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The physical exercise in the management of obesity

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Summary
The management of obesity essentially involves two aspects. The decrease of energy intake and increased energy expenditure. Regular physical activity contributes to the increase of energy expenditure and negative energy balance. Reducing weight and fat mass is supported by regular physical exercise. Likewise, maintaining weight and reducing fat is strongly linked to the continuity of physical activity. The management of obesity must integrate appropriate physical rehabilitation programs aimed not only at but also at metabolism. For this purpose, endurance training appears to be the most effective physical activity, although resistance training and high-intensity interval training play distinct roles. Physical activity is an essential tool, but it is often underestimated, in the management of obesity. The goal of this study is to highlight the evidence for the effectiveness of physical exercise in the management of obesity. The effects of exercise on the loss and stabilization of body weight and fat are going to be discussed. We will also deal with the effects on the metabolic factors linked to obesity in the second part. At the end of this article, mistakes not to commit in order to avoid exercise-related adverse effects will be discussed.

Keywords*: Energy balance; physical activity; obesity; weight loss; endurance*

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I. Introduction

Obesity is defined as an excessive and abnormal accumulation of fat in the body, this accumulation has negative effects on health [1]. Obesity has long disrupted healthcare systems around the world. In recent years, it has reached significant epidemic proportions [2]. It is a multifactorial metabolic disease. It is also often linked to a long-term imbalance in the energy balance where intake exceeds expenditure. This excess energy is stored in adipose tissue. The management of obesity (apart from pharmacological treatment) requires the establishment of a negative energy balance. Treatment tends to reduce dietary caloric intake and above all it aims to increase caloric expenditure linked to physical effort. Effectively achieving negative energy balance requires a combination of diet and physical activity as part of lifestyle modifications [3–5]. Significant weight loss seems to be due more to calorie restriction than to physical activity. However, calorie restriction exposes you to nutritional deficiencies that can lead to a loss of lean mass, especially muscle. The decrease in muscle mass restricts energy output from the muscle, which increases resting metabolism [6] (figures 1a, 1b). Moreover, stopping calorie restriction is likely to lead to weight regain [2,7]. Similarly, adherence to a physical exercise program plays a key role in long-term weight stabilization [3,8]. More than weight loss, the reduction of fatty tissue in general and visceral adipose tissue (VAT) specifically remains the fundamental concern of healthcare personnel in charge of obesity. The decrease in VAT can be obtained independently of changes in total weight. This reduction is more interesting than weight loss, especially since visceral fat is reduced better with physical exercise than with dietary restriction [9]. Ross has shown that increasing physical activity leads to appreciable reductions in abdominal obesity [10]. More than a caloric metabolic parameter, physical exercise has beneficial effects on health in the absence of weight loss [11,12]. Physical exercise is not devoid of adverse effects. In the obese subject, it should preferably be managed by qualified personnel in order to allow it to be put into practice and to avoid certain errors and preconceived ideas about physical activity.

II. The effects of physical activity on weight and body fat loss.

It seems that the deviation of energy expenditure to tip the energy balance towards its negative side is an effective strategy in the treatment of obesity. The greater the negative energy balance, the greater the weight loss (figures 1a, 1b). This type of deviation can be obtained by increasing physical activity in the form of supervised or unsupervised exercises [13]. Physiologically, energy expenditure is increased by complex cellular processes which tend to accelerate the breakdown of the body's energy stores of glycogen and triglycerides in the liver,

skeletal muscle and adipose tissue, thereby leading to a loss of weight. The increased need for energy substrates (glucose and fatty acids) activates the secretion of the hormones of glycolysis, glycogenolysis, gluconeogenesis and lipolysis. Neuro-hormonal modulation by glucagon, insulin, catecholamines and cortisol provides the energy pathways of the muscle with a sufficient quantity of substrates (figure 2). The benefits of physical activity also affect energy intake indirectly by modulating appetite [14]. It would seem, that at the very beginning of a training, the eating behavior is "altered" or more exactly upgraded. It results in a decrease in appetite [15]. Introducing a physical activity program is fundamental in the therapeutic education of obese subjects.

