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# Biochemical aspects of exercise in prevention of overweight and obesity

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## Abstract

Regular physical activity is an important component of healthy lifestyle providing many beneficial effects such as improving physical fitness, enhancing muscular strength, increasing endurance, promoting well-being and protecting against cardiovascular diseases, cancer or diabetes. Not lesser important is the role of exercise in the prevention and treatment of overweight and obesity. An important element in etiology of obesity seems to be inability to oxidize lipids. We rewieved factors influencing fat oxidation during physical activity such as exercise intensity aimed to enhance its effect on overweight or obese people. Many studies support the use of exercise as an ideal weight loss strategy, mainly in combination with dietary restriction. Some exercise programs fail to prove significant weight loss changes what may be caused by low adherence to the training. New, interesting, non-stereotype and individualized exercise programs such as dance should be found to improve adherence to the regular physical activity and consequently to promote general health.

**Key words:** exercise, physical activity, fat oxidation, prevention and treatment of obesity, dance

## Introduction

Results of many reviews support the use of exercise as a weight loss strategy, particularly when combined with dietary change. Regular physical activity induces favorable metabolic changes in muscle and adipose tissue and thus promotes use of fat as energy source instead of storing it. Some researchers indicate that exercise may even improve appetite control,

although further studies need to be continued in this area (Keim et al. 2004; Blundell et al. 2003; Waden et al. 1997). Nevertheless, it's important to say that the benefits of exercise extend far beyond weight loss. Exercise is associated with improved cardiovascular disease risk factors (Peréz 2008; Fang et al. 2005) such as favorable changes in lipid and lipoprotein profile (Kelley et al. 2004, 2005, 2006; Grandjean et al. 2000; Varady and Jones 2005; Halverstadt et al. 2007), reduction of hypertension (Hamer et al. 2006), improved insulin sensitivity (Ligibel et al. 2008) and lowered blood glucose level (Miller and Dunstan 2004; Derouich and Boutayeb 2002; Prior 2007) even if no weight is lost.

Seeing that prevalence of obesity is rapidly rising, with an estimated 50% of adults in the USA and some European countries being overweight (Dachs 2007), increasing number of medical and surgical interventions is used to prevent or treat obesity-related disorders, in spite of primary prevention of this widespread condition (Hawley and Dunstan 2008). When speaking about prevention, it is important to start with children and adolescents because obesity in young age usually leads to obesity in adulthood and to consequent illnesses such as hyperlipidemia, hypertension, abnormal glucose tolerance, psychosocial stigma and other less common complications (Ltd B 2005). Regular aerobic exercise decreases percentage of body fat, increases aerobic capacity in children (Kelley and Kelley 2008) and adults (Lan 2008) and generally improves the quality of life (Karvinen et al. 2007; Levinger et al. 2007). Actually, a negative association between regular physical activity and feeling of depression and anxiety has been documented (Goodwin 2003; Hoffmann and Hoffman 2007; Kerse et al. 2008).

Thus, this review emphasizes the importance of exercise alone or combined with dietary change in the treatment and predominantly in the prevention of obesity. The proper intensity of exercise and the various effects on metabolism are discussed. The adherence to the exercise program plays an important role in maintaining long-term effect, therefore type of exercise which is creative, interesting and non stereotype need to be found. We reviewed the use of dance as intervention to prevent or treat overweight in the last chapter.

### *Health benefits of exercise*

Regular physical activity is an important component of healthy lifestyle in children, adolescents and adults. A huge number of comprehensive reviews concluded that exercise is positively associated with improved cardiovascular fitness, skeletal health and psychological

well-being (Trost and Loprinzi 2008). Recognized health benefits of regular physical activity are presented in Figure 1.


Figure 1. Health benefits of exercise (Keim et al. 2004).

To understand how physical activity is associated with this health effects, it is important to define and understand the key terms. Physical activity (PA) can be defined as any bodily movement produced by skeletal muscles which results in energy expenditure. Regular, repetitive, planned and structured physical activity with the aim to improve or maintain physical fitness is called exercise (Griera et al. 2007). Physical fitness is body's ability to function efficiently and effectively in work and leisure activities and comprises of five categories including cardiorespiratory fitness, muscle strength and endurance, flexibility and body composition (Wharton and Crum 2008; Pollock et al. 1998).

Practically all organs are stimulated by physical activity in different ways. The complexity of functional responses not only in organs primarily involved in the genesis of the

muscular action but also secondary in maintaining homeostasis of the organism after an exercise bout is illustrated in Figure 2.

