weight loss produced by diet combined with the 30 min of CV exercises added to some strength exercises have produced the health benefits suggested by NHMRC (2003) and Douketis et al. (2005). In fact, health benefits occur at a moderate level of activity and epidemiological evidence clearly shows that this level of activity yields substantial metabolic benefits (reduced dyslipidaemia, reduced hypertension and improved blood glucose control) (Egger, 1999) with potential reductions in cardiovascular disease (Singh, 1992; Anderson, 2001b; Glazer, 2001).

4.2.2 Long-term results

4.2.2.1 6 months follow up

Although data obtained through telephonic interview must be considered with great caution, our results at 6 months from baseline were very encouraging, all tailored programs producing a further weight loss and maintaining a high level of PA. Subjects reported a PAR raging around 4 or 5, attesting to participate regularly in heavy physical exercise (such as jogging or cycling) or to engage in vigorous aerobic type activity (such as tennis or basketball) for 30 to 60 min per week.

The only significant differences were reported between EPNS and EPP groups, indicating a different level of motivation in the adherence to an exercise program after the acute short-term phase of the study. It is possible that the individualized nature of the physical activity performed on computerized devices by subjects of the EPP, with the personal assistance of a dedicated trainer, may have contributed to the perception of exercise as a relatively simple and gratifying task and further investigation on these cognitive aspects seems to be warranted. Moreover, no information is available at present about the different effect possibly exerted on motivation by low-intensity/high-volume as compared to moderate-intensity/low-volume exercise protocols in obese individuals. Oman and King (1998) recently reported that exercise program format as well as individual's initial cognitive and behavioral experiences in an exercise program play significant roles in determining exercise adherence. Therefore, an influence induced by the modality of exercise *per se* could not be excluded also in obese subjects. Another possible explanation is that the better overall performance level attained by EPP subjects at the end of the program may have strengthened subsequent motivation in physical activity participation. Whatever the basis for these results regarding exercise adherence, they seem particularly relevant in view of the concomitant trend in body weight (BW) during the period of the follow up, which consists in a further reduction of BW for the EPP subjects and a partial regain of BW for the EPNS subjects.

4.2.2.2 1 year follow up

In all studies the main findings have been:

- maintenance of the weight loss induced by the clinical intervention, with an average weight loss from baseline for tailored training programs of 6 kg;
- maintenance of the fat mass loss induced by the clinical intervention, with an average FM loss from baseline for tailored training programs of 5 kg with a non significant variation of fat free mass;
- enhancement of physiological parameters from baseline;
- lost of the health benefits induced by the BWR program;
- PAR level during 1y attested subjects participating in recreation or work requiring modest physical activity (such as calisthenics, gymnastics, walking) over one hour per week, which has not allowed a further weight loss after intervention, but was sufficient to enhance physiological parameters and to avoid weight regain;
- the significant correlation observed between PAR and Δ_3 PAR demonstrates the efficacy of our BWR program in obtaining a lifestyle modification in obese subjects, because it reveals that previous sedentary subjects have increased their level of PA;
- the PAR level is correlated with weight loss: subjects who exercised more have lost more BW;
- a different pattern has been observed between sex: a same behavior in weight loss with a FM decrease for women and a FM increase for men.

Some results from this thesis have been included in this article: Maffiuletti et al. (2005).

Our study contrasts with literature because of the length of the short-term intervention (3 weeks). In fact, the duration of the weight reduction interventions ranged from 8 weeks to 12 months. On the contrary, the duration of follow up (1 year) is in agreement with literature; in fact the duration of follow up ranged from one to more than 7 years (usually one to 3 years) (Fogelholm, 2000b). However, the results of this study confirm that a 3-week hospital-based BWR program entailing energy-restricted diet, physical activity, psychological counseling and nutritional education improved significantly body composition, physical performance and cardiovascular risk factors in severely obese subjects of both genders, attesting the validity of an integrated intervention at short-term and at long-term. Many studies attested that diet associated with exercise results in significant and clinically meaningful initial weight loss (Curioni, 2005) and that this is partially sustained after 1 y (Wing, 1999; Curioni, 2005; Jakicic, 2005b). Avenell et al. (2004b) underlined in their systematic review the importance of adding exercise to diet and behavior therapy.

The rate of clinical success observed in the current investigation is not very high (58%) if compared to previous research on medium-term follow up (Fogelholm, 2000b). Success rate introduces another important topic for weight loss success: adherence. In fact, Catenacci and Wyatt (2007) underline that a central issue in the effectiveness of a physical activity program is adherence; poor adherence to a given exercise protocol might be one of the main reasons why BWR interventions so often fail to find an association between physical activity and weight maintenance. Adherence to exercise may ultimately prove to be the cornerstone for long-term weight maintenance (Pronk, 1994).

Besides, one of the major problem clinicians are faced to is weight regain. Current treatment programs for obese individuals are not very effective over the long term, leading to the common wisdom that persons who successfully lose weight will regain it all within 5 y (Anderson, 2001a). Weight regain appears to be influenced by the volume of physical activity carried out. Exercise in excess of about 30 minutes' brisk walking a day has been associated with a 35 to 40% weight regain, whereas exercise of more than 80 minutes has been associated with less than 15% weight regain (NHMRC, 2003).

In our opinion, a crucial point is effectively which is the correct amount of exercise to ask obese subjects to perform during passive follow up to maintain their weight loss, thinking about the fact that one of the main barrier to be active is the lack of time. How can people find 80 min each day for PA? Sometimes, it is not possible to distinguish the effects of the higher exercise level per se from the effects of the strategies used to promote adherence to the high exercise goal—namely, the involvement of friends, the use of exercise coaches, and monetary incentives (Jeffery, 2003). In our opinion, it would be better to focus on minor time spent in PA, primarily looking for health benefits than weight loss or weight-regain.

Our results are very promising, founding that 75% of the original subjects maintained a body weight lower than baseline after the end of the in-patient BWR program. Interestingly, clinical success at follow up was associated with higher levels of self-reported physical activity with respect to clinical failure, and as a consequence, weight losers had higher muscle strength and lower cardiovascular risk factors than regainers at the end of the study. We have obtained a weight loss maintenance and a maintenance of FM without a significant variation of FFM with a PAL of vigorous aerobic type activity of 30 to 60 min per week in the first 6 months and a PAL attesting subjects participating in recreation or work requiring modest physical activity over one hour per week in the next 6 months. We can speculate that these results are not due only to PA but also to a positive effect of the nutritional education sessions that have produced a change in the dietary pattern with a little difference between sex. We have observed a same behavior in weight loss with a FM decrease for women and a FM increase for men. We can presume a different macronutrient composition of diet between sex.

Franz et al. (2007) in their systematic review and meta-analysis of weight loss clinical trials with a minimum 1-year follow up well summarized what happens at the end of clinical interventions. After 6 months, weight loss plateaus but none of the groups experienced complete regression to baseline weights by study end. In fact, in general interventions resulted in a mean weight loss of approximately 5 to 8,5 kg from starting weight during the first 6 months. Weight loss plateaus at approximately 6 months and stabilized to a weight loss of approximately 4,5 to 7,5 kg at 12 months.

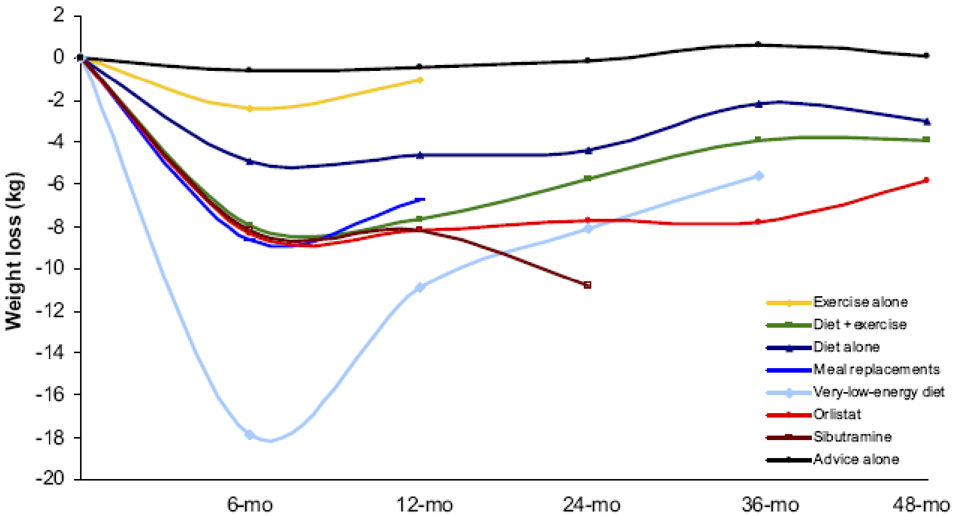


Figure 1. Average weight loss of subjects completing a minimum 1-year weight-management intervention; based on review of 80 studies (N=26,455; 18,199 completers [69%]).

From: Franz. J Am Diet Assoc. 2007 Oct;107(10):1755-67.

