Strength training and weight loss

Treinamento de força e emagrecimento

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Abstract

The aims of this study were (a) consider the effectiveness of strength training (ST) to weight loss and (b) present the main physiological mechanisms that explain this relationship. Through literature review, analyzed studies published originally in international language. As the search strategy was used the Medline database (National Library of Medicine) with the combination of the following keywords: resistance exercise, strength training, weight exercise, strength exercise, energy expenditure, weight loss. No results were found involving concurrent or aerobic exercises. The selected studies show that the ST can effectively collaborate with the weight loss process as a complement to aerobic exercise training and diet. Mentioned cooperation occurs mainly through the increase or maintenance in the resting metabolic rate, energy expenditure of the activity itself and also under the effect related to excessive oxygen consumption after exercise. Moreover, in general, ST periodization is ideal for long-term success because it enables combinations of the beneficial effects of ST-related weight loss.

Descriptors: Exercise; Weight lifting; Resistance training; Weight loss; Obesity

Resumo

Os objetivos deste trabalho foram (a) analisar a eficácia do treinamento de força muscular (TF) sobre o emagrecimento e (b) apresentar os principais mecanismos fisiológicos que explicam tal relação. Por meio de revisão de literatura foram analisados estudos publicados originalmente em idioma internacional. Como estratégia de busca, foi utilizada a base de dados Medline (*National Library of Medicine*) com a combinação das seguintes palavras-chave: *resistance exercise, strength training, weight exercise, strength exercis, energy expendidture, weight loss.* Não foram considerados resultados que implicavam em exercícios concorrentes ou aeróbios. Os trabalhos selecionados mostram que o TF pode efetivamente colaborar com o processo de emagrecimento como complemento ao treinamento aeróbio e à dieta. Citada cooperação ocorre, principalmente, por meio do aumento ou manutenção na taxa metabólica de repouso, do gasto energético da própria atividade de força e também pelo efeito relacionado ao consumo de oxigênio excessivo após o exercício. Além disso, de forma geral, a periodização do TF é ideal para o sucesso em longo prazo, pois possibilita combinações dos efeitos benéficos do TF relacionados ao emagrecimento.

Descritores: Exercício; Levantamento de peso; Treinamento de resistência; Perda de peso; Obesidade

Introduction

Muscle strength is the capacity of the neuromuscular system to win or to oppose the external resistance such as weights, elastic bands, the very body mass and strength training machines. The systematic implementation of such exercise is called strength training (ST) and has a positive impact in several activities of daily living. This benefit is obvious because these activities require a certain percentage of the individual capacity to perform tasks and improvement in muscle strength result in less physiological stress to implement them[1].

The ST, also called resistance training or weight training has been considered an important component of exercise programs aimed at physical fitness and health[2]. This link occurs by the association of the metabolic effects caused by the loss of muscle mass to the high prevalence of obesity, insulin resistance, type 2 diabetes, dyslipidemia and hypertension[3]. Conversely, the gain and/or the preservation of muscle mass through the ST, has been regarded as formidable factor in preventing or combating the harmful effects of aging[2].

On the other hand, excess of body fat is related to various diseases and its prevalence has increased significantly in recent decades[4]. By definition, the weight loss occurs when there is reduction of body fat relative to total body mass. That is, the percentage of body fat is decreased and this condition is positive for the promotion of health[5].

Traditionally, the predominant aerobic exercise training has been recommended as priority by the international scientific community when it comes to exercise and weight loss[5]. This suggestion probably is based on the higher oxygen consumption (VO_2) (and energetic expenditure) than the aerobic activities have compared the strength for the same time of exercise[1,6] together with the fact of the aerobics oxidize more lipids when compared to ST, which predominantly use carbohydrate as fuel energy for its accomplishment. However, more recent studies have suggested that ST plays an important role in controlling body weight and results in unique effects that the implementation of aerobic exercise alone can not achieve[6].