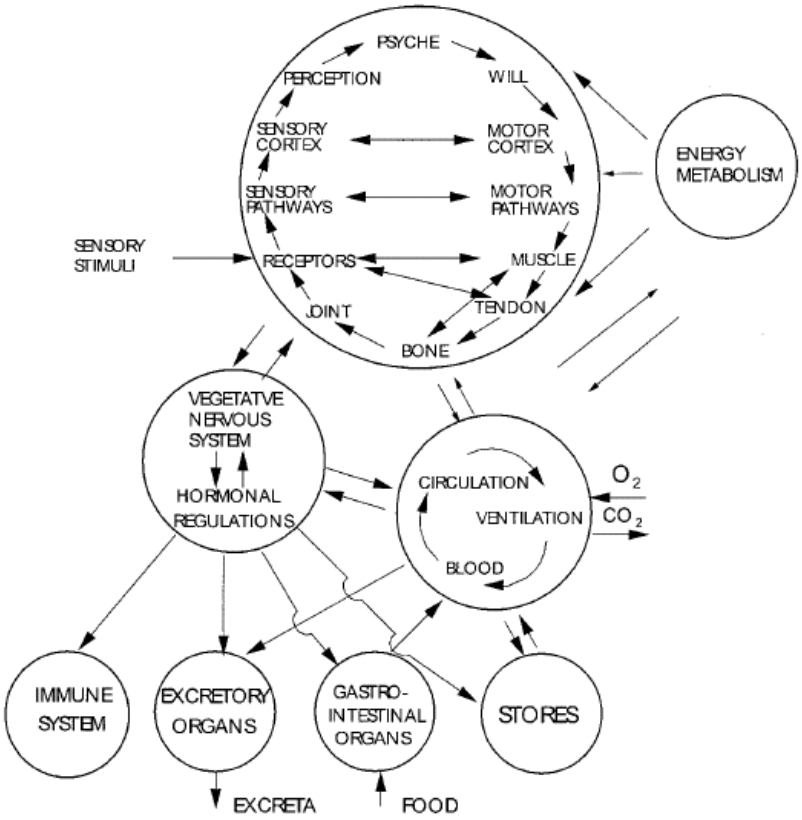


Figure 2. Functional responses of the whole organism after a bout of exercise (Vuori 2001).

When defining the amount of physical activity or exercise, an important interrelation exists between the dose of activity and the intensity at which the activity is performed. Dose expresses total amount of energy expended in physical activities. Intensity can be seen in absolute or relative terms. Absolute intensity describes the rate of energy expenditure during exercise and may be described as absolute work in Watts per body mass, or more common as metabolic energy turnover (MET, metabolic equivalent) (Lagerros and Langiou 2007; Shephard and Balady 1999). MET is used to indicate the rate of energy expenditure during activity to resting metabolic rate (RMR). It is a multiple of RMR given to a specific activity, what enables us to compare the energy costs of physical activities among persons of different weight and age (Keim et al. 2004). One MET is a unit of resting oxygen uptake (≈ 3,5 ml $O_2$ per kg of body weight per minute) (Fletcher et al. 2001). Relative intensity of physical activity refers to the relative percentage of maximal aerobic power that is maintained during

exercise (described as % of maximal heart rate- $HR_{max}$ or % of maximal oxygen intake- $VO_{2max}$) (Table 1).

Table1. Relative (%) and absolute intensities (metabolic energy turnover in kcal/kg/h) adjusted for various ages (adapted from Fletcher et al. 2001).

| | **Relative intensity** | | **Absolute intensity in METs (age in years)** | | | |
|---|---|---|---|---|---|---|
| **Intensity** | *$VO_{2max}$(%) | **$HR_{max}$ (%) | Young (20-39) | Middle-aged (40-64) | Old (65-79) | Very old (≥80) |
| Very light | <20 | <35 | <2,4 | <2,0 | <1,6 | <1,0 |
| Light | 20-39 | 35-54 | 2,4-4,7 | 2,0-3,9 | 1,6-3,1 | 1,1-1,9 |
| Moderate | 40-59 | 55-69 | 4,8-7,1 | 4,0-5,9 | 3,2-4,7 | 2,0-2,9 |
| Hard | 60-84 | 70-89 | 7,2-10,1 | 6,0-8,4 | 4,8-6,7 | 3,0-4,25 |
| Very hard | ≥85 | ≥90 | ≥10,2 | ≥8,5 | ≥6,8 | >4,25 |

*$VO_{2max}$ – maximal oxygen consumption (amount of oxygen transported and used in cellular metabolism; influenced by age, sex, exercise habits, heredity and cardiovascular clinical status), ** $HR_{max}$ (%)– maximal heart rate.

Exercise not only increases energy expenditure during an exercise bout, some authors suggest, that energy expenditure remains elevated even for a period of time following exercise. Returning to the pre-exercise metabolic rate can require several minutes following light exercise or several hours following heavy exercise (Mota 2005). Speakman and Selman (2003) reviewed short-term and long-term effect of exercise on RMR. Although the results are still inconsistent, a persistent augmentation in RMR caused by regular exercise has been found (Boreham and Murphy 2005).

The importance of exercise is accentuated in the overall recommendations aimed to improve fitness and endurance, regulate or manage weight, change body composition or prevent various disease risks.

### *Role of exercise in both prevention and treatment of obesity*

The relation between exercise and body weight control can be evaluated from several perspectives. From physiological point of view we can accentuate the beneficial effect of exercise on basal metabolic rate, fat cell size and distribution or diet induced thermogenesis (Speakman and Selman 2003; Redman et al. 2007). Psychologists may highlight the positive effect of exercise on body image or self-concept, feelings of well-being (Burgess et al. 2006), and adherence to an exercise plan. Clinicians may emphasize the role of exercise in

decreasing disease risk (Thompson 2009; Haskell et al. 2007; Blair 1993) (Figure 3). The beneficial effects are quite clear but there is still a debate about the amount (quantitative aspect) and intensity (qualitative aspect) of physical activity which is required either to prevent weight gain in normal-weight population or to induce and maintain weight loss in people who are already obese or overweight (Bauman 2004).