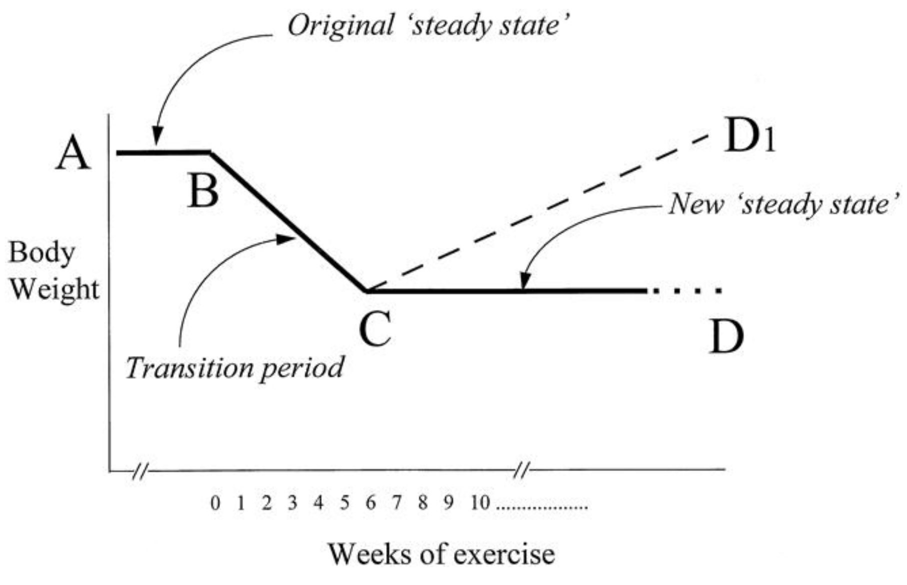
If we compare our results (average weight loss of 6 kg after 1y) with literature, we can state to have obtained a positive effect on weight loss: Curioni and Lourenço (2005) reported that in both groups, almost half of the initial weight loss was regained after 1 y; Fogelholm (2000) reported a maintenance of body weight with high PA. Our data are very closed with weight reduction after 1y of 5 kg reported by Avenell et al. (2004a); on the contrary they are below the average weight reduction reported by Miller at al. (1997) and Chambliss (2005) of 7,6 kg. Douketis et al. (2005) in a systematic review of long-term weight loss studies in obese adults reported a weight reduction of <5kg after 2–4 y. Further investigation, to establish the long-term effects (e.g., at 2–5 y) associated to our type of intervention for severely obese subjects, is necessary.

A surprising result in our studies was a cardiorespiratory fitness increase and a weight loss maintenance without a maintenance of health benefits, as reported by Franz et al. (2007). However a weight loss not consistently associated with improvements in cardiovascular risk factors has been observed also by St Jeor et al. (1995), Avenell et al. (2004a) and Douketis et al. (2005). Abundant data in the scientific literature have shown weight loss to be associated with decreases in blood pressure, total cholesterol and glucose levels as well as increases in HDL cholesterol (Dattilo, 1992; Svendsen, 1994; Fox, 1996; Kraemer, 1999; Neter, 2003; Avenell, 2004a), which are very similar to those observed at the completion of the present BWR program. Different factors, alone or in combination, are responsible for these changes, although their independent role is at present difficult to determine. In fact, both weight loss and exercise have been shown to independently promote a shift in the balance between parasympathetic and sympathetic activity in obese subjects (Arrone, 1995), responsible for a significant decrease in resting systolic blood pressure. Moreover, data from the meta-analysis of Dattilo and Kris-Etherton (1992) confirm that weight reduction is associated with a significant decrease in total cholesterol, and a biphasic trend for HDL-cholesterol, that is, a significant decrease during the phase of active weight loss followed by an increase at a stabilized reduced weight, in keeping with our results. The more fascinating results were, however, observed when cardiovascular risk factors were compared between weight losers and weight regainers. At baseline, cardiovascular risk factors were not significantly different between the two groups, even if a trend was observed for total cholesterol to be higher and for HDL-cholesterol to be lower in regainers. Surprisingly, these between-group differences became significant at the end of the BWR program and more particularly after the follow up. This would imply that low levels of total cholesterol and high levels of HDL-cholesterol could be associated in some measure to medium-term clinical success in severely obese individuals. This hypothesis remains to be checked carefully in the future.

In all groups of subjects, the level of self-reported physical activity at month 6 was twice with respect to baseline, therefore indicating that severely obese subjects modified their lifestyle in the first months consecutive to the completion of the BWR program. This hypothesis should be verified with objective measurement of PA in daily living. These effects were however less evident after 12 months, since the physical activity rating score significantly decreased with respect to month 6, even though it remained still higher than baseline. The more interesting finding was, however, observed when physical activity rating score was studied in clinical success vs failure groups. Indeed, the former subjects almost saturated the questionnaire at month 6 and then maintained the same score at follow up, while the self-reported level of physical activity in weight regainers did not change significantly during the course of the study, therefore confirming that low levels of physical activity are predictive of subsequent weight regain in both men and women (Kuczmarski, 1994). These findings are also reinforced by the fact that higher muscle strength and lower cardiovascular risk factors were observed in weight losers at follow up. We have also found a significant dose-response relationship between amount of exercise and amount of weight loss and fat mass loss as reported by Fogelholm and Kukkonen-Harjula (2000b), Anderson et al. (2001a), Fabbricatore (2003) and Slentz et al. (2004). These findings strongly suggest that, absent changes in diet, a higher amount of activity is necessary for weight maintenance and that a positive caloric imbalance can be reversed by a modest amount of exercise. Most individuals can accomplish this by walking 30 minutes every day (1000 kcal/wk) (Poirier, 2001; Slentz, 2004) without attaining more unrealistic amount of exercise suggested by other authors: 1500-2000 kcal/wk (Fogelholm, 2000b), 2500 kcal physical activity/wk (Tate, 2007), amount of exercise that could not be actually achieved by obese subjects.

Changes in body composition, physical performance and cardiovascular risk factors induced by a short-term hospital based treatment in severely obese individuals were studied concomitantly in these present investigations. An original finding is that male individuals lost approximately 3 kg of fat-free mass after the treatment, while reductions were negligible in their female counterparts. Different body composition changes were observed between genders, where women mainly reduced the proportion of fat mass and only to a lesser extent fat-free mass, while the opposite outcome was observed in men. These findings are in accordance with the study of Goodpaster et al. (1999), who reported that obese men lost more fat-free mass than obese women following a 16-week caloric restriction-induced weight loss program. These authors also demonstrated that glucose levels were almost identical between obese males and females both before and after the intervention, therefore confirming that in our study the absence of sex effect in glucose levels at post-BWR or follow up was not strictly related to the significant gender differences in fat-free mass during the same time frames. Other studies failed to demonstrate such a sex difference in the composition of weight loss (Ballor, 1994; Garrow, 1995; Dionne, 1999; Doucet, 2002), since changes in fat-free mass associated to diet and/or exercise were comparable between men and women. These conflicting findings are mainly attributable to the heterogeneity in experimental subjects, study design, exercise intensity and type, as well as intervention length between the present and the above-cited studies. In their meta-analysis, Garrow and Summerbell (1995) indicated that, at any given weight loss, the loss of fat-free mass is likely to be less in exercising subjects than in sedentary ones. It is indeed possible that our male obese subjects were more sedentary than their female counterparts, since baseline maximal oxygen consumption normalized to the fat-free mass was higher in the latter group with respect to the former. The fat-free mass reductions reported here for male subjects are very similar to the losses observed in obese overweight men following 12–16 weeks of diet (Kraemer, 1999; Cox, 2003) or diet plus aerobic exercise (Hagan, 1986). In obese children, fat-free mass reduction during a 3-week BWR program similar to that adopted here has been recognized as a major factor for later regain in body weight (Schwingshandl, 1995). In this context, it is noteworthy that consistent fat-free mass losses observed in our males after the short-term treatment were associated with a lower rate of medium-term success compared to their female counterparts. Therefore, one could conclude that 3 weeks of diet plus exercise performed at moderate intensity for five sessions per week may not have been sufficient enough to maintain fat-free mass in severely obese men. It is indeed recommended that the resistance training considered in the present study must be increased in intensity, at least for male individuals, in order to preserve the amount of fat free mass during body weight reduction as obtained by other studies (Donnelly, 2003). Besides the effect of a high protein diet must be controlled.

In conclusion, the present investigations demonstrated that a 3-week BWR program resulted in a high rate of clinical success in severely obese individuals at 1-y follow up (particularly in females), which was associated with increased levels of self-reported physical activity. This attests a lifestyle modification induced by the interventions. We can also speculate an improvement in well being as reported by Avenell et al. (2004b). Our studies confirm the important role of exercise in weight loss maintenance (Anderson, 2001a). Thus, the maintenance of weight loss may be a result of a constellation of behaviors, of which exercise is one of the important behaviors (Jakicic, 2005b). Our aim to create a clinical intervention obtaining a gradual weight loss year after year through multiple hospitalization (one per year), with the idea to allow a weight loss of 6 kg during each intervention and a weight maintenance during the passive follow up, is supported by Blundell and King (1999).



From: Blundell. Med. Sci. Sports Exerc., Vol. 31, No. 11, Suppl., pp. S573–S583, 1999.

A represents baseline. *B-C* is the clinical intervention where an imbalance between energy intake (EI) and energy expenditure (EE) is created. This period of imbalance or adjustment has been labeled as the 'transition period'. *C-D* is the passive follow up which aim is a new coupling between EE and EI (steady state), e.g., a constant body weight. It follows, of course, that if exercise is abandoned at point C the weight would be restored to point D1 (or possibly above this).

There are some limitations of this study.

I. It has been difficult to coordinate all the persons involved in the data collection and this has caused some loose of the data especially at 6 months and 1 year. My personal contribution has been addressed in: conceiving the study, participating in its design and implementation of the exercise intervention, conducting the analyses and drafting the manuscript.

II. We have not been able to determine which of the training programs could effectively elicit the better weight loss and the better enhancement of health related and physiological parameters. We can speculate that this is due to the scanty number of subjects per group.

III. Insufficient sample size may be concomitant with a type II error.

IV. We have not had the possibility to carry out a randomized controlled trial, because in the hospital environment where we operated it was not possible to organize a controlled group without any type of intervention. Randomization was also not possible for the scanty number of subjects per group.

V. Another limitation of this study is the absence of an accurate estimation of weight changes or physiological changes in an identical untreated population. Thus, weight changes or physiological changes can only be compared with baseline body weights.