2.1 The volume of a physical exercise program:

Physical exercise programming requires knowledge and mastery of its components, volume and type of exercise. Exercise volume is expressed in terms of duration and frequency. Type of exercise is most often related to intensity. The volume of physical exercise is in perfect correlation with the exercise-related thermogenesis (ERT). Donnelly showed, in obese subjects who practiced a physical activity of 400 Kcal/session for 5 sessions per week (without calorie restriction), had recorded a loss of 4.3% of the initial weight [16]. In the same study for another group which has a physical activity of 600 Kcal/session, at the rate of 5 sessions/week, there is a loss of 5.7% of the initial weight. The volume of a program therefore depends on the targeted weight. For, the *American College of Sports Medicine (ACSM)* [3, 13], the European College of Sports Science position paper (ECSS) [17, 18], and the American College *of Cardiology* and the *American Heart Association* (ACC-AHA) [19], a minimum exercise of physical activity of about 150 minutes of moderate intensity per week, without food restriction can induce a weight loss of about 2 to 3 kg. However, this modest weight loss is inconsistent with a clinically significant weight goal (≥ 5% of initial weight) [3, 13, 18, 19]. Achieving this goal requires approximately 225–420 minutes of exercise per week [13, 20]. More than 150 minutes/week is needed to lose weight. Above all, it allows better long-term weight control [21]. It is thus necessary, a training of 250 minutes per week, to achieve a loss of 5 kg in 6 months. This is the equivalent of physical activity for 50 minutes per week with an average loss of around 1 kg over 6 months. Moderate-intensity exercise is characterized by 3 to 6 Mets (Metabolic of equivalent task), i.e., 3 to 6 times resting energy expenditure [22]. Several parameters have been identified which appear to be usable when prescribing physical activity in obese subjects. 40–50% of maximal oxygen consumption rate (VO2max) 50–60% of maximal heart rate or maximal aerobic power (MAP) [23–26]. All these parameters are very interesting in specialized environments which have specific equipment. The ideal is to be able to visualize in real time the consumption of non-protein energy substrates (carbohydrates and lipids) by respiratory indirect calorimetry. This technique, obviously cumbersome in clinical practice, seems to be the most accurate tool for measuring maximum lipid oxidation or Lip ox $_{max}$ [24]. Several examples of physical exercises are cited according to their intensity in table 1a.

2.2 Type of physical exercise. Endurance, resistance or high-intensity interval training are all possible avenues.

2.2.1 **Endurance training versus resistance training**

The type of physical exercise is a parameter to be taken into consideration in the management of obesity. Endurance training, that is, the body's ability to maintain a generalized aerobic effort, is probably the best known and most effective exercise for weight loss. In fact, endurance training improves fat oxidation and reduces body weight [27]. This type of exercise is easily applicable to obese subjects. It can cover a fairly large energy expenditure. Furthermore, resistance exercise, i.e., the body's ability to maintain a relatively intense generalized effort of the anaerobic type, and intermittent exercise, i.e., exercises at high intensity interspersed with rest periods, can also be included in an obesity management program. Resistance training or intermittent exercises provide additional health benefits and improve physical abilities. Thus, resistance exercise stimulates lipolysis of adipose tissue in normal-weight and obese men [28], in the same way as endurance exercise [29]. This suggests that resistance training of obese subjects may aid fat mobilization allowing fatty acid oxidation leading to fat loss (Figure 2). Notwithstanding, in a resistance exercise, the rest intervals are long, therefore the energy expenditure linked to this type of effort is low and a large part of the fatty acids produced by lipolysis are not oxidized. These fatty acids are re-esterified again into triglycerides. If the weight loss by resistance training cannot be significant [20], it strengthens on the other hand, the muscle mass which promotes the increase in the use of lipid substrates by the skeletal muscle (figure 2). In the long term, resistance training can play an important role in successful weight loss, by altering body composition [20] and eating behavior by reducing appetite (figure 3).

2.2.2 **High intensity interval training.**

Another type of exercise can also be proposed in the management of obesity, it is the High Intensity Interval Training" (HIIT). This type of training is characterized by short periods of high-intensity exercise alternating with periods of rest or low-intensity exercise. HIIT is currently a commonly applied strategy in weight loss among the general population [30]. According to Türk et al, this type of exercise, which is quite feasible, is fairly well tolerated by obese subjects [31]. HIIT allowed a significant loss of total weight (minus 1.3 kg)

compared to control groups who did not exercise [32]. It is as effective as the Moderate Intensity Continuous Training" (MICT) of which the retraining in Lip ox $_{max}$ is its most known entity. A loss of fat mass without change in total weight was observed by comparing two groups of obese subjects, the first trained in HIIC and the second trained in MICT [33].