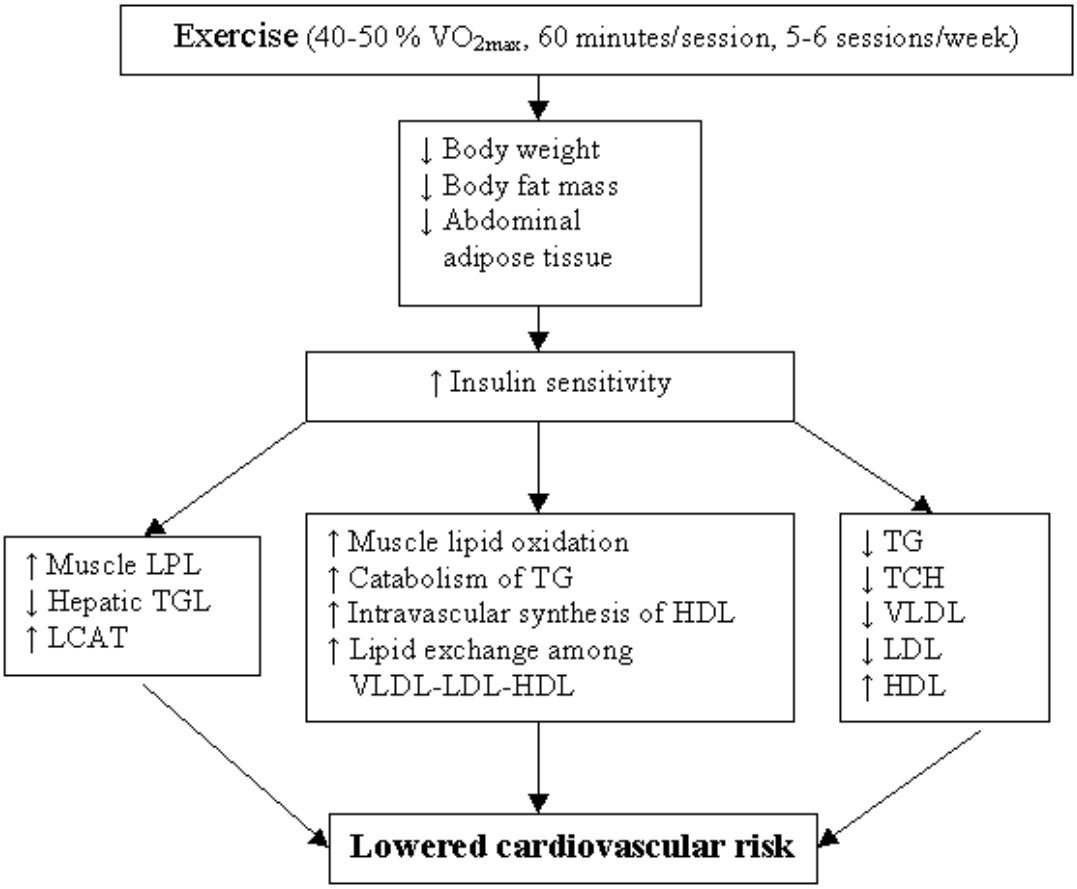


Figure 3. Metabolic changes caused by regular exercise (adapted from Vuori 2001).

TG- triglycerids, TCH- total cholesterol, VLDL- very low density lipoproteins, LDL- low density lipoproteins, HDL- high density lipoproteins, LPL- lipoprotein lipase, TGL- triglyceride lipase, LCAT- lecthin-cholesterol acyltransferase.

***Physical activity as a prevention strategy***

Increased prevalence of obesity resulted in the need to identify interventions that prevent weight gain. Data from population-based surveys and longitudinal observational studies indicate that exercise may be an important strategy. Results of several intervention trials

support the use of physical activity in the prevention of obesity, although the optimal dose and intensity of performed exercise need to be evaluated (Jakicic 2002).

Saris et al. (2003) presented in their article "How much physical activity is enough to prevent unhealthy weight gain" that following the current guideline for adults of 30 minutes moderate intensity exercise 7 days per week is important for lowering health risks such as chronic diseases including coronary heart disease and diabetes. However, for preventing weight gain or regain, it is likely to be insufficient for many individuals. Although definite data are still lacking, it seems that moderate intensity activity of approximately 45-60 minutes per day is required to prevent the transition to overweight or obesity. For prevention of weight regain in formerly obese individuals even more, 60–90 minutes of moderate intensity activity are required (Bauman 2004). The examples of various activities and their intensities together with energy expenditure are shown in Table 2.

Table 2. Rates of energy expenditures during various types of physical activity of adults (Griera et al. 2007; Bhagavan 2002). *REE- resting energy expenditure.

| **Type of activity** | **Energy as REE* multiple** | **Kcal/min (man, 70 kg)** |
|---|---|---|
| Sleeping, lying down | REEx1.0 | 1-1.2 |
| Sitting, standing, painting, driving, laboratory work, playing instrument | REEx1,5 | Until 2.5 |
| Walking (4-5km/h), shopping, working in the garage, playing glof or table tennis | REEx2.5 | 2.5-4.9 |
| Walking(5.6-6.4km/h), cycling, skiing, playing tennis, skating, dancing | REEx5.0 | 5.0-7.4 |
| Walking uphill with load, swimming, climbing, playing basketball or football | REEx7.0 | 7.5-12.0 |

Blair (2004) also concludes that recommended 30 minutes per day may be insufficient for some individuals. Persons, exercising 30 minutes daily and consuming appropriate number of calories, but are still having trouble controlling their weight should implement additional exercise up to 60 minutes per day or restrict their caloric intake. Furthermore, it is desirable to extend aerobic exercise adding activities that build musculoskeletal fitness such as resistance training and flexibility exercises at least twice a week to promote maintenance of lean body mass and to improve muscular strength and endurance.

Changing sedentary habits into active, a long-term approach with slow start is recommended. If the person is capable of following 30 minutes training 5 days a week,

additional training could be implemented. Spanish Society for the Study of Obesity proposed a pyramid of physical activities for adults presented in Figure 4.