VI. The great difficulty and limitation of weight loss studies, including us, is that they only report the mean group weight changes and not the frequency of expected responses to the interventions, e.g., how many people actually lost weight. Means are not appropriate to evaluate how many people attained a clinically significant weight loss (Curioni, 2005). Our choice to include only mean values is from an epidemiological perspective, with the aim to find which could be the better training protocol in order to extend our intervention strategy to all hospital environment and primary care.

VII. Another limitation of the current investigation is represented by the lack of control exerted on subjects' lifestyle after the BWR program. Our study has been conceived as a structured clinical trials in the first part of the intervention and after that subjects were only encouraged to practice 30 min of aerobic exercises almost all days of the week without any other support.

VIII. It would have been desirable to use monitors of PA during the 1y follow up to have an objective measurement of the amount of time spent in moderate or vigorous intensities. In fact, physical activity has also been established by a self-reported level of PA, without any objective measurement. Self-reported levels of PA are prone to error. Fitness is a more objective measure of physical activity (Blair, 2007). It is for this reason that at 1y we repeated all anthropometric and physiological measurements in order to control the efficacy of the level of PA maintained.

IX. Participants were only contacted once during the free-living period and consequently they did not have a constant reminder to control nutritional intake and physical activity until these behaviors were incorporated into their lifestyle. We could extend more the length of treatment contact through a continued professional support provided in face-to-face encounters, or thanks to telephone consults, or Internet contacts (Franz, 2007), or interactive workshops (Dzator, 2004). Perhaps, it is for this reason that only 58% of the sample returned for testing at the end of 1 year.

X. We could structured a more complete home-based program (Perri, 1997) or recommended intermittent exercise using brisk walking which would be more easy to apply in daily living routines during the 1y unsupervised follow up (Donnelly, 2000).

XI. We were not able to control dropouts and we were not able also to verify their reasons. This would allow a better knowledge of the factors that affect adherence to therapeutic programs.

XII. Physical activity rating questionnaire allowed to control, at least partially, the achievement of the requested goals even but no attempt was made to investigate the adherence to nutritional instructions. We can't provide information on dieting practices between the weight loss phase and the follow up periods.

Study design modifications to enhance efficacy of results:

I. To include a control group.
II. To directly measure physiological values.
III. To conceive a more structured follow-up.
IV. To extend more the length of treatment contact.
V. To objectively measure PA during free living.
VI. To examine the reasons for drop out.

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4.3 Conclusion

Obesity is a fast growing epidemic that is primarily due to environmental influences (Volek, 2005). Obesity is a chronic metabolic disorder associated with CVD and increased morbidity and mortality. When the BMI is > or = 30 kg/m^2, mortality rates from all causes, and especially CVD, are increased by 50% to 100% (Poirier, 2001; Wilson, 2002), becoming a public health problem. Obesity leads to less physical activity (Petersen, 2004) and physical inactivity is the major public health problem (Troiano, 2001; Livingstone, 2003). At the same time low levels of physical activity are associated with an increased risk of weight gain and obesity (Jebb, 1999). Physical inactivity and adiposity are important determinants of mortality risk (Katzmarzyk, 2003). From these first assumptions, it is clear that our attention is focused on two primary aspects: obesity and physical activity.

The increasing worldwide prevalence of obesity suggests that there is a chronic positive energy balance. This situation implies poor coupling between energy intake and energy expenditure, but the contribution of each of these factors remains unclear. Epidemiological data suggests that physical activity has a role in the prevention of weight gain, although there is little evidence that it has a beneficial role in weight loss (Moore, 2000). Behavioral interventions are able to provide only modest results in term of weight loss that are difficult to maintain, due also to individual responses to diet and exercise interventions (Astrup, 2000; Volek, 2005). The challenge is to get the exercise prescription right at an individual level (Hills, 2004). Exercise can have positive effects on weight loss, weight control and overall general health, although debate exists concerning the most effective mode, duration and intensity of exercise required to achieve these effects. Importantly, any effective weight control treatment must consider a life-long plan or there will likely be weight regain (Volek, 2005).

A critical piece of recommending a PAL is in the definition of what we want to accomplish (what's the benefit?) and to whom are we making the recommendation (who's the target?). The PAL target for different objectives may in fact be very different (Saris, 2003). Our question is: instead of focusing our attention on the optimal PAL for producing a weight loss by producing a negative energy balance, or on the optimal PAL for preventing weight gain across a general population? is it not more worth full to focus our attention on the advantages induced by physical activity independently from weight loss?

Since 1984, Paffenbarger and Hyde have related that epidemiological studies have left no doubt as to the existence of a strong inverse relationship between physical exercise and coronary heart disease (CHD) risk. British studies of transport workers and civil servants, together with American studies of stevedores and college alumni, have provided persuasive evidence that contemporary vigorous activity is accompanied by lower risk of both fatal and nonfatal CHD. The relationship is largely independent of influential characteristics of high risk such as cigarette smoking, hypertension, obesity, and family history of hypertensive-atherosclerotic disease. Physical activity can provide improvements in physical functioning, general health, vitality, and mental health and many of these improvements in health-related quality of life (HRQL) could be maintained, despite participants regaining weight (Blissmer, 2006). Furthermore, it has been demonstrated that 5%-10% weight loss will often provide sufficient health gains to be considered a success (Dixon, 2006), confirming that regular exercise has health-promoting effects, which are beyond its effect on weight control (Pedersen, 2007). Moreover, Blair and Brodney (1999) demonstrated that 1) regular physical activity clearly attenuates many of the health risks associated with overweight or obesity; 2) physical activity appears to not only attenuate the health risks of overweight and obesity, but active obese individuals actually have lower morbidity and mortality than normal weight individuals who are sedentary; 3) inactivity and low cardiorespiratory fitness are as important as overweight and obesity as mortality predictors.

In our opinion the only key issues in exercise prescription for weight loss and weight loss maintenance should be moderate intensity, moderate volume, and individuality (Fogelholm, 2000a). Most individuals can accomplish this by walking 30 minutes every day (Donnelly, 2000; Slentz, 2004), reducing time spent watching television and in other similar sedentary behaviors (Donnelly, 2000).

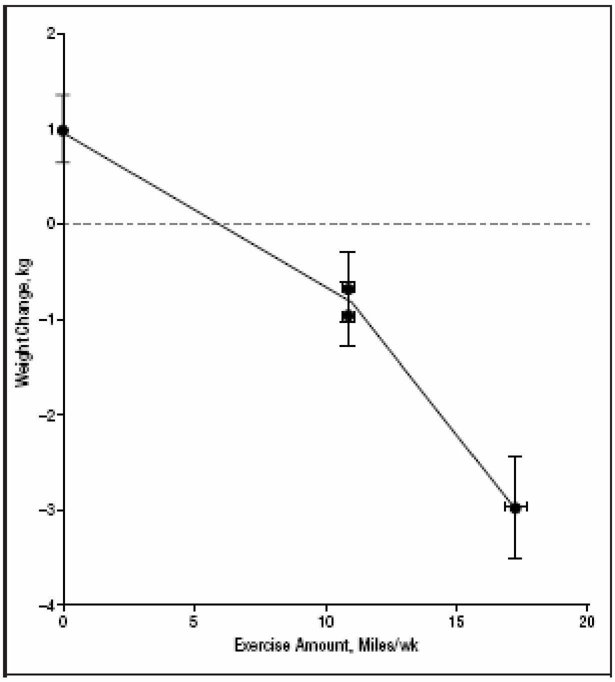

Figure 5. The relationship between mean amount of weight change and amount of exercise. Error bars show SE.

From: Slentz. Arch Intern Med. 2004 Jan 12;164(1):31-9.

Our aim is to change obese subjects expectations so that they can take satisfaction in smaller weight losses (Allison, 2003). The primary concern should be one of health and not appearance (Donnelly, 2000; Franz, 2007).

We want to introduce and conclude with the concept of *'FIT FAT'*. Physically active individuals have a lower risk of mortality by comparison to physically inactive peers, independent of level of adiposity. Although it is hard to determine whether it is better to be physically active and overweight than physically inactive and lean from this study, it is clear that for the lowest mortality risk one should strive to be both lean and active (Katzmarzyk, 2003; Hills, 2004).

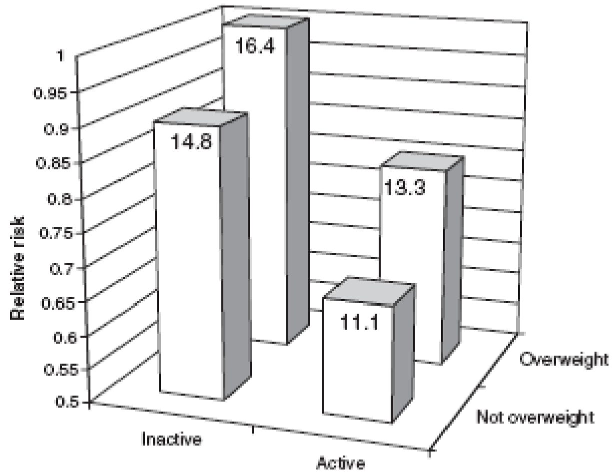

Figure 4 Relative risks of all-cause mortality according to baseline physical activity and overweight status in men from the Harvard Alumni Study (1977–92). Overweight was defined as a body mass index >25 kg m^{-2} and physical inactivity is defined as expending <4200 kJ $week^{-1}$ in leisure-time physical activity (70). The numbers on the bars indicate the mortality rates per 1000.

From: Katzmarzyk. Obes Rev. 2003 Nov;4(4):257-90.

Regular physical activity clearly attenuates many of the health risks associated with overweight or obesity. However, it is possible to be fit and fat, as well as to be thin and unfit, regardless of body shape (Blair, 2007). From a public health standpoint, it is prudent at this juncture to recommend both a physically active lifestyle and the maintenance of 'normal' or healthy body weights (Katzmarzyk, 2003).