III. The stabilization phase of weight and fat loss: the choice of exercise and/or the choice of diets

The greatest difficulty in the management of the obese subject is the fact of stabilizing the weight loss obtained following retraining whether by endurance, resistance or HIIT. This is a perpetual challenge for the obese subject. Weight stabilization is probably the biggest problem in obesity management. Weight gain is extremely common and sometimes even a slight increase of 2–6% in weight can reverse the metabolic benefits of weight loss [34]. Only about 20% of overweight subjects (25 Kg/m ^{2} ≤BMI≤29.9 Kg/m ^{2}) appear to be able to maintain the 10% weight loss for over a year [35]. For the obese, exercise is likely seen as an integral part of the weight stabilization strategy. In fact, weight stabilization can only be substantial for average caloric expenditure of 2621 kcal/week of physical activity. Corresponding to moderate intensity exercise of more than 60 minutes per day such as brisk walking. It can also correspond to intense exercise of more than 35 minutes per day such as jogging [36]. In a meta-analysis having focused on weight stabilization after an initial weight loss with low-calorie or very low-calorie diets combined or not with physical exercise, that no significant improvement could be observed between the group which was in addition of the diet a physical activity and the control one who did only the diet [37]. In fact, many randomized studies that addressed weight gain did not show a significant effect of exercise [38–41]. It was shown that after a follow-up of 12 months, significant differences in the maintenance of weight loss between a group which practiced a physical exercise of 2500 kcal/week (75 minutes of walking per day) and a group which followed standard behavioral therapy and which spent 1000 kcal/week (30 minutes of walking per day) [42]. Kerns et al confirmed that significant physical activity (80 min of moderate-intensity activity or 35 min of intense activity per day) resulted in initial weight loss with weight stabilization after 6 years [43]. Indeed, it is only after 5 years that the weight loss is maintained at (-7.52±2.07kg) or (-8.29±2.28%) of the initial weight [44]. ACSM recommendations for weight stabilization after weight loss are 200 to 300 min of moderate-intensity physical activity per week [13]. The National Institutes of Health (NIH) suggests regarding the exercise needed for weight loss stabilization that further research can focus on two main areas. The first aspect is to deepen the understanding of the mechanisms by which physical exercise can counter the various biological factors that are at the origin of weight gain. Some of these factors are depicted in figures 1 and 2. The second aspect is to understand the factors that promote adherence (or not) to the long-term prescription of physical exercise [45].

IV. The effects of physical activity on obesity-related metabolic factors.

Apart from weight loss, regular physical activity can improve the health of obese subjects. By reducing the metabolic complications of obesity even in the absence of weight loss. Several studies have shown that physical exercise improves cardiorespiratory capacity and, at the same time, it beneficially modifies the metabolic factors linked to obesity such as the risk of mortality, weight, fat visceral, lipid profile, hypertension and insulin sensitivity[46-49]. In addition to lipid disorders and insulin resistance, the abnormally high accumulation of triglycerides in the liver is a significant metabolic complication of obesity. Known as non -alcoholic fatty liver disease (NAFLD), this condition increases the risk of insulin resistance, metabolic syndrome and cardiovascular disease, independent of obesity [50]. A meta-analysis of 20 randomized controlled trials in overweight and obese patients with NAFLD [51] concluded that regular exercise reduced serum concentrations of alanine aminotransferase (ALT) and aspartate aminotransferase (ASAT) corollaries of hepatic cytolysis. This improvement is independent of weight loss.

V.Mistakes to avoid when treating obese subjects with physical exercise

When implementing a physical exercise program for obese people, some special precautions must be taken into account to avoid misuse of the prescribed exercise. Errors during training are likely to cause injuries and thus the cessation of physical activity. Obese individuals are at increased risk of muscle injury due to the significant pressure exerted by weight on the knee and hip joints. Vincent et al explain that obesity seems to be at the origin of several pathways predisposing to osteoarthritis [52]. The joint overload becomes more important if the exercise rate increases, therefore it is proposed to carry out weak exercises and of short duration until a certain level of weight loss is reached from which a greater effort can be undertaken. At the beginning of the training program, fatigue is almost constant in the obese, because they have low cardiorespiratory capacity this results in an aversion to continuing the program [53]. Thus, gradually increasing the exercise load is important to ensure better adherence to the training program and even better to avoid injury. In addition, it is important to ensure preparation for exercise sessions by performing a correct warm-up and devoting sufficient time to recovery. Finally, a clear definition of goals and continuous monitoring of retraining progress increase the chances of a

successful exercise program. The supervision of the sessions by a competent "coach" guaranteeing coaching and even better counseling, at least at the start of a program, is more than recommended in order to allow the application of the support program. Some misconceptions are to be feared. The possibility of inducing local fat loss by doing an exercise specifically localized to one part of the body (for example, to reduce abdominal fat by performing sit-ups). It must be recognized that adipose tissue by itself does not exercise and therefore is not energetically active. It receives neuroendocrine signals (endocrine, paracrine and autocrine) to accelerate lipolysis (figure 2). There is little theoretical basis for weight loss to affect fats in a targeted and especially localized way. Katch et al [54] refuted this hypothesis. They demonstrated that if enough exercise is done to achieve fat loss, it will come from the whole body and not from one part of the body specifically exercised. Another common misconception is that passive exercise through equipment that "vibrates" parts of the body, or electrical stimulation of a body part, is sometimes advocated as a means of weight and fat loss. Such equipment was developed mainly for fitness purposes, but some of this type of tool has found an oversized place in the market, because it seems effective on weight loss. Given that this type of instrument does not or only slightly increase energy expenditure and even more so the negativity of the energy balance, it does not seem to be as effective as physical exercise [23] (figure 1a). Finally, intentionally induced exercise in a hot environment, water deprivation during exercise, and the use of sweatbands or other types of clothing that increase sweating are often touted as ways that helps improve weight loss. These practices by default target water loss rather than fat mass. They are ineffective because the body will retain more water and excrete less after the next fluid intake through its homeostatic mechanisms. These practices are probably harmful [23], as they increase the risk of dehydration, with consequences for physical performance and health.