We analyzed the most relevant studies published originally in international language. As the search strategy was used the database Medline (National Library of Medicine) with the combination of the following keywords: resistance exercise, strength training, weight exercise, strength exercise, energy expenditure, weight loss. No results were considered if involving aerobic or concurrent exercises.

Thus, the aims of this review were (a) analyze the effectiveness of ST on the weight loss process and (b) present the main physiological mechanisms that explain this.

Discussion

Energy balance

The change in body mass is explained mathematically by ± 95% of cases. Less than 5% occur from hereditary diseases that cause obesity or slimness[7]. Thus, the weight loss occurs when there is negative energy balance. That is, the total daily energy expenditure (TEE) exceeds your energy consumption. Conversely, when caloric intake exceeds the TEE, there will be a condition of positive energy balance, with subsequent gain in body mass. If both (TEE and food intake) are equal to the body mass[1] maintenance will occur (Table 1).

Table 1. Balance energy and implications for body mass

Input energy	Output energy	Result on body mass
Equal	Equal	No change
Higher	Minor	Increase
Minor	Higher	Decrease

Components of total daily energy expenditure

Considering that weight loss will happen if the TTE is greater than the calorie intake (Table 1), it is imperative to understand how the body spends energy in the twenty-four hours. Basically there are three components: (a) resting metabolic rate, which involves energy expenditure to maintain physiological functions during sleep and in situations close to the resting state. It is estimated that approximately 60-75% of TTE is devoted to this component, (b) thermic effect of food which is the component responsible for digestion, absorption and assimilation of nutrients from foods eaten with ± 10% of TTE and (c) thermic effect of physical activity that is ± 15 to 30% of TTE1 (Table 2). Clearly, these values are approximate and that there are always individual variations. That said, we will look from here the effect of ST on each of these components through the literature.

Table 2. Estimated values of total daily energy expenditure

Components	Energy expenditure
Resting metabolic rate	± 60 a 75%
Thermic effect of food	± 10%
Thermic effect of physical activity	± 15 a 30%

Prescription of strength training and weight loss

Whereas the resting metabolic rate is the major component of the TTE and that it relates to the amount of individual muscle mass[8], the hypothesis that the ST to provide muscle hypertrophy contributes to the process of weight loss[5]. Logically this physiological effect (hypertrophy) not only depend on the training itself, but also on other factors such as genetics, and action hormonal[9] and nutrition[2,10].

The postulated mechanism for the collaboration of the ST with weight loss via muscle hypertrophy, it would be this: the increase in muscle mass creates greater resting metabolic rate and this, in turn, increases the TTE, thereby reducing the fat corporal[5].

As noted above, muscle hypertrophy depends not only on physical training. Nevertheless, for purposes of this study will focus on the major aspects of the prescription of ST that could maximize hypertrophy and, thus, contribute to the negative energy balance.

Intensity

The ideal intensity (weight used) of ST to stimulate and generate hypertrophy has been a subject of great curiosity among researchers. In general, it is recommended that a weight falls between 6 and 12 repetitions maximum (RM)[11] or ± 70 to 90% 1RM[2]. Importantly, small variations in these values also stimulate muscle hypertrophy, but with a lower rate hypertrophic.

An interesting study looked at three groups of ST with different protocols (4 sets of 3 to 5RM; 3 sets of 9 to 11RM and 2 sets of 20 to 28RM) for eight weeks and found that all groups improved maximal strength (1RM) and muscular endurance (maximum number of repetitions with 60% 1RM) in relation to control group and also to their own values of the pre-training. With regard to muscle hypertrophy, all training groups, except the "high repetitions" improved compared to its pre-training values and control. These results suggest that almost all combinations of the components of ST generate benefits (strength, power, endurance, hypertrophy), but that certain combinations of variables that make up the ST emphasize more (or less) such results due to the specificity of training[11].