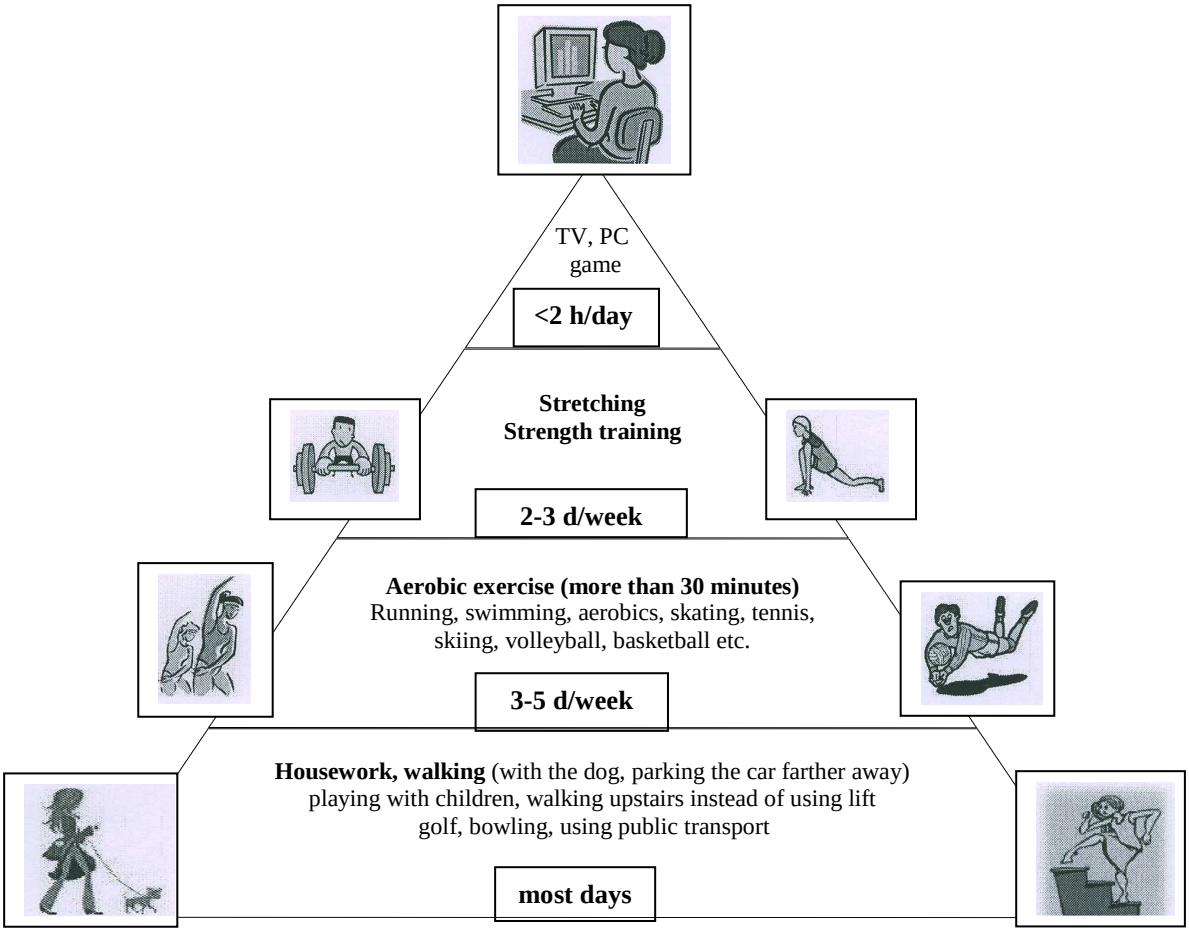


Figure 4. Physical activity pyramid proposed by Spanish Society for the Study of Obesity (adapted from Griera 2007).

In conclusion, previous research on the relationship between physical activity and obesity demonstrate a clear association. The success of the controlled exercise interventions indicates an extremely promising area for prevention of obesity. However, further studies are needed to elucidate the specific effect of various types of exercise and their intensities on the key features of body weight regulation (Goran et al.1999; Hill and Wyatt 2005).

### *Exercise alone as a weight loss strategy and biochemical mechanism of action*

Weight loss occurs when a negative energy balance is maintained for longer period of time. The effectiveness of increased physical activity with the aim to lose weight is controversial. Most controlled studies evaluating exercise alone show only modest weight loss (usually 2-3

kg) in the treated group compared to the control (Blair 1993). Nonetheless, some reviewers conclude that exercise alone appears to be largely ineffective as a weight loss strategy (Votruba 2000), whereas other authors suggest that exercise alone (Fontana et al. 2007) when performed 60 minutes per day as recommended by U.S. Department of Agriculture and Institute of medicine quidelines, is useful regarding weight and fat loss (McTiernan et al. 2007). Borer (2008) suggests that when exercise is implemented without any change in food intake, a daily expenditure of 400 kcal produces a fat loss that is about one third of that expected on the basis of caloric deficit incurred by exercise.

Shaw et al. (2006) reviewed a total of 43 randomized controlled clinical trials examining exercise as a mean to achieve weight loss in persons with overweight or obesity. Twelve of them compared exercise with no treatment as a weight loss intervention. The influence of exercise intensity on weight loss was also seen; with increasing intensity of exercise increased also weight loss if participants were not on a diet (Slentz et al. 2004). Intensity of exercise is important also when comparing fat loss, hence low intensity exercise does permit higher rates of fat oxidation than higher intensity exercise (Table 3).

Table 3. The relation between intensity of exercise and fat oxidation (Borer 2008).

| Intensity | Type of metabolic fuel providing energy (rate in %) |
|---|---|
| 25 % | 90 % E fat oxidation derived from fat depots; 10 % E liver glucose |
| 65 % | 50 % E FFA (½ fat depots, ½ intramuscular fat); 50 % E mainly muscle glycogen |
| 85 % | 30 % E derived from fat (½ fat depots, ½ intramuscular fat); 70 % glycogen |

E-energy, FFA- free fatty acids; intensity- % of maximal effort.

Choosing the lowest intensity of exercise to maximize fat depots oxidation is not realistic. One would have to exercise for several hours a day at low intensity to produce a desirable fat loss (Borer 2008). The optimal intensity of an activity for weight and fat loss is moderate load (50-75 % of maximal effort), achieving heart rates between 141-165 beats per minute (20 years old men) (Bobrík 2009, conference proceeding).

Additional complications in using exercise to create fat loss include genetics, aerobic fitness, body composition, health status and obesity stage of an individual. Factors influencing capacity to oxidize fat are shown in Figure 5.