VI. Conclusion

Physical exercise is an essential therapeutic means for the management of obesity. It is often underestimated compared to other means such as so-called "weight loss diets", drugs and bariatric surgery. Health professionals in charge of obesity should be further convinced that physical exercise remains a highly exploitable therapeutic weapon. Whatever the type of endurance, resistance or high-intensity interval exercise, the loss of weight, fat mass and the stabilization of these losses can allow the achievement of the weight objective. Similarly, supervised or unsupervised physical exercise (in volume, intensity and duration) has beneficial effects on health without achieving the weight objective.

References

[1]. World Health organisation (who). Definition of obesity and overweight https://www.who.int/topics/obesity/fr/
[2]. Bray G, Heisel W, Afshin A, Jensen M, Dietz W, Long M et al. the science of obesity management: an endocrine society scientific statement. Endocrine Reviews. 2018;39(2):79-132.
[3]. Jakicic J, Clark K, Coleman E, Donnelly J, Foreyt J, Melanson E et al. appropriate intervention strategies for weight loss and prevention of weight regain for adults. Medicine & Science in Sports & Exercise. 2001;33(12):2145-2156.
[4]. Johns D, Hartmann-Boyce J, Jebb S, Aveyard P. Diet or exercise interventions vs combined behavioral weight management programs: a systematic review and meta-analysis of direct comparisons. Journal of the Academy of Nutrition and Dietetics. 2014;114(10):1557-1568.
[5]. Jakicic J, Rogers R, Davis K, Collins K. Role of physical activity and exercise in treating patients with overweight and obesity. Clinical Chemistry. 2018;64(1):99-107.
[6]. DiPietro L, Stachenfeld NS. Exercise treatment of obesity. Endotext; 2000. p. 1–11
[7]. Headland M, Clifton P, Carter S, Keogh J. Weight-Loss Outcomes: A systematic review and meta-analysis of intermittent energy restriction trials lasting a minimum of 6 months. Nutrients. 2016;8(6):354.
[8]. Avenell A, Brown T, McGee M, Campbell M, Grant A, Broom J et al. What interventions should we add to weight reducing diets in adults with obesity? A systematic review of randomized controlled trials of adding drug therapy, exercise, behaviour therapy or combinations of these interventions. Journal of Human Nutrition and Dietetics. 2004;17(4):293-316.
[9]. Verheggen R, Maessen M, Green D, Hermus A, Hopman M, Thijssen D. A systematic review and meta-analysis on the effects of exercise training versus hypocaloric diet: distinct effects on body weight and visceral adipose tissue. Obesity Reviews. 2016;17(8):664-690.
[10]. Ross R, Bradshaw A. The future of obesity reduction: beyond weight loss. Nature Reviews Endocrinology. 2009;5(6):319-325.
[11]. Laskowski E. The role of exercise in the treatment of obesity. PM&R. 2012;4(11):840-844.
[12]. Chaput J, Klingenberg L, Rosenkilde M, Gilbert J, Tremblay A, Sjödin A. Physical activity plays an important role in body weight regulation. Journal of Obesity. 2011;2011:1-11.
[13]. Donnelly J, Blair S, Jakicic J, Manore M, Rankin J, Smith B. Appropriate Physical activity intervention strategies for weight loss and prevention of weight regain for adults. Medicine & Science in Sports & Exercise. 2009;41(2):459-471.
[14]. Schubert M, Desbrow B, Sabapathy S, Leveritt M. Acute exercise and subsequent energy intake. A meta-analysis. Appetite. 2013;63:92-104.
[15]. Javernaud E, Brun JF, Richou M, Bughin M, Mercier M. Les effets du réentraînement ciblé au LIPOXmax sur le comportement alimentaire et la composition corporelle. 2017. Journées Francophones de Nutrition (JFN) Nantes 13-15 décembre 2017, poster P058. Livre des résumés p 165.
[16]. Donnelly J, Honas J, Smith B, Mayo M, Gibson C, Sullivan D et al. Aerobic exercise alone results in clinically significant weight loss for men and women: Midwest exercise trial 2. Obesity. 2013;21(3):E219-E228.
[17]. Fogelholm M, Stallknecht B, Van Baak M. ECSS position statement: Exercise and obesity. European Journal of Sport Science. 2006;6(1):15-24.
[18]. Jensen M, Ryan D, Apovian C, Ard J, Comuzzie A, Donato K et al. 2013 AHA/ACC/TOS Guideline for the management of overweight and obesity in adults. Circulation. 2013;129(25 suppl 2):S102-S138.