Exercise can have positive effects on weight loss, weight control and overall general health, although debate exists concerning the most effective mode, duration and intensity of exercise required to achieve these effects. The aim of this study was to try to answer to some of these questions.

The major findings of this research have been:

- all behavioral interventions structured in this study provided positive effects at short-term for weight loss and body composition, physiological and health parameters and at the long-term for weight-maintenance;
- a weight maintenance was achieved after intervention and a total weight loss of 6 kg from baseline was obtained after 1y thanks to PA;
- the studied intervention had a positive effect on lifestyle modification because inactive obese subjects had increase their PA level;
- PAR maintained during 1y was sufficient to enhance physiological parameters but not to obtain health benefits;
- PA had a positive effect for weight loss and for FM decrease;
- an identification of responders for weight loss (subjects at baseline with a higher BMI) and for FM decrease (subjects at baseline with the lower BW) has been studied;
- 30 min of moderate aerobic exercise 5 days/week has been well tolerated during a LCD and allowed an increase in physiological parameters in obese sedentary subjects;
- the higher the PAR level was maintained during 1y, the higher the weight loss obtained;
- strength training has been an important component of the weight loss program at short-term by helping to preserve FFM only for women;
- an increase in intensity has not been necessary at the short-term, since it has not determined any advantages for weight loss, physical fitness enhancement or any health benefits.

At the end of this study we can conclude that in our opinion the optimal daily living PAL for obese people is walking 30 minutes every day.

At the end of this study we can conclude that in our opinion

the greatest obesity challenge is to find

how to obtain a permanent lifestyle modification for obese subjects.

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ANNEXE I

PA guidelines for weight-loss

Type of physical activity

Lifestyle guidelines

Realistic goals

ANNEXE II

Etude des corrélations significatives dans la population DEPAST

PA guidelines for weight-loss	
AACE/ACE Obesity Task Force, 1998 Revision	30 minutes of moderate-intensity physical activity 5 to 7 times per week. Encourage appropriate, intermittent physical activity when needed. Initially, several 10-minute periods of physical activity throughout the day—for example, a 30-minute daily aggregate of brisk walking, aerobic physical activity such as exercise tapes, or housework such as vacuuming—performed 3 days per week may be more important than 30 minutes of continuous physical activity performed 6 days per week.
NHLBI, 1998	The exercise can be done all at one time or intermittently over the day. Initial activities may be walking or swimming at a slow pace. The patient can start by walking 30 minutes for 3 days a week and can build to 45 minutes of more intense walking at least 5 days a week. All adults should set a long-term goal to accumulate at least 30 minutes or more of moderate-intensity physical activity on most, and preferably all, days of the week.
Poirier, 2001	Thirty to 45 minutes of physical activity of moderate intensity, performed 3 to 5 days a week, should be encouraged. All adults should set a long-term goal to accumulate at least 30 minutes or more of moderate-intensity physical activity on most, and preferably all days. Public health interventions promoting walking are likely to be the most successful.
ACSM, 2001	The American College of Sports Medicine recommends a minimum weekly exercise goal of 1000 kcal and a recommended energy expenditure of 2000 kcal/wk as an optimal physical activity level.
Dohm, 2002	Exercise of 2-5 METs is usually advisable for obese individuals who are in a weight loss program. As they become more fit, they can increase the intensity, and thus the energy expenditure.
Jakicic, 2002	Physical activity levels greater than the minimal level that is currently recommended to improve health may be necessary to prevent weight regain after a period of weight loss. However, data from randomized clinical trials are needed to confirm these findings. Obese adults can realize significant improvements in health and fitness by increasing participation in moderate intensity physical activity to at least 150 min/wk.
NHMRC, 2003	3 to 5 hours a week of moderate to vigorous activity create an expenditure of about 4 megajoules a week (for example, walking briskly for 30 minutes a day).
Racette, 2003	Recommendations that Americans participate in a minimum of 30 minutes of modest-intensity physical activity almost every day, regardless of body weight.
Jakicic, 2005	Encouraging levels of physical activity greater than the minimum public health recommendation (150 min/wk) may be necessary for improving long-term weight loss outcomes.
Lakka, 2005	The best long-term results may be achieved when physical activity produces an energy expenditure of at least 2500 kcal/week.

Bensimhon, 2006	To have a significant impact on their weight, obese subjects need to burn approximately 10500 kcal/wk—the equivalent of walking or jogging 25 mile/wk or roughly 80 minutes of moderate aerobic activity on most days of the week
Hills, 2006	1500-1750 kcal/wk (or 250-300min brisk walking per week)
Jakicic, 2006	Combining modest reductions in energy intake with modest increases in energy expenditure to elicit a 500 to 1000 kcal/d energy deficit may be the most practical approach to achieving 1 to 2 pounds of weight loss per week. 30 min/d of moderate-intensity activity reduces the risk of chronic diseases. 60 min/d of moderate-intensity activity may be the target level for preventing weight gain. Energy expenditure rather than exercise intensity is important for enhancing weight loss outcomes.
Catenacci, 2007	When the exercise prescription is of sufficient magnitude to produce an energy deficit of 500–1000 kcal per day (a deficit usually produced by programs involving caloric restriction) substantial weight loss can occur.
Kouris-Blazos, 2007	For metabolic fitness and weight maintenance: about 30min/day of walking or other moderate intensity exercise is required (or 195-220min/wk, 1500-1750 kcal/wk). For weight loss and prevention of weight gain: about 30-45min/day of walking or other moderate intensity exercise is required (or 250-300min/wk, ≥2000 kcal/wk).

Type of physical activity	
ACSM, 2001	Amount of exercise necessary for successful long-term weight loss_ 200–300 min of exercise per week or 2000 kcal/wk.
ACSM, 2001	A sufficient amount of moderate-intensity (55–69% of maximal heart rate) exercise can be beneficial for management of body weight, with limited published scientific evidence from randomized trials to support the necessity of more vigorous (70% of maximal heart rate) forms of exercise for management of body weight long-term
Poirier, 2001	It appears that as long as the increase in energy expenditure is sufficient, low-intensity endurance exercise is likely to generate beneficial metabolic effects that would be essentially similar to those produced by high-intensity exercise.
NHMRC, 2003	For very immobile obese patients, a reduced weight-bearing form of activity (such as swimming, walking in water, or cycling) may be best in the early stages of a weight-loss program, until their fitness increases and weight-bearing activities (such as walking) can be more easily carried out.
Hansen, 2007	Considering the relationship between caloric expenditure during training and fat-mass loss, walking (and/or running) exercise seems to be the preferred type of exercise in obese patients
Hills, 2006	Exercise modality is an individual issue. Generally, aerobic weight bearing activity such as walking is the activity of choice for most people. However, other options include swimming and cycling. Another suitable activity for those who do not have major joint problems but to strengthen large muscles of the lower limb is stepping up and down from a step or bench.
Kouris-Blazos, 2007	Stepping: As little as 5-10minutes of stair climbing daily has been shown to improve fitness and cardiovascular risk factors and to be equivalent to a 30min walk.
ACSM, 2001	The use of intermittent exercise may be advantageous for individuals that dislike continuous exercise or perceive barriers to continuous exercise.
De Mello Meirelles, 2004	For resistance exercise volume is the variable with greatest impact on energy expenditure during the training session, and that intensity has its largest impact on EPOC.

Lifestyle guidelines	
AACE/ACE Obesity Task Force, 1998 Revision	Identify opportunities for increased activity—such as using stairs rather than elevators, parking a distance from the mall rather than at the store entrance, and taking 10- to 15-minute walks after meals.
NHLBI, 1998	Patients should be encouraged to increase "every day" activities such as taking the stairs instead of the elevator. Reducing sedentary time is another strategy to increase activity by undertaking frequent, less strenuous activities. With time, depending on progress and functional capacity, the patient may engage in more strenuous activities. Competitive sports, such as tennis and volleyball, can provide an enjoyable form of exercise for many.
Fabricatore, 2003	Lifestyle activity involves increasing energy expenditure throughout the day by methods such as using stairs rather than escalators or choosing a distant parking spot. Lifestyle activity would appear to be ideal for obese individuals who say they hate to exercise.
Racette, 2003	Engaging in exercise and leading physically active lifestyles are especially important for individuals who are obese.
Kouris-Blazos, 2007	Increased physical activity may decrease the risk of cardiovascular morbidity and mortality, even in the absence of achieving normal body weight.

Realistic goals	
NHLBI, 1998	All adults should set a long-term goal to accumulate at least 30 minutes or more of moderate-intensity physical activity on most, and preferably all, days of the week.
Poirier, 2001	Realistic goals should be set between the clinician and the patient, with a weight loss of approximately of 0.5 to 1 pound per week.
Fabricatore, 2003	PA: a program of walking 45–60 minutes 4 days a week will create a deficit of approximately 1000 kcal over the course of a week, with the resulting loss of 0,15 kg. Diet: LCDs are designed to induce weekly deficits of 3500–7000 kcal, with weight losses of 0,5–1 kg per week.
Haskell, 2007	To lose weight or maintain weight loss, 60 to 90 minutes of physical activity may be necessary.

PA guidelines for weight-loss maintenance	
NHMRC, 2003	An activity level equivalent to about 45 kilojoules per kilogram per day (about 80 minutes a day) is probably the minimum required for effective weight maintenance.
Hill, 2005	Available data are consistent in that 60-90 min/day of moderate-intensity physical activity is required to maintain a significant weight loss.
Jakicic, 2005	At least 60 min of moderate-intensity physical activity may be necessary to maximize weight loss and prevent significant weight regain.
Lakka, 2005	A minimum of 60 min, but most likely 80-90 min of moderate-intensity physical activity per day may be needed to avoid or limit weight regain in formerly overweight or obese individuals.
Astrup, 2006	Maintenance of a healthy body weight in susceptible individuals requires 45-60 minutes physical activity daily.
Hills, 2006	2000-2500 kcal/wk (or 400-500min brisk walking per week)
Jakicic, 2006	60 to 90 min/d may be the target level for preventing weight regain following significant weight loss.
Kouris-Blazos, 2007	Prevention of weight regain after weight reduction: about 60min/day of walking or other moderate intensity exercise is required (400-500min/wk, 2000-2500 kcal/wk).
Wilding, 2007	Weight-loss maintenance: activity levels equivalent to 45–60 min of brisk walking each day.