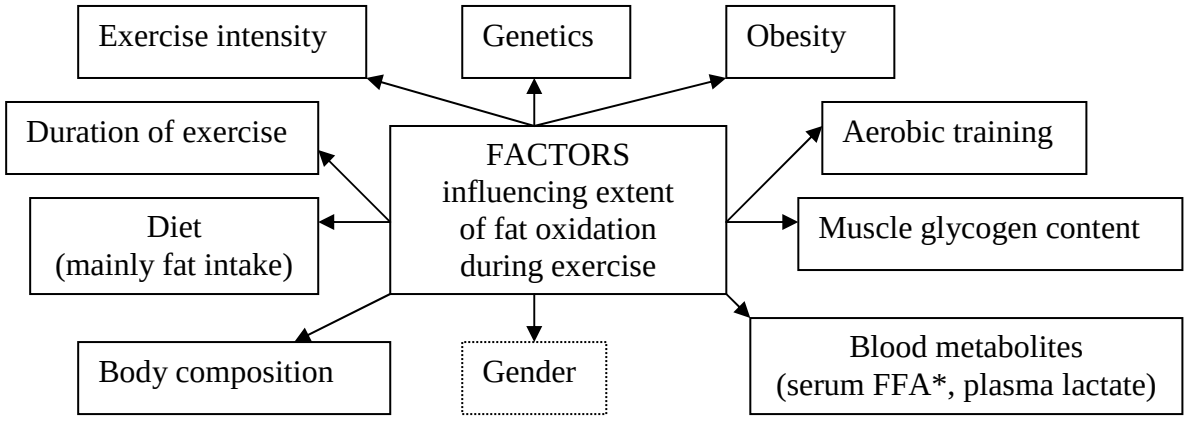


Figure 5. Various factors influencing extent of fat depots oxidation during exercise (adapted from Borer 2008, Venables 2005)* FFA- free fatty acids.

Effects of obesity condition and aerobic fitness level on fat oxidation during exercise are discussed in more detail in Table 4.

Table 4. Effect of obesity and aerobic fitness on the capacity to oxidize fat (Borer 2008).

| **OBESITY CONDITION ↓ fat oxidation** | **AEROBIC TRAINING ↑ fat oxidation** |
|---|---|
| Lower proportion of oxidative fibres and reduced mitochondrial mass in skeletal muscles | Favours shift in the expression of oxidative fibres in skeletal muscles |
| Higher circulation of fatty acids (insulin resistance)→ reduced capacity of insulin to suppress adipose tissue lipolysis | Enhances cardio-respiratory and circulatory capacities to supply oxygen to the working muscle |
| High free fatty acids flux→ production of ROS*→ shift from fat to CHO** metabolism | Increasing volume and improving function of mitochondria |
| ↓ expression of adiponectin (adipose tissue hormone stimulating mitochondrial biogenesis) | ↑ expression of adiponectin→ stimulates biogenesis of mitochondria |

*ROS- reactive oxygen species, **CHO- carbohydrates.

One of the most important regulators of substrate oxidation remains still exercise intensity. Rominj (2000) studied substrate metabolism durig different exercise intensities in healthy endurance-trained women. Carbohydrate oxidation increased progressively with exercise

intensity, whereas fat oxidation reflected an inverted hyperbola with the highest rate at 65 % $VO_{2max}$.

Contribution of plasma free fatty acids, glucose, muscle triglyceride and glycogen stores during various intensities of exercise are shown in Figure 6.

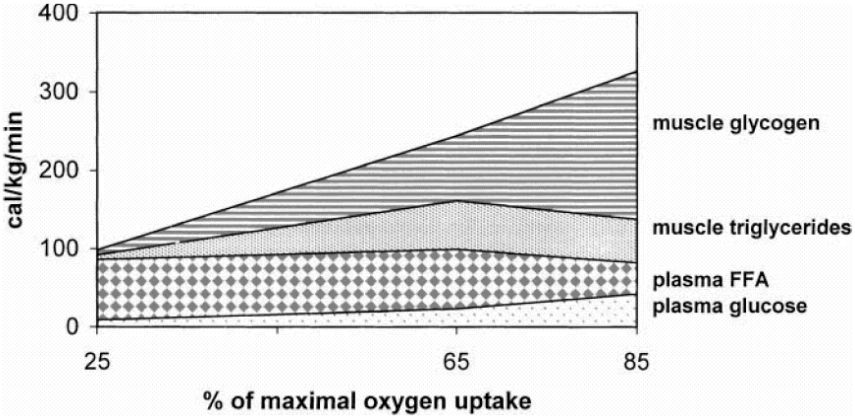


Figure 6. Maximal caloric contribution of plasma free fatty acids (FFA) and glucose and minimal contribution of muscle triglyceride and glycogen stores in relation to exercise intensity expressed as % of maximal oxygen uptake (Rominj 2000).

Votruba et al. (2000) discusses whether exercise therapy without addition of some degree of caloric restriction is a receivable weight loss aid. Examining 11 studies, six showed some amount of weight loss with exercise alone, five studies showed no change in weight. The amount of weight loss differed markedly according to the volume (intensity x duration) type of exercise and length of intervention. In two of these studies military recruits were used to evaluate the effect of daily physical activity on weight loss, having to exercise as a full-time job what is unrealistic for most subjects. Authors concluded that there are limitations in these studies because only very few studies examined had a non-intervention control. A diet only control group was often used but authors failed to include a non-diet and non-exercise control. Another authors concluded that an important correlation was found, although exercise alone does not provide effective weight loss, it could play a key role in the maintenance of lost weight (Zoeller 2007; Vuori 2001).