[19]. Hagobian T, Evero N. Exercise and weight loss: what is the evidence of sex differences? Current Obesity Reports. 2012;2(1):86-92.
[20]. Swift D, McGee J, Earnest C, Carlisle E, Nygard M, Johannsen N. The effects of exercise and physical activity on weight loss and maintenance. Progress in Cardiovascular Diseases. 2018;61(2):206-213.
[21]. Sword D. Exercise as a management strategy for the overweight and obese. Strength and Conditioning Journal. 2012;34(5):47-55.
[22]. Garber C, Blissmer B, Deschenes M, Franklin B, Lamonte M, Lee I et al. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults. Medicine & Science in Sports & Exercise. 2011;43(7):1334-1359.
[23]. Petridou A, Siopi A, Mougios V. Exercise in the management of obesity. Metabolism. 2019;92:163-169.
[24]. Achten J, Gleeson M, Jeukendrup A. Determination of the exercise intensity that elicits maximal fat oxidation. Medicine & Science in Sports & Exercise. 2002;34(1):92–97.
[25]. Mendelson M, Guinot M, Favre-Juvin A, Wuyam B, Flore P. Aspects méthodologiques de la mesure du lipoxmax : conditions d'application pour les personnes atteintes de pathologies métaboliques. Mouvement & Sport Sciences. 2014;(84):61–70.
[26]. Brun, J.-F.; Myzia, J.; Varlet-Marie, E.; Raynaud de Mauverger, E.; Mercier, J. Beyond the Calorie Paradigm: Taking into Account in Practice the Balance of Fat and Carbohydrate Oxidation during Exercise? *Nutrients* **2022**, *14*, 1605.
[27]. Rosenkilde M, Reichkendler M, Auerbach P, Bonne T, Sjödin A, Ploug T et al. Changes in peak fat oxidation in response to different doses of endurance training. Scandinavian Journal of Medicine & Science in Sports. 2013;25(1):41-52.
[28]. Chatzinikolaou A, Fatouros I, Petridou A, Jamurtas A, Avloniti A, Douroudos I et al. Adipose tissue lipolysis is upregulated in lean and obese men during acute resistance exercise. Diabetes Care. 2008;31(7):1397-1399.
[29]. Petridou A, Chatzinikolaou A, Avloniti A, Jamurtas A, Loules G, Papassotiriou I et al. Increased triacylglycerol lipase activity in adipose tissue of lean and obese men during endurance exercise. The Journal of Clinical Endocrinology & Metabolism. 2017;102(11):3945-3952.
[30]. Obert J, Pearlman M, Obert L, Chapin S. Popular weight loss strategies: a review of four weight loss techniques. Current Gastroenterology Reports. 2017;19(12).
[31]. Türk Y, Theel W, Kasteleyn M, Franssen F, Hiemstra P, Rudolphus A et al. High intensity training in obesity: a Meta-analysis. Obesity Science & Practice. 2017;3(3):258-271.
[32]. Jelleyman C, Yates T, O'Donovan G, Gray L, King J, Khunti K et al. The effects of high-intensity interval training on glucose regulation and insulin resistance: a meta-analysis. Obesity Reviews. 2015;16(11):942-961.
[33]. Wewege M, van den Berg R, Ward R, Keech A. The effects of high-intensity interval training vs. moderate-intensity continuous training on body composition in overweight and obese adults: a systematic review and meta-analysis. Obesity Reviews. 2017;18(6):635-646.
[34]. Kroeger C, Hoddy K, Varady K. Impact of weight regain on metabolic disease risk: a review of human trials. Journal of Obesity. 2014;2014:1-8.
[35]. Wing R, Phelan S. Long-term weight loss maintenance. The American Journal of Clinical Nutrition. 2005;82(1):222S-225S.
[36]. Catenacci V, Ogden L, Stuht J, Phelan S, Wing R, Hill J et al. Physical activity patterns in the national weight control registry. Obesity. 2008;16(1):153-161.
[37]. Johansson K, Neovius M, Hemmingsson E. Effects of anti-obesity drugs, diet, and exercise on weight-loss maintenance after a very-low-calorie diet or low-calorie diet: a systematic review and meta-analysis of randomized controlled trials. The American Journal of Clinical Nutrition. 2013;99(1):14-23.
[38]. Borg P, Kukkonen-Harjula K, Fogelholm M, Pasanen M. Effects of walking or resistance training on weight loss maintenance in obese, middle-aged men: a randomized trial. International Journal of Obesity. 2002;26(5):676-683.
[39]. Fogelholm M, Kukkonen-Harjula K, Nenomen A, Pasanen M. Effects of walking training on weight maintenance after a very-low-energy diet in premenopausal obese women. Journal of Cardiopulmonary Rehabilitation. 2001;21(1):52.
[40]. Jakicic J. effect of exercise on 24-month weight loss maintenance in overweight women. Archives of Internal Medicine. 2008;168(14):1550.
[41]. Tate D, Jeffery R, Sherwood N, Wing R. Long-term weight losses associated with prescription of higher physical activity goals. Are higher levels of physical activity protective against weight regain?. The American Journal of Clinical Nutrition. 2007;85(4):954-959.
[42]. Jeffery R, Wing R, Sherwood N, Tate D. Physical activity and weight loss: does prescribing higher physical activity goals improve outcome?. The American Journal of Clinical Nutrition. 2003;78(4):684-689.
[43]. Kerns J, Guo J, Fothergill E, Howard L, Knuth N, Brychta R et al. Increased physical activity associated with less weight regain six years after "the biggest loser" competition. Obesity. 2017;25(11):1838-1843.
[44]. JF Brun. Rennes 27-29 Novembre 2019 Journées Francophones de Nutrition, Rennes 27-29 Novembre 2019. Poster P044. Abstract book p 150.
[45]. MacLean P, Wing R, Davidson T, Epstein L, Goodpaster B, Hall K et al. NIH working group report: Innovative research to improve maintenance of weight loss. Obesity. 2014;23(1):7-15.
[46]. Farrell S, Fitzgerald S, McAuley P, Barlow C. Cardiorespiratory fitness, adiposity, and all-cause mortality in women. Medicine & Science in Sports & Exercise. 2010;42(11):2006-2012.
[47]. Lyerly G, Sui X, Lavie C, Church T, Hand G, Blair S. the association between cardiorespiratory fitness and risk of all-cause mortality among women with impaired fasting glucose or undiagnosed diabetes mellitus. Mayo Clinic Proceedings. 2009;84(9):780-786.
[48]. Larson-Meyer D, Redman L, Heilbronn L, Martin C, Ravussin E. Caloric restriction with or without exercise. Medicine & Science in Sports & Exercise. 2010;42(1):152-159.
[49]. Coker R, Williams R, Yeo S, Kortebein P, Bodenner D, Kern P et al. The impact of exercise training compared to caloric restriction on hepatic and peripheral insulin resistance in obesity. The Journal of Clinical Endocrinology & Metabolism. 2009;94(11):4258-4266.
[50]. Johnson N, Sachinwalla T, Walton D, Smith K, Armstrong A, Thompson M et al. Aerobic exercise training reduces hepatic and visceral lipids in obese individuals without weight loss. Hepatology. 2009;50(4):1105-1112.
[51]. Katsagoni C, Georgoulis M, Papatheodoridis G, Panagiotakos D, Kontogianni M. Effects of lifestyle interventions on clinical characteristics of patients with non-alcoholic fatty liver disease: A meta-analysis. Metabolism. 2017;68:119-132.
[52]. Vincent H, Heywood K, Connelly J, Hurley R. Obesity and weight loss in the treatment and prevention of osteoarthritis. PM&R. 2012;4: S59-S67.
[53]. Zdarsky LA, Wasser JG, Vincent HK. Chronic pain management in the obese patient: a focused review of key challenges and potential exercise solutions. J Pain Res 2015; 8:63-77.
[54]. Katch F, Clarkson P, Kroll W, McBride T, Wilcox A. Effects of sit up exercise training on adipose cell size and adiposity. Research Quarterly for Exercise and Sport. 1984;55(3):242-247.