ANNEXE I

PA guidelines for weight-loss

Type of physical activity

Lifestyle guidelines

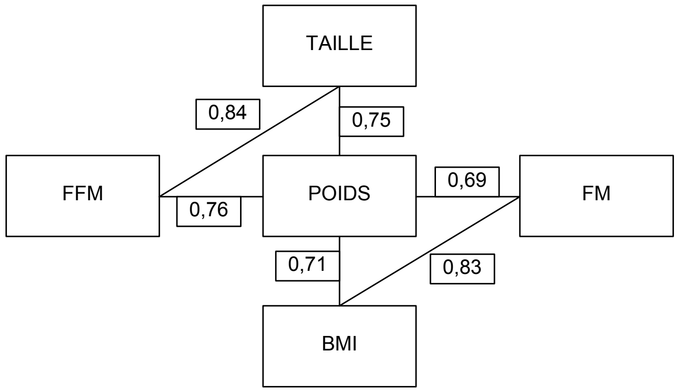
Realistic goals

ANNEXE II

Etude des corrélations significatives dans le groupe DEPAST

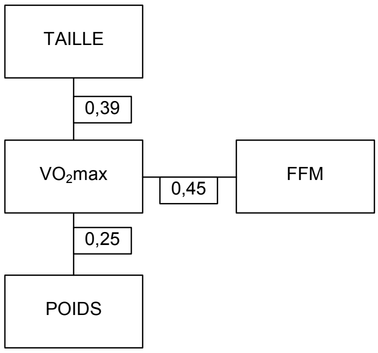
Paramètres de départ

PARAMETRES ANTHROPOMETRIQUES ENTRE EUX



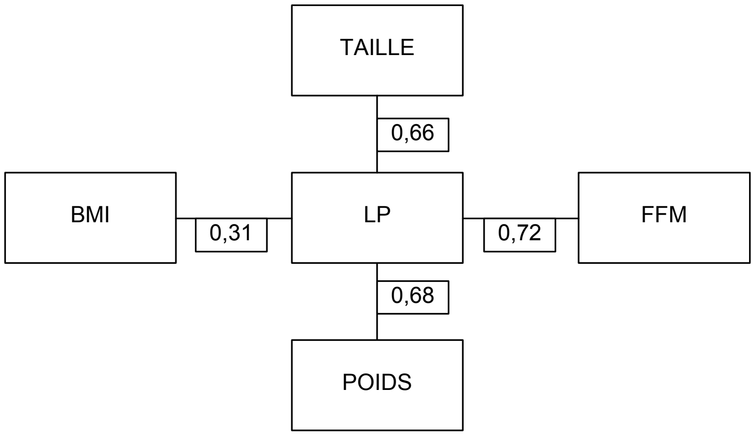
PARAMETRES PHYSIOLOGIQUES ET ANTHROPOMETRIQUES