We can conclude that the degree of obesity or overweight is important when regarding the outcomes of all studies examining the role of exercise in weight loss process seeing that a 2-4 kg weight loss may be considered as a great success in a mildly overweight person (90 kg) but not in a case of an obese person weighing 150 kg. The results of weight loss strategies

should be explained as a difference in BMI or even better in percentage of lost body fat what can facilitate comparing outcomes of all trials (Blair 1993). Another complication in using exercise alone as an obesity treatment is that many overweight or obese persons are too unfit to maintain sufficient energy expenditure for longer period of time to achieve negative energy balance.

Obese people have generally lowered daily physical activity and it may take several months to become fit enough to exercise at required level to burn a significant number of calories. Thus, addition of a diet to the exercise program can help to achieve the negative energy balance much sooner (Blair 1993; Catennacci and Wyatt 2007).

***Exercise versus diet as a treatment of overweight or obesity***

To compare the effect of a diet program with exercise intervention, it is important to specify the type of diet used. Many diet approaches have been proven in weight loss strategies and all of them have their own merits and also limitations. Anderson (2000) confronted eight popular diets based on various principles using computer analysis to predict their relative benefits and potential harm. The main principles of these popular diets are outlined in Table 5.

Table 5. Main diet principles used in weight loss programs and their popular representatives (Anderson et al. 2000).

| **The fundamental of the diet** | **The popular representative of the diet** |
|---|---|
| ↑ protein and fat, ↓ carbohydrate | Atkins diet, Protein Power, Sugar Busters, Zone diet |
| ↑ fiber and carbohydrate | High Fiber Fitness, ADA* Exchange diet |
| ↓ low fat | Pritikin, Ornish diet |

*ADA- American Dietetic Association.

While high fat diets may promote short-term weight loss due to high satiating effect, the potential hazards for worsening risk of atherosclerosis override the short-term benefits. According to analysis, individuals derive the greatest health benefits from diets low in saturated fat and high in carbohydrates and fiber. These components increase insulin sensitivity and lower the risk for coronary heart disease (Anderson et al. 2000). High carbohydrate diet, especially, when rich in whole grains is associated with decreased

inflammatory markers and thus may protect against systemic inflammation. In addition, this type of diet appears to have a favorable effect on cholesterol levels (Liu 2008). To this protective effect widely contribute dietary and added fiber which is thought to have several positive mechanisms affecting our health. Promotion of satiation, prolonged feeling of fullness, increased saliva and gastric production and alteration of gut hormones are believed to help in weight management (Slavin 2005; Dutia 2008). Health authorities and medical societies also recommend a high-carbohydrate, fat restricted diet comprising of less than 30 % fat, ≈ 55 % carbohydrates (25 % fiber) and up to 25 % of proteins for the treatment of obesity (Hainer et al. 2008). Sacks et al. (2009) compared four energetically equal diets based on various principles in two years long randomized controlled trial. Seeing the results, the author concluded that reduced-calorie diets result in clinically relevant weight loss regardless of which macronutrient they emphasize.

Shaw and colleagues (2006) reviewed ten trials comparing exercise and diet as weight loss intervention in people with overweight or obesity. Authors summarized that diet resulted in greater weight losses compared with exercise alone. Increasing intensity of performed PA did not increase the weight loss if participants were on a diet. In summary, diet restriction and PA may provide comparable weight loss, when they provide similar levels of negative energy balance (Donnelly et al. 2009). In most randomized controlled trials the energy deficit produced by the prescribed exercise is far smaller than that usually produced by dietary restriction. When high levels of exercise were prescribed, enrolled participants achieved substantially greater weight loss comparable to those who produced similar energy deficits by caloric restriction. However, high levels of exercise may be very difficult to achieve or to sustain for overweight or obese persons.

Another issue is that change of adipose tissue to the lean muscle mass caused by exercise may be connected with the rise of weight what leads to difficulties in interpreting results, mainly when change in body weight is the only outcome. Studies involving body composition show that exercise training improves body composition often independently of weight loss (Catenacci and Wyatt 2007). Lowered visceral fat area as a consequence of exercise training may help to prevent coronary heart disease, lipid metabolic disorders, hypertension and non-insulin dependent diabetes (Okura et al. 2007).

***Exercise and diet versus diet alone in treatment of overweight or obesity***

The reduction in energy intake general of specifically in amount of fat or carbohydrates plays a significant role in reduction of body weight what was intensively reviewed (Astrup et al. 2000; Roberts et al. 2002; Djuric et al. 2002; Dansinger et al. 2005; McMillan-Price et al. 2006; Shai et al. 2008; Sacks et al. 2009). However, diets alone may have some disadvantages. First, people generally stay on a diet for the first few days or weeks and when their lifestyle is not permanently changed, the lost weight is regained back. Diet itself reduces basal metabolism and thus it may be more difficult to loose weight. Moreover, weight loss without exercise results often in flabbiness in the skin what may alter body image, especially in women. Exercise combined with the diet tones muscles, increases energy expenditure and basal metabolism what is further connected with post exercise energy expenditure (Petrofsky et al. 2008).

The results of 11 previously conducted trials comparing the effectiveness of diet alone and diet combined with exercise reviewed Blair in 1993. He presented that the modest additional weight loss of slightly less than 2 kg had been found, what is consistent with finding of even earlier extensive reviews. Author concluded that exercise training results in modest decreases in total and fat weight as well as in small increase in lean body mass weight.

Votruba (2000) wrote that exercise should enhance or speed up the weight loss process by further increasing the amount of energy expended. Even though, from 13 evaluated studies, she found only two which were able to show an increased weight loss with the addition of aerobic exercise to a reduction diet. She concluded that the majority of studies indicated no greater weight loss with the addition of an exercise regime.

On the contrary, seventeen trials comparing exercise in combination with diet to diet alone aimed to reduce weight in overweight or obese people have been studied by Shaw et al. (2006). A low calorie diet was used for 11 trials, a low fat diet for three interventions and a combination either low fat or low calorie diet was used for three experiments. These studies showed that diet plus exercise resulted in greater weight loss than diet alone.