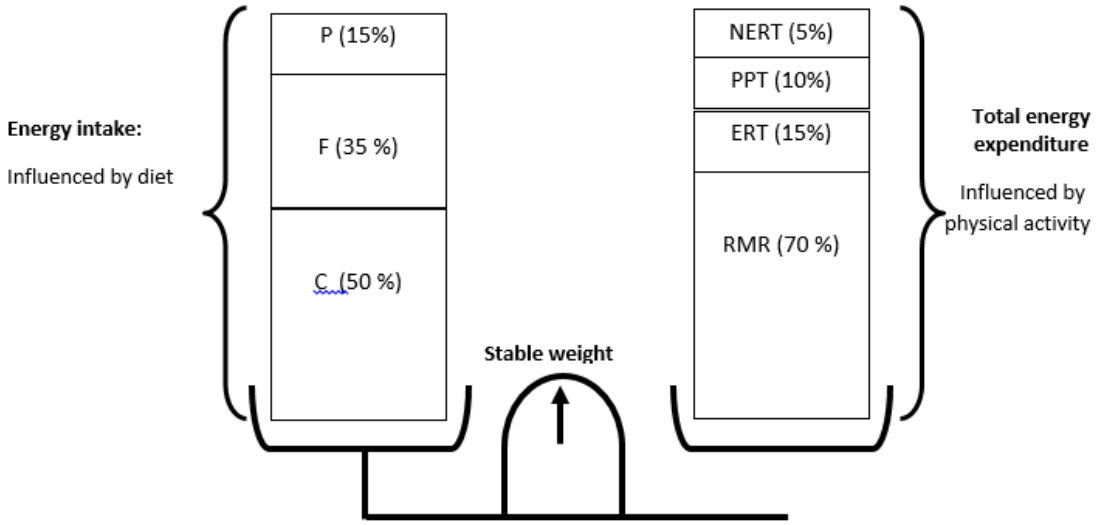

Figure 1a. Factors influencing energy balance

C: carbohydrate, F: fat, P: protein, RM: resting metabolism rate, ERT: exercise-related thermogenesis, PPT: postprandial thermogenesis, NERT: non-exercise-related thermogenesis.
RM and NERT represent the compressible/decompressible energies of total daily energy expenditure (TDEE). Increasing exercise (by building muscle mass) decreases resting metabolism. Conversely, decreasing exercise (by reducing muscle mass) increases resting metabolism.