ENDURANCE

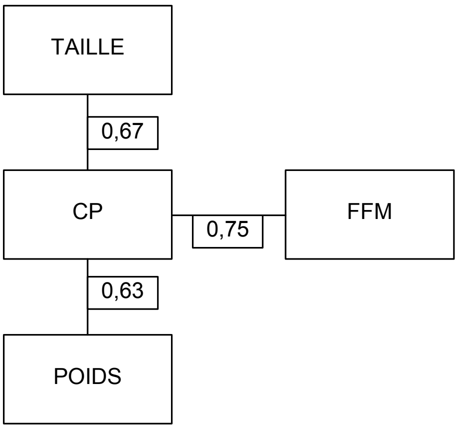


FORCE

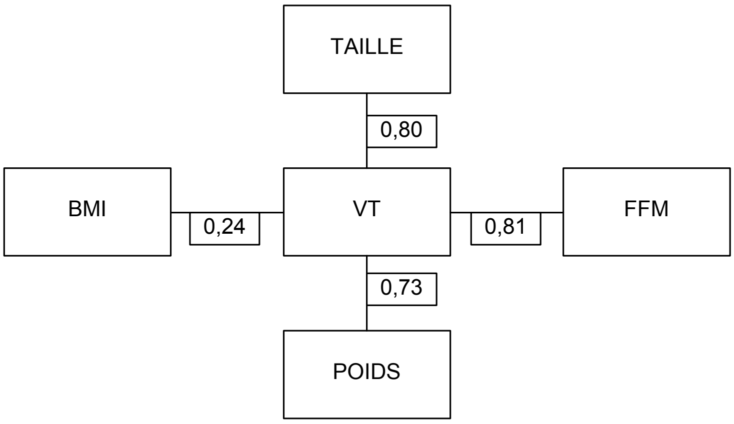
Leg Press



Chest Press

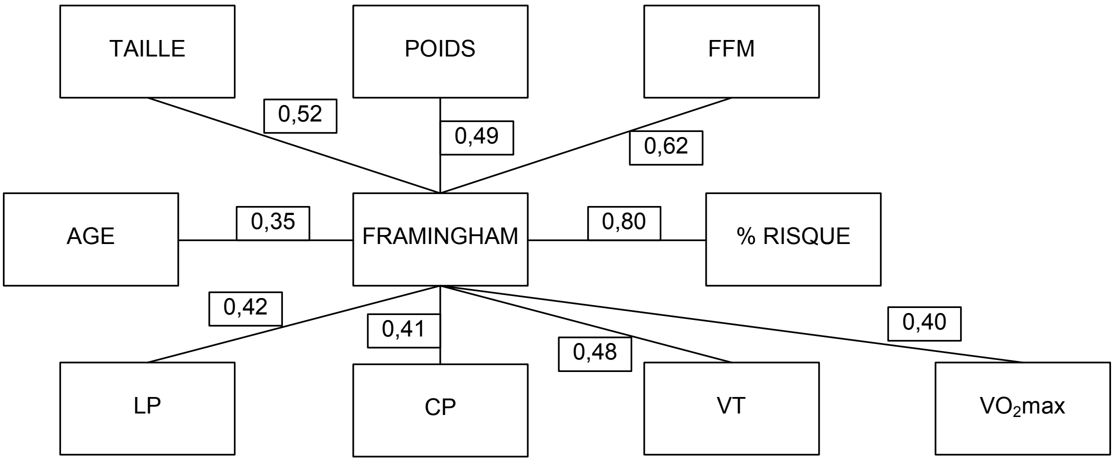


Vertical Traction

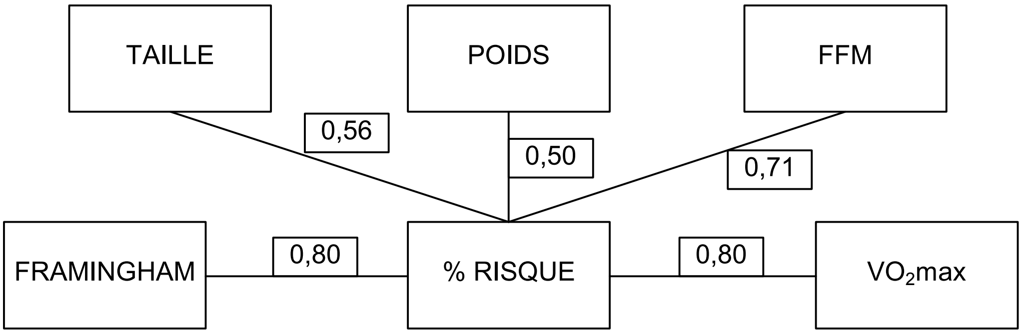


FACTEURS DE RISQUE

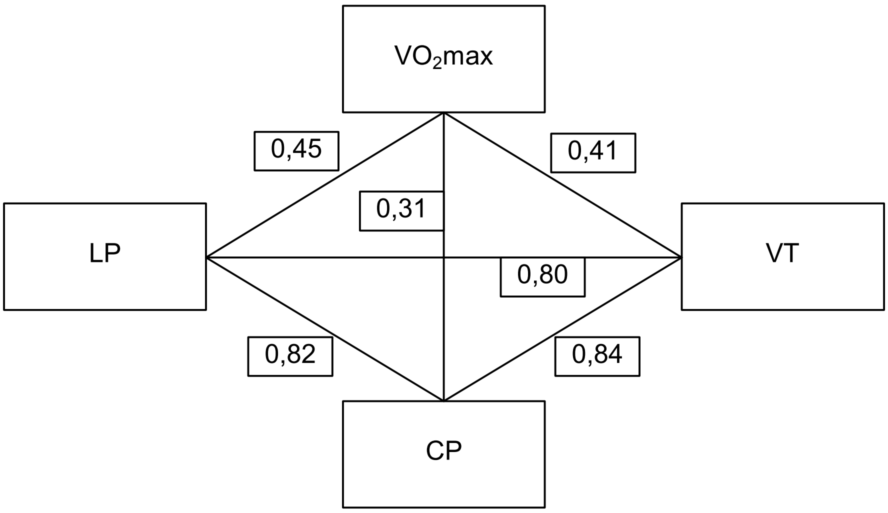
FRAMINGHAM



% RISQUE



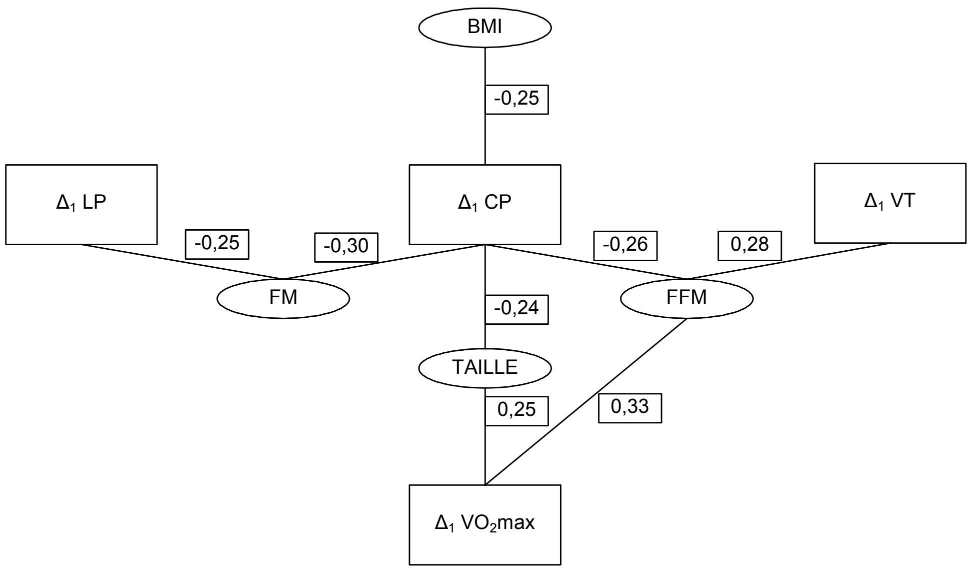
PARAMETRES PHYSIOLOGIQUES ENTRE EUX



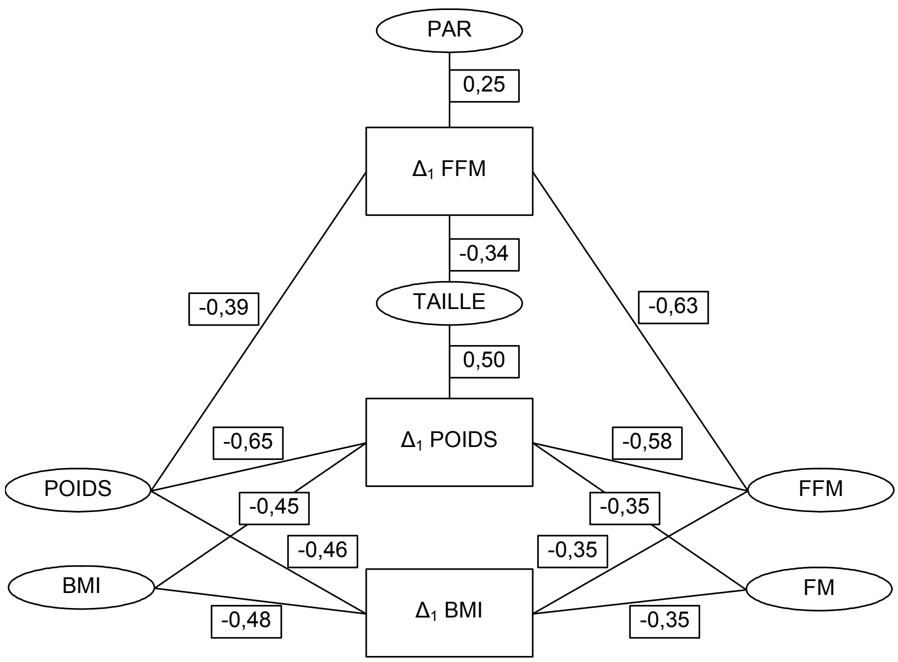
Corrélations Δ

CORRELATIONS DELTA ET VALEURS INITIALES

Corrélations Δ_1 capacités physiologiques et données anthropométriques

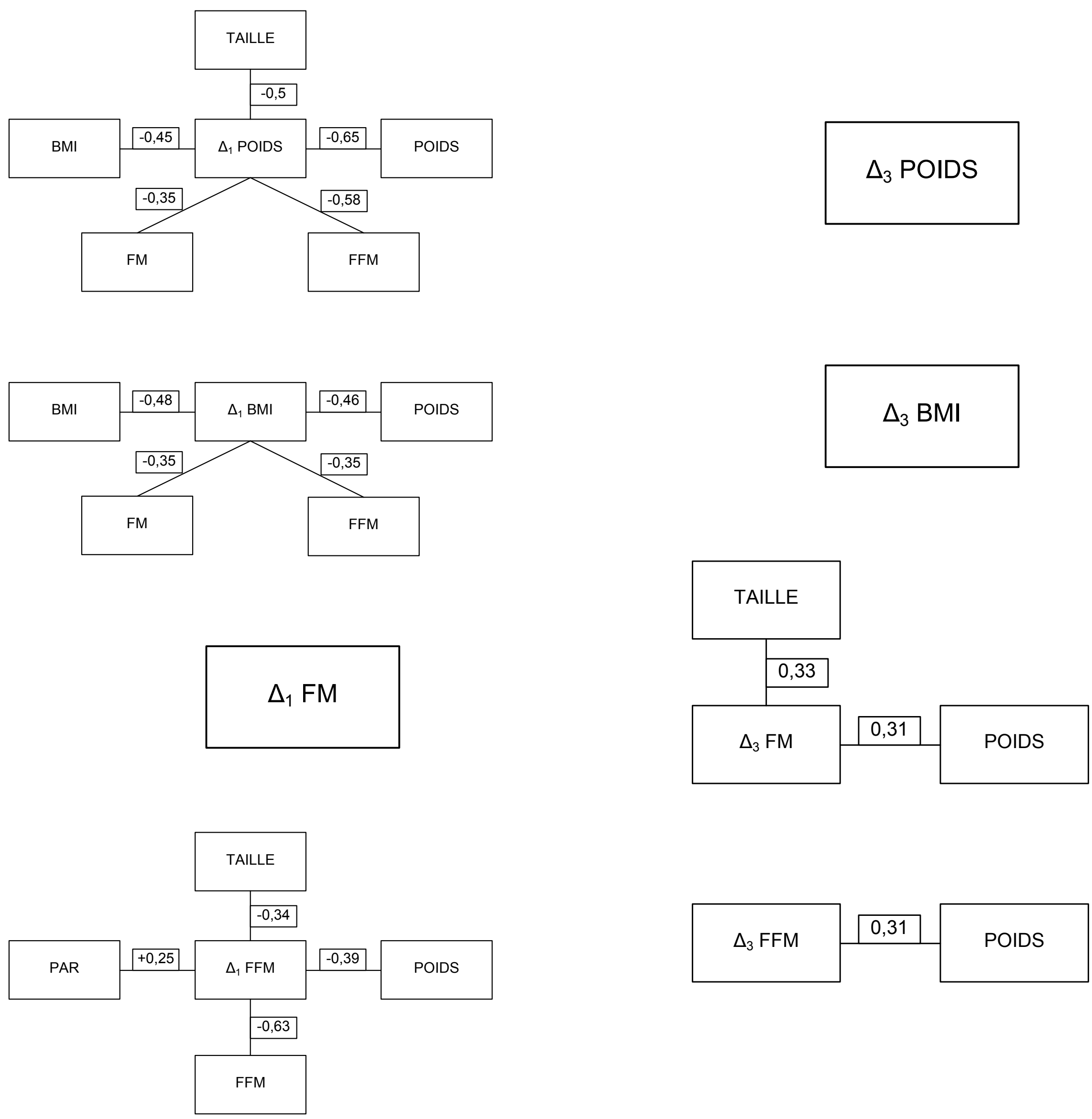


Corrélations Δ_1 données anthropométriques et données anthropométriques



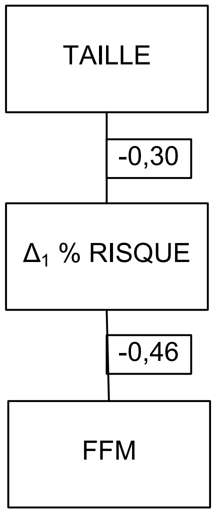
PARAMETRES ANTHROPOMETRIQUES ENTRE EUX

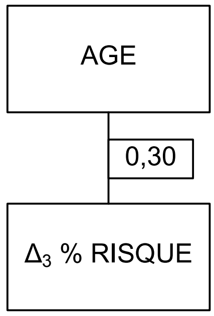
Δ_1 **Δ_3**



FACTEURS DE RISQUE ET PARAMETRES ANTHROPOMETRIQUES

Δ_1 **Δ_3**

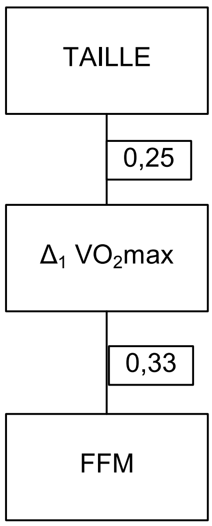


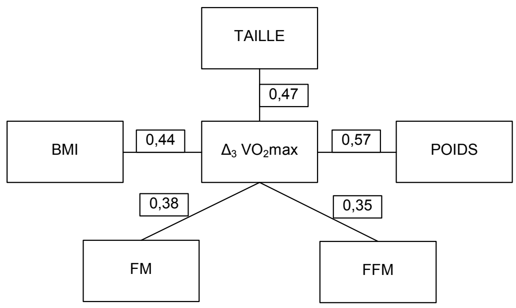


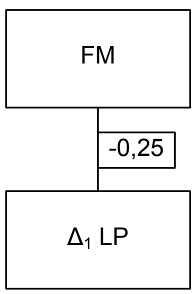
PARAMETRES PHYSIOLOGIQUES ET PARAMETRES ANTHROPOMETRIQUES

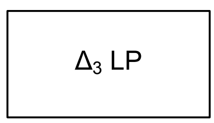
Δ_1

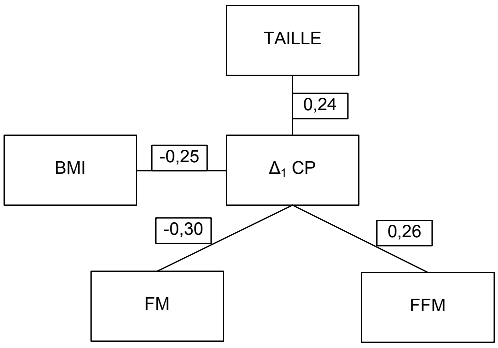
Δ_3

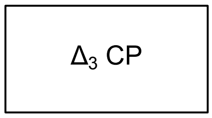


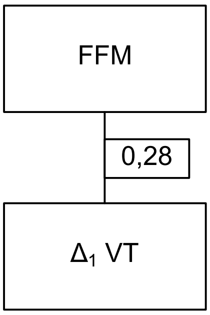


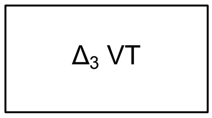






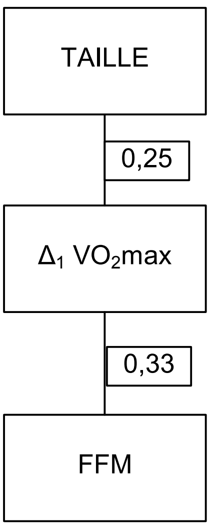


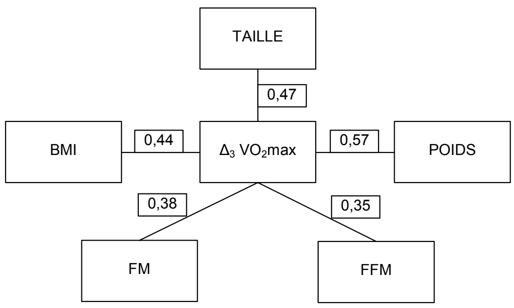


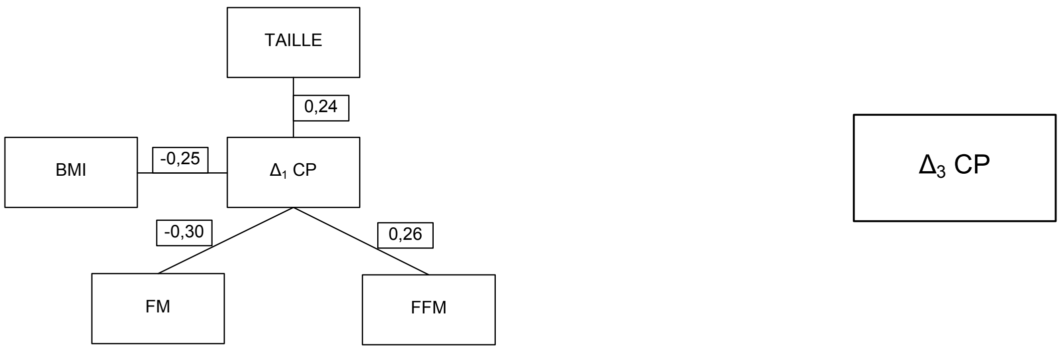


PARAMETRES PHYSIOLOGIQUES ET PARAMETRES ANTHROPOMETRIQUES

Δ_1 **Δ_3**

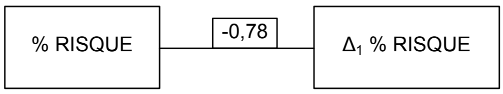


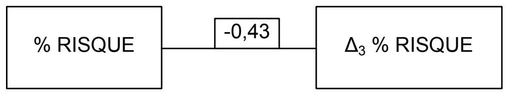


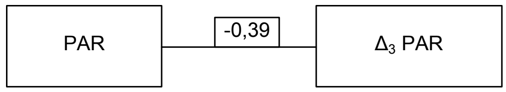


FACTEURS DE RISQUE ENTRE EUX

Δ_1 **Δ_3**

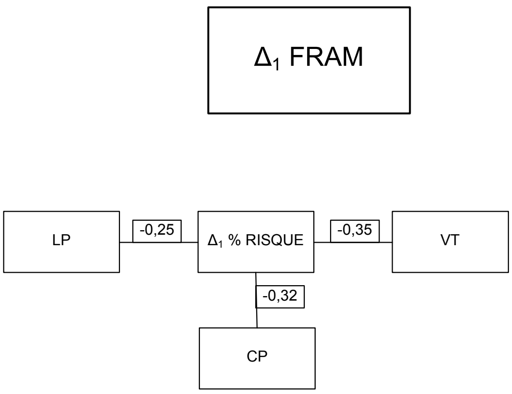




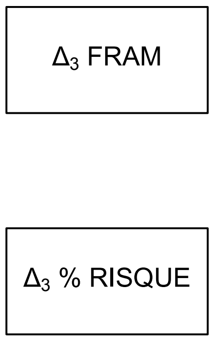


Facteurs de risque et parametres physiologiques

Δ_1

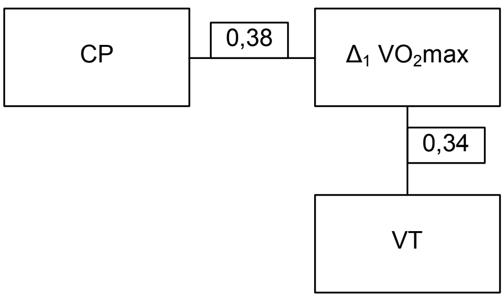


Δ_3

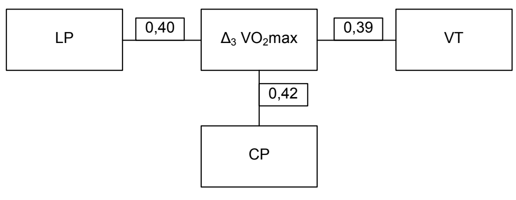


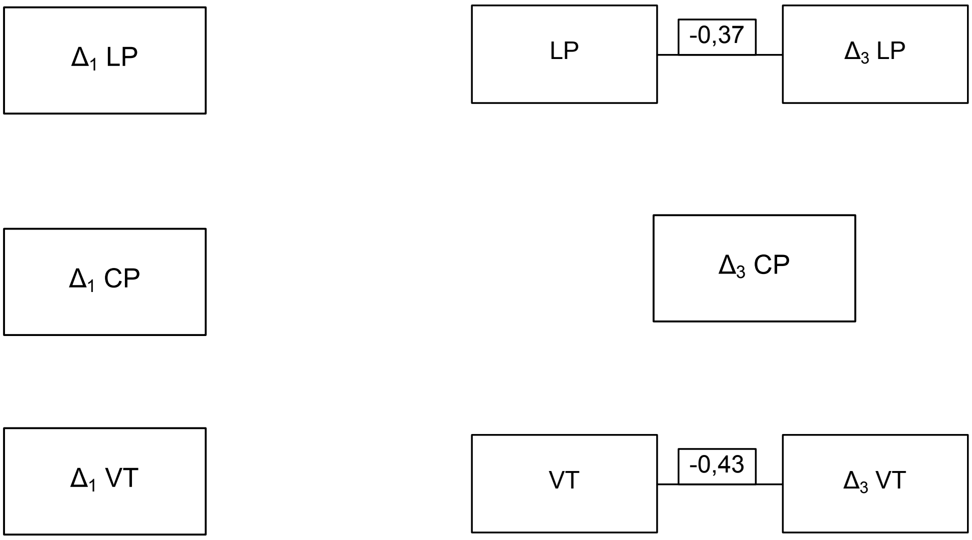
Parametres physiologiques entre eux

Δ_1

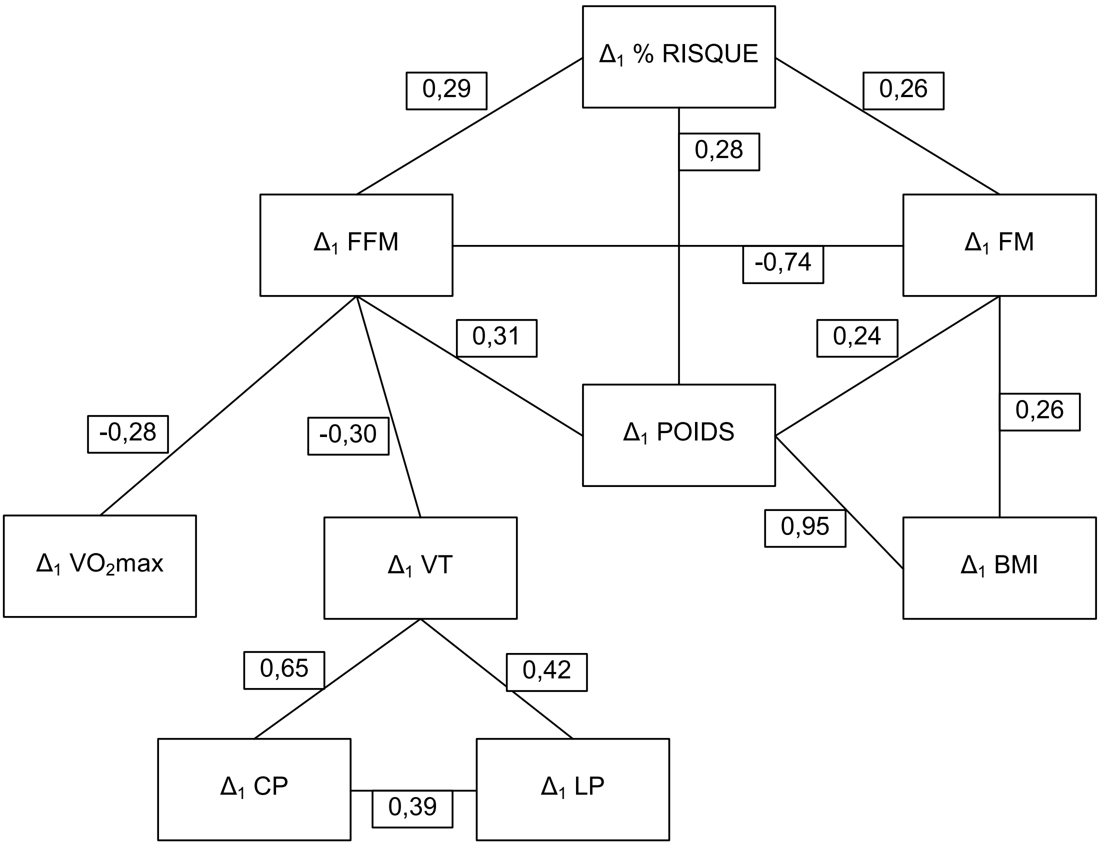


Δ_3