Catenacci and Wyatt (2007) identified 17 randomized controlled trials that compared weight loss produced by food restriction combined with exercise to food restriction alone. According to the author, most studies suggest that adding physical activity to a diet strategy tends to produce greater weight loss than dietary restriction alone. However, in only two of these studies the difference showed statistical significance. Resistance training arm was also

included in seven trials, but this intervention led to no greater weight loss difference between exercising group and only dieting group. These findings are consistent with results of extensive meta-analysis of Miller et al. (1997) which Catenacci and Wyatt also interpret in their review. A meta-analysis combines the results of several studies that address a set of related research hypotheses (from last 25 years of weight loss research), normally done by measuring effect size, using a form of meta-regression. Diet alone (-10,7 kg) and diet plus exercise (-11,0 kg) were superior to exercise alone (-2,9 kg) in weight reduction but there were no significant difference between diet groups and diet plus exercise groups. The main results of Miller's meta-analysis are shown in Table 6.

Table 6. The main results of Miller's meta-analysis surveying 25 years of weight loss research (data are means ± standard error of measurement; n= number of studies reporting data for particular variable; BMI- body mass index) (Miller et al. 1997).

| **Variable** | **Diet** | **Exercise** | **Diet + Exercise** |
|---|---|---|---|
| Weight loss (kg) | 10,7 ± 0,5 (n=269) | 2,9 ± 0,4 (n=90) | 11,0 ± 0,6 (n=134) |
| Initial BMI ($kg/m^2$) | 34,9 ± 0,6 (n=87) | 26,4 ± 1,5 (n=27) | 34,8 ± 1,0 (n=56) |
| BMI decrease ($kg/m^2$) | 4,0 ± 0,4 (n=53) | 0,8 ± 0,1 (n=27) | 4,2±0,4 (n=43) |
| Initial % of body fat | 38,5 ± 0,9 (n=56) | 28,5 ± 1,2 (n=55) | 36,6 ± 1,0 (n=42) |
| % body fat decrease | 6,0 ± 1,0 (n=46) | 3,5 ± 0,5 (n=56) | 7,3 ± 0,8 (n=43) |
| Maintained weight loss at 1year (kg) | 6,6 ± 0,5 (n=91) | 6,1 ±2,1 (n=7) | 8,6 ± 0,8 (n=54) |
| Study duration (weeks) | 15,1 ± 0,8 (n=224) | 20,9 ± 1,8 (n=76) | 13,4 ± 0,7 (n=119) |

The small effect of PA added to energy restriction may be caused generally by low amount of exercise prescribed in trials (mostly 1000-1500 kcal per week) when comparing with caloric restriction in the diet (often 500-1000 kcal per day). Catenacci and Wyatt (2007) concluded, that to be effective for weight management, exercise need to be prescribed and adhered to for longer time to improve individual's fitness to that point where he/she can perform enough work and expend sufficient energy to cause weight loss.

Donnelly et al. (2009) pointed out that the amount of energy restriction in the diet is important when evaluating the effect of added exercise into the weight loss program. When the energy deficit imposed by diet-only and diet plus PA are similar, weight loss is also similar. In studies where energy restriction is not severe the association between diet combined with PA and greater weight loss in comparison with diet alone has been found. When energy intake is reduced severely, diet and diet plus PA tend to have similar results. Addition of PA to a severe diet restriction may result in metabolic adaptations that diminish any additive effect of the exercise on weight loss. In summary, it seems that physical activity increases weight loss in combination with diet restriction mainly if the restriction is moderate, not sever.

### *Dance in the prevention and treatment of overweight and obesity*

Many trials indicate that there is a weak adherence to the exercise activity and completion of weight loss programs. Poor adherence to a given exercise protocol might be one of the main reasons why randomized controlled trials fail to find an association between physical activity and weight loss or weight maintenance (Catenacci and Wyatt 2007).

Using attractive and creative physical activity which is not stereotype and monotonous may improve attendance to the exercise program even after the weight loss period and help to maintain lost weight. Dance with its myriad forms may provide physical activity with varying intensity (Table 7). We reviewed interventions of children and adults where dance as exercising activity was used either to prevent or to treat overweight and obesity.

Table 7. Energy expenditure of various types of dance expressed as MET (metabolic equivalent) and kJ /kg /h (Fletcher et al. 2001; Maughan 2005).

| **MET** | **kJ/kg/h** | **Type of Dance** |
|---|---|---|
| 3,0 | 13 | Slow ballroom dance |
| 5,5 | 23 | Fast ballroom dance |
| 5,5 | 23 | Square dance |
| 6,0 | 25 | Aerobics |
| 6,0 | 25 | Ballet |

***Dance classes for children and adolescents***

A few controlled trials was undertaken to evaluate the positive effect of dance classes helping students maintain or reduce weight, improve self-perception and body image or reduce the risk of obesity and its associated co-morbidities.

In 1995 designed Flores a small-scale controlled trial to determine the effect of "Dance for Health", an enjoyable school-based aerobic exercise program for low-income Afro-American and Hispanic adolescents. 110 boys and girls aged 10-13 participated in an aerobic-dance pilot program three times per week 50 minutes for 3 months. To keep the students from getting bored, different types of popular music was used during intervention. The study provided other advantages such as minimal needed skills (dancing skills improve with practicing), non-competitive activity with routines which don't repeat; minimal equipment requirements and possibility for overweight students to participate. The program was associated with significant decrease in BMI and heart rate, favorable changes in the timed mile run and with attitudes toward physical activity. In summary, Dance for Health has proved to be an effective program to improve fitness and reduce weight in adolescents.