Pause between sets

Pauses or rest intervals between sets can modify the metabolic stress of ST and thus the chronic adaptations provided by the ST. For example, short intervals (± 45 sec to 1 min 30 sec) further stimulate the lactic anaerobic system, while long pauses (± 3-5 min), by allowing more creatine phosphate[12] regeneration, stress less the same bioenergetic system . How high blood lactate values are related to the release of anabolic hormones such as testosterone and GH, and greater hypertrophy muscular[13] the recommendation for shorter pauses is useful for the purpose of increasing the resting energy expenditure due to increased muscle mass.

Muscle actions

Concentric muscle actions, eccentric and isometric muscle strains produce different results and therefore in different training effects. In general, when isolated, the eccentric muscle action is the one that generates micro lesions compared to others[14]. These small lesions are called adaptive micro-trauma and are fundamental to stimulate muscle hypertrophy. However, in practice the ST, all types of muscle actions are performed with, once again, different emphases depending on the training method.

Speed of movement

Relatively recent works show that the fast movement of exercise promotes greater stimulus for muscle hypertrophy than slower[15]. Thus, the periodization of ST should also consider this variable (speed of movement) in the different cycles of training and promoting changes to better stimulate the muscles constantly requested.

Increase resting metabolic rate

It is believed that the main mechanism by which ST contributes significantly to the weight loss process is the increase in resting metabolic rate and, finally, TTE[5]. As the largest component of TEE is the resting metabolism and the main energy substrate used in this situation is the fat, this would be an efficient way to promote weight reduction and, ultimately, the body fat. However, is necessary to understand that the caloric expenditure (kcal) by increased muscle mass is modest when viewed daily. It has been estimated at 30 to 50 kcal/day in the resting metabolic rate for 1 kg of muscle mass acquired[16]. Furthermore, incorporating 1 kg of muscle mass does not occur quickly, nor is it as simple as it depends not only on ST. Nevertheless, long-term (one year, for example), these low values would generate daily reduction from 1.42 to 2.37 kg of body fat. Seen in this light, the ST and its chronic effect on muscle mass appear to be extremely healthy for weight loss.

A study compared ST with the endurance and concurrent (concurrent endurance and ST) in physically active men, for ten weeks. Before and after the intervention, among other parameters, the authors reported greater increases in basal metabolic rate with ST than endurance. Moreover, changes in lean mass was related to change in this rate[17].

Another study that found positive changes in TTE after 26 weeks of ST was conducted in older of both sexes. In this case, these authors found increases in strength (36%) and resting energy expenditure (6.8%) and decreased respiratory quotient of ± 3.5% which means increased fat oxidation at rest[18]. In the same line of work mentioned, but investigating elderly with coronary artery disease, has been reported that ST increases the TTE after 6 months with a 4% increase in resting metabolic rate measured by indirect calorimetry[19].

Aiming to compare the TEE and nutrient oxidation in 24 hours, research carried out with ten men on three different occasions (cycle ergometer at 70% VO_2max; ST circuit at 70% 1RM and control) concluded that both TTE as the oxidation of macronutrients of ST was similar to that of aerobic exercise and superior to control[20].

Recently, randomized study of two groups (control and ST) showed that only a set of 3-6RM (9 exercises, 3 days/week, 6 months) significantly increased resting and sleep metabolic rates, and increased oxidation fat during sleep in young[21]. The impressive is that the total time of the session was only 11 ± 1 min, which reveals to be suitable for people who have little time to exercise and need or want to improve body composition.

Energy expenditure with strength training itself

The energy expenditure provided by the ST is considered relatively small when compared to aerobic exercises. Because aerobic can run for longer periods and often recruit more muscle mass, they require higher VO_2 and promote, thereby, higher energy expenditure[6]. For example, a 70 kg person running at 6 mph for 30 minutes ± 338 kcal spend while during the same period, the ST spent between 60 and 150 kcal whereas a ratio of 15 and 15 min of exercise min breaks due intermittent nature of ST[1].