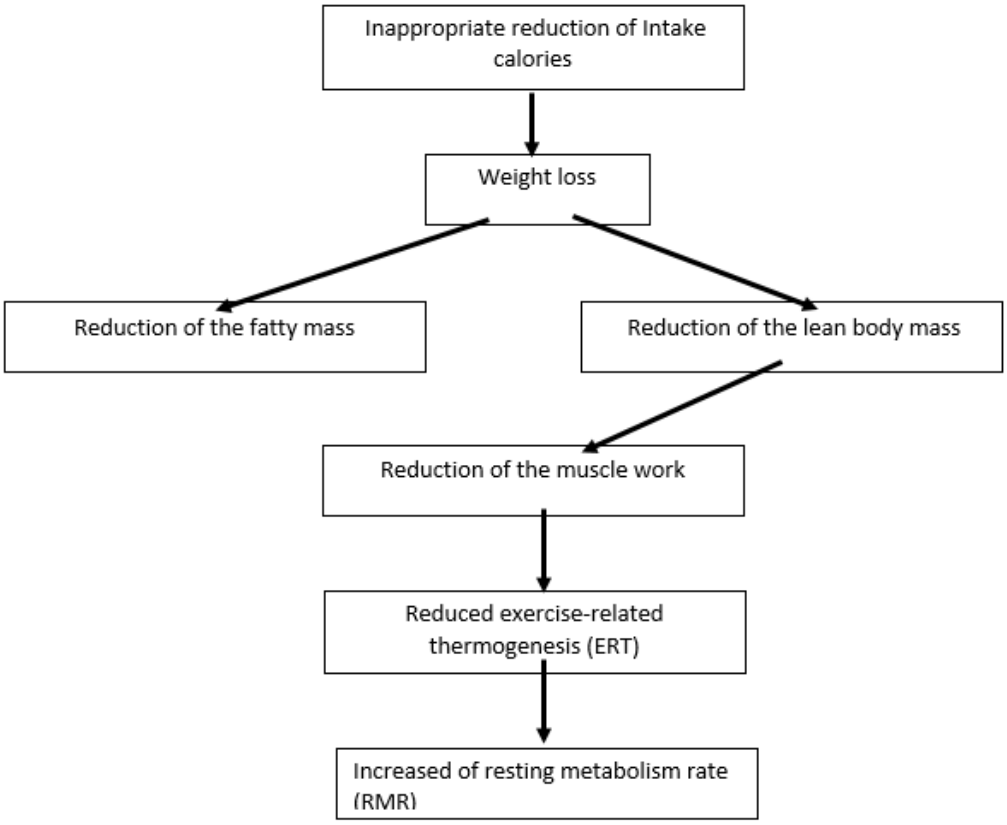

Figure 1b. Effects of calorie restriction on the compressible/decompressible components of total daily energy expenditure (TDEE).