Similar pilot intervention to prevent excessive weight gain among Afro-American girls was designed in Stanford, California (Robinson et al. 2003). The acceptability and potential efficacy of after-school dance classes and a family-based intervention to reduce TV watching was tested in 12 week randomized controlled trial. Dance classes were chosen because they provide opportunities for immediate positive effects such as having fun, belonging to the group, discovering the cultural meaning of the dance and at the same time classes provide sustained bouts of moderate-to-vigorous physical activity. Besides, girls were familiarized with cultural and historical importance of traditional African dance in which many popular dance styles have their origin. Results suggest that girls in the treatment group tended to have lower BMI and waist circumference at follow up compared to the control group. Moreover, increased after-school physical activity and reduced television, videotape- and videogame-use was recorded and high satisfaction rating was achieved. Summarizing all benefits, dance classes represent a practical and adaptable strategy for promoting physical activity in girls (Robinson et al. 2003). After successful pilot study in 2002, two-year community- and family-based intervention was designed to reduce weight gain in low-income, pre-adolescent Afro-American girls. The baseline data of Stanford trial with BMI as main outcome measure have already been published, showing that large proportion of this community-based sample can be

considered at risk according to their high body mass index and fasting total cholesterol (Robinson et al. 2008).

Burgess et al. (2006) studied the impact of 6-week aerobic exercise on body image and self-perception. The results revealed that participation in the program significantly reduced body image dissatisfaction (attractiveness, feeling fat, strength and fitness) and enhanced physical self-perception (body attractiveness, physical self-worth). The benefits of aerobic dance teaching could be attributed to weight loss and muscle toning that created a perception of feeling less fat, more physically fit and attractive.

### *Dance as a prevention and treatment strategy for adults*

There are only few studies evaluating the effect of dance in the treatment of overweight or obese adults we are aware of. Several studies assessed the impact of commercial aerobics classes, such as bench stepping or traditional low- or high- impact aerobic lessons (Okura et al. 2007; Andersen et al. 2002; Andersen et al. 1999; Waden et al. 1997). Fewer trials were conducted to evaluate dance in their more traditional way and its health benefits (Kreutz 2008). Dance in any form involves body, emotion and mind and may promote well-being by various physiological processes, reduce injury, disease and stress (Hanna 1995).

The positive effect of low impact aerobic dance combined with the diet on body mass index and percentage of fat connected with increase in aerobic power have been found in 60 mildly obese middle-aged Japanese women (Shimamoto et al. 1998). Okura et al. (2003) evaluated the effect of exercise intensity combined with diet on physical fitness and risk factors for coronary heart disease in 90 sedentary women. Low intensity exercise was represented by walking, high intensity by aerobic dance (bench stepping). The change in BMI was -4,2 ± 1,2 kg in the dancing group, -3,7 ± 1,1 kg in walking group in comparison to diet only group -3,1 ± 1,3 kg. Waist circumference (in dancing group) and percentage of fat mass were also significantly lower in both exercising groups in comparison to diet only group. In later research, 67 overweight subjects with metabolic syndrome underwent 14-week treatment with low caloric diet plus aerobic exercise (DE) or diet alone (D). The average weight reductions in the D group and DE group were 6,0 kg and 8,8 kg respectively. Important reduction in visceral fat area was found in exercising group (53%) in comparison to a 24% reduction in diet only group. According to the authors, the results suggest that adding aerobic exercise training to a dietary weight reduction program further reduces visceral adipose tissue

and improves CHD risk factors compared to diet alone, even if the weight reduction is the same with either treatment (Okura et al. 2007).

The influence of church-based culturally specific dance intervention aimed to decrease obesity measured as body fat and BMI in Afro-American women has been evaluated. 8-week dance intervention was choreographed to gospel music twice a week and revealed significant differences in BMI and % of body fat between treatment and control group (Murrock and Gary 2008).

Petrofsky et al. (2008) studied the effect of an aerobic dance video together with a diet program on cardiovascular fitness, body composition and weight loss in 60 females. Two one-hour long aerobic dance videos were alternated each day for a total of 10 days, combined with a calorie restricted diet. The program created weight loss in average of 2,1 ± 0,6 kg and 3,0 ± 1,1 fat decrease. Girth at the waist was reduced to 3,7 ± 1,1 cm. A psychological motivation was used in the study as additional factor. Because of a desire to excel at dancing, this program was meant to inspire women to get fit and feel good. High level of compliance was found through exit interviews, reporting that subjects not only lost weight but they also looked forward to the dance video each day. The program involved both muscles used for anaerobic and cardiovascular training, the body was toned and strengthened and general fitness of participants was improved.

Cultural activities including dance have often been conceptualized as enhancing well-being as well as promoting mental and physical health (Kreutz 2008). There are many physical activities that children can learn at school, but only a few of them – such as walking and dancing are likely to help them to keep active attitude life-long until old age (Tanas and Renzo 2006). A wide variety of exercise classes is offered today to help people become fit and control their weight, from the 30-min circuit training to very trendy hip-hop or belly-dancing (Christensen and Kushner 2006). Dancing is an agreeable and inexpensive activity, practicable at every age, season and time, especially with friends in free time with huge benefits, including treatment of overweight or obesity (Tanas and Renzo 2006).

## Conclusion

Increased prevalence of obesity resulted in the need to identify possibilities how to prevent unhealthy weight gain. Exercise, combined with dietary change and performed at moderate intensity for longer period of time, may be an important strategy how to loose or maintain weight. In addition, large number of other beneficial effects of exercise are known, including improved physical fitness, lowered cardiovascular disease risk and reduced liability to diseases such as colon cancer, hypertension or diabetes. Expressive promotion of psychological well-being, reduced feelings of depression and general improvement in quality of life is connected with regular physical activity. Dance seems to be efficacious type of exercise to prevent obesity of wide population regardless of their age, gender or level of physical fitness.

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