CORRELATIONS ENTRE Δ_1 ENTRE EUX



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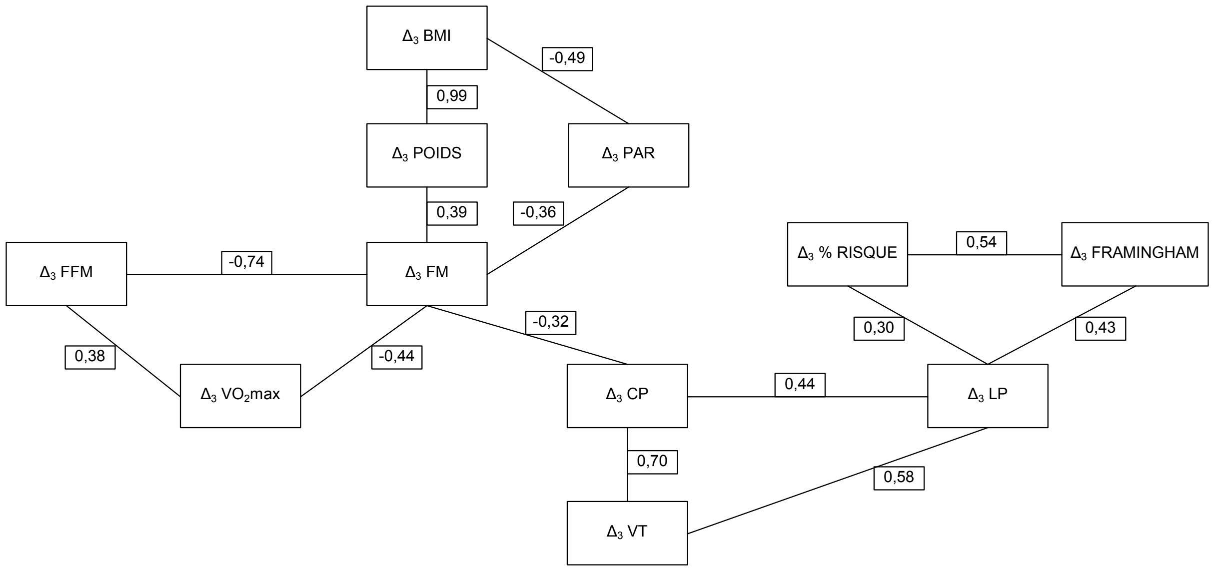
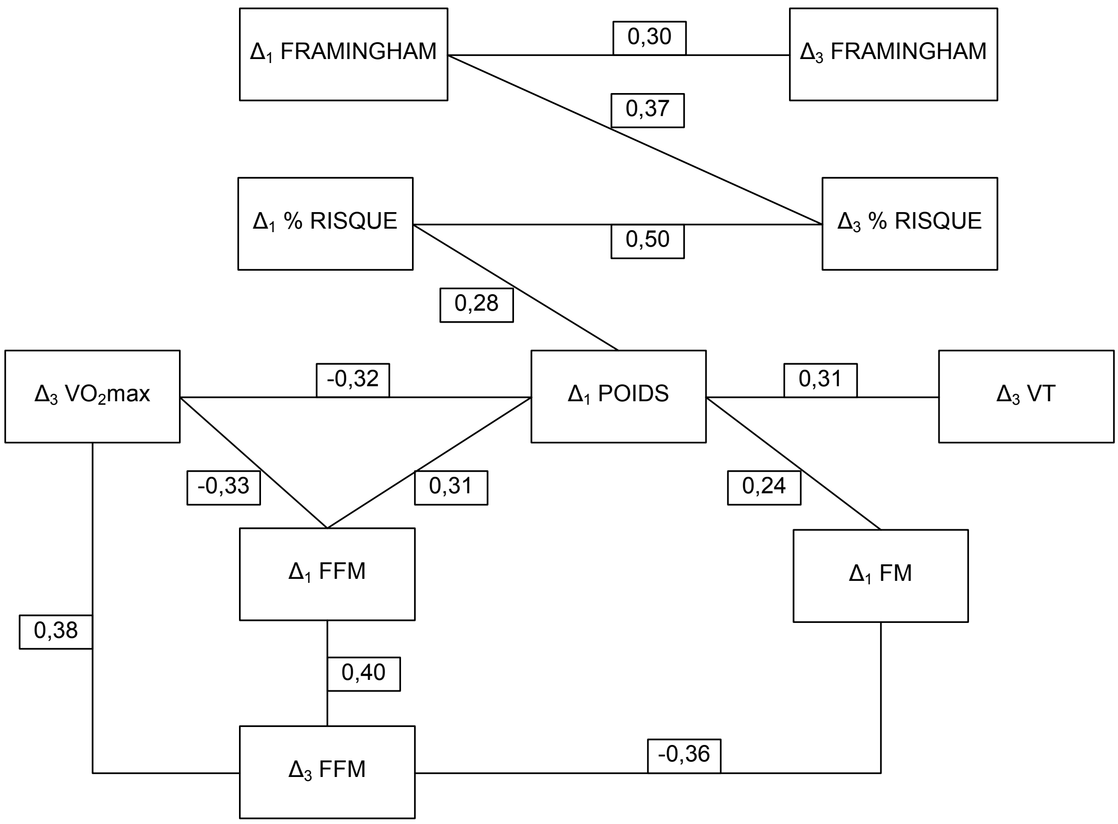


CORRELATIONS Δ_1 / Δ_3



EFFET DE L'ACTIVITE PHYSIQUE ET DU REGIME DIETETIQUE SUR UNE POPULATION DE GRANDS OBESES A COURT ET A LONG TERME

Résumé

Cette thèse a été conçue pour évaluer les différences de réponses du point de vu anthropométrique, physiologique et des paramètres liés à la santé entre différents programmes d'entraînement sur une population de sujets fortement obèses non morbides. Tous les sujets ont suivi un programme intégré de réduction de la masse corporelle (RMC) d'une durée de trois semaines. Le programme intégré comprenait les éléments suivants : régime hypocalorique, éducation nutritionnelle, conseils psychologiques et entraînement physique. Tous les tests ont été effectués la veille du début du programme intégré et répétés à la fin de celui-ci (soit au bout de 3 semaines et à la fin d'une année de follow up). Les résultats principaux ont été les suivants : 1) le programme intégré de RMC a fonctionné, car les sujets inactifs ont augmenté leur niveau d'activité physique ; sur la population globale on a observé une amélioration des capacités physiologiques à court terme et à long terme qui s'accompagne d'une perte de poids (en moyenne 6 kg); 2) la *guideline* principale qui ressort de cette étude est qu'il est nécessaire d'introduire l'activité physique comme élément indispensable dans la vie quotidienne en marchand 30 min par jour ; 3) notre étude ne permet pas d'étayer l'avantage d'un entraînement en force pour éviter la perte de masse maigre pendant un régime diététique mais l'entraînement en force a permis l'amélioration de la force maximale des sujets ; 4) notre étude a permis de déterminer que dans une première phase d'entraînement une intensité moyenne d'exercice peut suffire. Efforts supplémentaires doivent être fait pour permettre une modification du style de vie permanente.