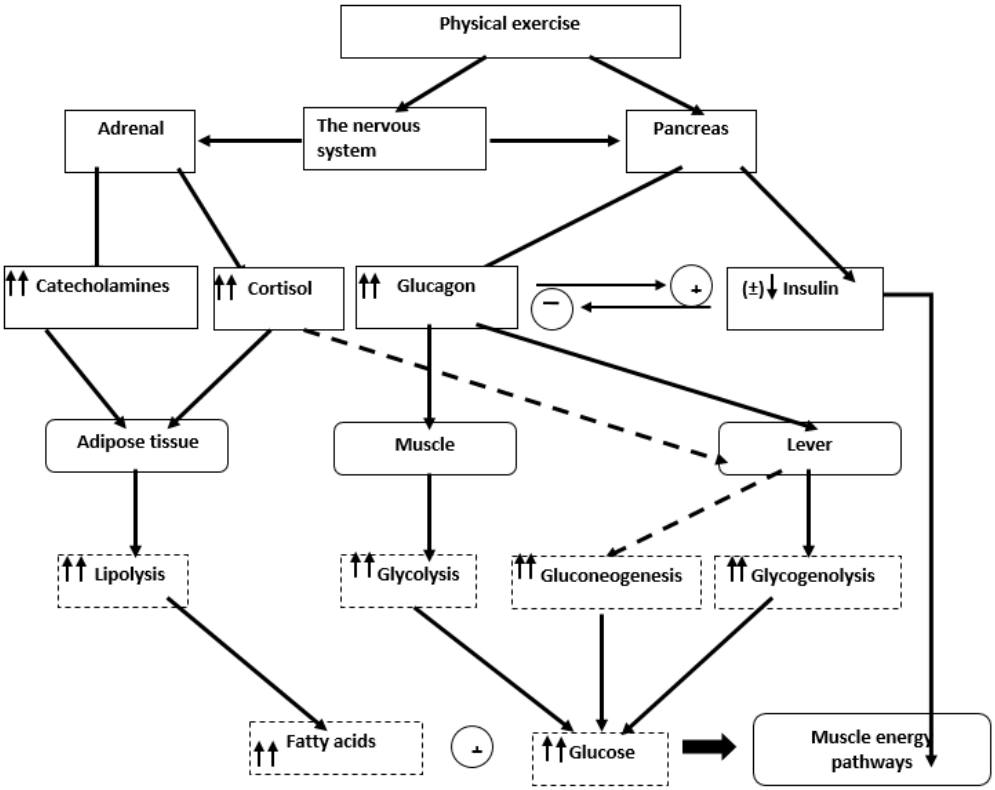

Figure 2. Effects of exercise on carbohydrate and lipid metabolic pathways

Exercise increases glucagon secretion to meet muscle glucose requirements. The autonomic nervous system activates this pathway and the pathway of the other hyperglycemic hormones, cortisol and catecholamines. Since insulin is essential for the activation of the muscle energy pathways, its level is modulated by glucagon and the autonomic nervous system. Glucagon increases glycogenolysis and glycolysis releasing a large amount of glucose to the muscle. Cortisol and adrenaline accelerate lipolysis of fatty tissue, making it easier for the muscle to use energy during exercise. Neoglucogenesis is a secondary pathway in case of increased glucose requirements.

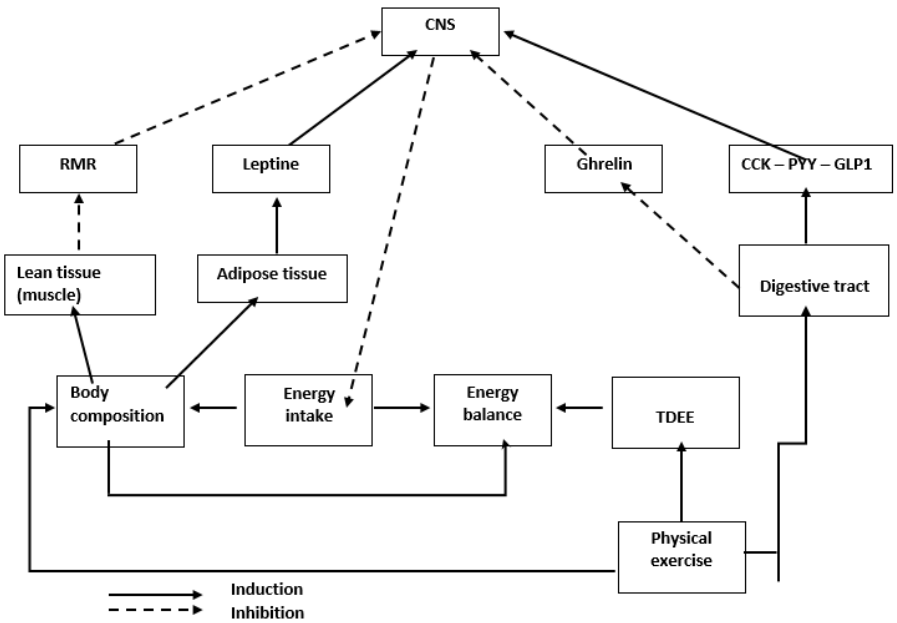

Figure 3. The effects of exercise on the pathways modulating eating behavior (orexigenic -anorexigenic). CCK: Cholecystokinin, TDEE: Total Daily Energy Expenditure, GLP1: Glucagon Like peptide 1, MR: Resting Metabolism, PYY: Peptide tyrosine tyrosine.

The satiety effects of physical exercise are dependent and independent of the energy balance. Through its actions on the digestive tract, exercise reinforces the satiety pathway through the action of the hormones PYY, CCK and GLP1. Conversely, it inhibits the hunger pathway normally activated by Ghrelin. On body composition, it reinforces the satiety pathway by increasing the secretion of Leptin by the adipose tissue. Conversely, physical exercise inhibits the resting metabolic pathway by increasing lean muscle mass. In total, the CNS decreases the food intake pathway through an anorectic effect by decreasing appetite.

Table 1. Examples of moderate physical activities

Intensity of physical activity	Type of activities	Mets
Low	- Billiards	2,5
	- Slow dance	2,5
	- Gardening	2,5 - 3
	- Slow to moderate walking < 5Km/h	2,5 - 3
	- Volleyball in recreation	2,9
Moderate	- Housework	3 – 4
	- Bicycle	3,5 – 4
	- Walking tour	3,5 – 4
	- Social dance (Disco – Folklore)	4,5
	- Swimming	5
	- Fast walking (5 – 7 Km/h)	3,5 – 5
High	- Stationary bicycle	5,5 – 7
	- Aerobic dance	6,5
	- Moderate cycling (16 – 22 Km/h)	6 – 8
	- Basketball	7
	- Walking up	7,5 – 8
	- Jogging (10 Km/h)	8 – 10

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