A research was conducted to compare the energy expenditure of aerobic activity to ST with relatively similar time and intensity. Ten youths trained both held on separate days (crossover design) 30 min of continuous cycle ergometer (± 70% VO_2max) and 30 min of intermittent squat (± 70% of 1RM). Energy expenditure was higher for the aerobic situation (441 ± 17 kcal) versus the ST (269 ± 13 kcal). However, the author concludes that although energy expenditure was lower in ST, this mode of exercise produced an expenditure for interest for the purpose of health and, chronically, unique benefits that only aerobics would not enable, such as power, endurance and muscular strength[6]. Importantly, a limitation of study is that the author did not match the duration of movement execution of ST, as it was intermittent, the total time spent on this exercise was lower (6.21 ± 1.3 minutes) compared to the aerobic (30 minutes). Furthermore, the intensities used can not be considered the same (70% 1RM versus 70% VO_2max), as they have very different metabolic behaviors, whereas 70% 1RM represents an intensity well above the anaerobic threshold[6].

Another aspect to consider is that, according to Scott[22] (2002), VO_2 during the ST does not properly reflect the energy expenditure, since factors such as occlusion of blood flow during intense muscular contraction and the absence of steady-state "reflect limitation of VO_2 to quantify energy expenditure in ST. Thus, the caloric expenditure would be underestimated for this type of exercise when the VO_2 is used and blood lactate concentration would be more appropriate for this aims[22].

Strength training and EPOC

The excessive oxygen consumption after exercise (EPOC) refers to the greater use of this gas relative to resting values, soon after physical exercises. Interestingly, the return of VO_2 to the rest pattern can take anywhere from a few minutes[23] until to several hours[24].

The basical and traditional explanation for EPOC occurrence involve regeneration of creatine phosphate, lactate removal and hormones, restoring the muscle stores of oxygen and return temperature, as well as heart and respiratory rates to resting values. It has also made clear in the literature, is the fact that more intense exercise provides greater EPOC when compared to less intense[25]. As the VO_2 is related to energy expenditure, physical activities that provide greater EPOC would be contributing more to raise the TTE and, thus, potentiate to the weight loss.

Accordingly, studies have been conducted to investigate the effect of ST on EPOC. One showed that 45 minutes of ST in trained young women created a greater EPOC and fat oxidation during the 2 hours after ST than control day measures[26].

Other authors[24] reported that EPOC can last up to 38 hours after a single session of high intensity of ST in healthy men and young (31 min circuit, four passages in bench press, dead lift and squat, with 10RM until momentary concentric failure). Undoubtedly these positive findings raise hypotheses about the real efficacy of ST in the process of weight loss by means of EPOC, and shows that values from previous studies[27] (16 hours) were much lower.

When the ST occurs in the circuit, the pause between each station must also be considered. Haltom *et al.*[28] (1999) compared 20 versus 60 seconds (both eight exercises with 75% from 20RM) and saw that the EPOC was greater for the slightest pause (10.3 ± 0.6 $L.min^{-1}$) compared the largest (7.4 ± 0.4 $L.min^{-1}$). This finding also demonstrates the effect of intensity on EPOC, since the interval between sets is a variable that determines the intensity in ST. Interestingly, although the EPOC was higher with the slightest pause, when the total energy expenditure (exercise + recovery) was computed, the protocol with the highest pause (60 seconds) spent more energy (277 kcal) than the 20 seconds (242 kcal). Thus, it is important to analyze the energy expenditure as a whole (exercise and recovery).

Another relevant factor in the control of body mass is the substrate oxidation that occurs in response to ST. Studies have shown increased lipid oxidation after a single session of ST when compared to pre-exercise time and/or group control measures[26,29]. This is because, in recovery, the lipids become the predominant fuel to limit the use of carbohydrate and regenerate depleted glycogen stores in ST[30].

Conclusions

Analyzing the studies reviewed, we conclude that strength training can actually help weight loss as an excellent complement to aerobic exercise training and diet. The mechanisms that govern this process are (a) increasing or maintaining their resting metabolic rate, (b) increase in total energy expenditure considering their own strength activity and (c) also the effects related to excessive oxygen consumption after exercise. Moreover, the periodization of the training program appears to be ideal for long-term success because it allows combinations of the beneficial effects of strength training related to weight loss.

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