Mots clés : obésité grave, activité physique et diète, effets à court et à long terme

SHORT-TERM AND LONG-TERM IMPACT OF PHYSICAL ACTIVITY AND DIET ON SEVERE OBESE SUBJECTS

Abstract

This study deals with the comparison of different training protocols for healthy severe obese subjects in terms of body weight and body composition, physiological and health related enhancement parameters. All subjects participated in an integrated body mass reduction program (duration: 3 weeks), consisting in: a) energy-restricted diet, b) nutritional education, c) psychological counseling, d) exercise training. All tests were performed the day before the beginning of the integrated program and repeated after 3 weeks (end of the first intervention phase of the program) and once again during a day hospital organized 1 y after the beginning of the treatment. These are the major findings of this research: 1) all behavioral interventions structured in this study provided positive effects at short-term for weight loss and body composition, physiological and health parameters and at the long-term for weight-maintenance; the studied interventions had a positive effect on lifestyle modification because inactive obese subjects had increase their physical activity level (PAL); 2) 30 min of moderate aerobic exercise 5 days/week has been well tolerated during a low caloric diet and it is the PAL we suggest to maintain; 3) strength training has been an important component of the weight loss program at short-term to enhance maximal strength but has not allowed to preserve fat free mass; 4) an increase in intensity has not been necessary at the short-term, since it has not determined any advantages. At the end of this study we can conclude that in our opinion the greatest obesity challenge is to find how to obtain a permanent lifestyle modification for obese subjects.

Keywords : severe obesity, physical activity and diet, short-term and long-term effects

Discipline : Sciences et Techniques des Activités Physiques et Sportives

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