

Physical activity, energy balance and obesity

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Abstract

Obesity appears when energy intake exceeds energy expenditure. The most important variable compound of energy expenditure is physical activity. The global epidemics of obesity seem closely related to reduced physical activity and sedentariness widely increasing nowadays. Once obesity has developed, caloric intake becomes similar to energy expenditure. To lose weight, besides decreasing energy intake, energy expenditure must be increased. The promotion of physical activity is difficult and so the results of treatment of obesity are discouraging for doctors, other health professionals and patients. Proactive efforts from patients and health providers with an intensive feedback between them may be extremely helpful. Nevertheless, more studies are needed to provide better approaches on the role of physical activity for the prevention and treatment of obesity and for long-term weight-loss maintenance.

Keywords
Physical activity
Obesity
Exercise

Epidemiology, prevention and treatment of obesity cannot be fully understood without considering physical activity. *Physical activity* is defined as any bodily movement produced by skeletal muscle that results in energy expenditure beyond resting expenditure. *Exercise* is a subset of physical activity that is planned, structured, repetitive and purposeful in the sense that improvement or maintenance of physical fitness is the objective.

Interrelations between low physical activity and the epidemiology of obesity and its effects on health are now clear¹. So, prevention of obesity might be achieved by increasing physical activity. Increasing physical activity is a logical tool for any weight-loss programme and is effective². More controversies persist on weight maintenance, but there are data suggesting that those persons who exercise tend to maintain their weight better³.

Effects of sedentary lifestyle on obesity epidemics

There is evidence that low levels of physical activity may be contributing to the increasing incidence of obesity. In several studies, baseline measures of physical activity were inversely related to body mass index (BMI). A low level of physical activity predicted high weight gain, and decreases in physical activity over time were associated with greater weight gain⁴. Physical activity can be divided into leisure-time physical activity (LTPA) and activity

performed in daily living, or lifestyle physical activity (LSPA)⁵. LTPA can be divided into exercise, sport, and household and other daily chores. Transportation to and from work is referred to as commuting physical activity. Video games, home computers and watching television with remote control devices now compete for LTPA. At the same time, jobs are more comfortable and sedentary⁶, and less physical activity is required for transportation⁷. The environment is a critical component for sedentariness. Industrialisation, urbanisation and improving income are each associated with car use, lifts, automatic washing machines and microwave ovens. While each may reduce physical activity only slightly, together they can have an important impact on total energy expenditure (TEE)⁴.

Role of physical activity on energy balance

The human body consumes energy in the form of resting energy expenditure (REE), thermal effect of food (TEF) and energy expenditure resulting from physical activity. TEF and REE are relatively constant and account for 70–80% of the TEE⁸. In contrast, the contribution of physical activity is highly variable between individuals and therefore may provide the opportunity to increase energy expenditure. REE serves as a reference value when the energy expenditure produced by different

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activities is measured. A light physical activity like reading and driving can be equal to $REE \times 1.5$. Other activities can be estimated in the same way (Table 1)⁹. There are tables depicting the caloric expenditure produced by different activities, which show the energy expenditure to carry one's own weight around increases it. For instance, playing tennis induces an expenditure of 165 kcal in 30 min for a person of 110 lb, but 312 if he or she weighs 210 lb¹⁰. As a person loses weight, for a given amount of time exercising, doing the same activity at the same intensity, fewer calories are lost. So, to maintain the same level of energy expenditure, more physical activity is required¹¹.

Physical activity effects on obesity: benefits and risks

Increasing physical activity alone without a meal plan is hardly effective in treating obesity^{2,12}, but exercise in combination with diet produces a greater weight loss (1.9 kg) than diet alone^{2,12,13}; and it has many benefits for health¹⁴. For example, there have been observed improvements in prevention of type 2 diabetes mellitus¹⁵, lower levels of blood pressure, lipids and glycemia^{16–18}, reduction in cardiovascular disease¹⁹, particularly heart disease, and in mortality²⁰. Improvements in biliary disease, respiratory capacity, cancer, and in psychological parameters such as anxiety, depression and stress have also been reported²¹.

The most common risk of physical activity in adults is musculoskeletal injury. Risk of injury increases with obesity, volume of exercise and participation in vigorous exercise such as competitive sports, whereas higher fitness, supervision, stretching exercises, protective equipment such as bike helmets, and well-designed environments protect against injury. Vigorous physical activity acutely increases the risk of sudden cardiac death and myocardial infarction among individuals with both diagnosed and occult heart disease. The relative risk of both exercise-related myocardial infarction and sudden

death is greatest in individuals who are infrequently physically active¹⁹.

How much physical activity and how often

Earlier guidelines advocating vigorous exercise for at least 20 min three times per week have been changed by a recommendation of 30 min of moderate-intensity physical activity on most days of the week^{14,22} to achieve a general health improvement. But to reach and maintain a weight loss, at least 150 min of moderate activity each week or 200–300 min²³ or 60 min of daily moderate activity²⁴ have been advocated. Recently, the International Association for the Study of Obesity gave two separate recommendations: To prevent the transition of overweight to obesity at least of 45–60 min day⁻¹ of moderate activity are needed, but to prevent weight regain 60–90 min day⁻¹ of moderate activity are required in formerly obese individuals²⁵. Lesser amounts of vigorous intensity activity are effective as well. For children, even more activity time is recommended (Table 2)²⁶.

Changes in activities that people engage in routinely are usually easier to make and sustain than the more substantial changes involved in adding a structured exercise programme such as jogging. Such programmes should start slowly. First, walking, then walking faster and then running or bicycling, aerobic dancing or swimming, 30 min, 5 days a week (150 min week⁻¹). If the patient is capable of following that rhythm and shows a reasonable attitude and reaches that level with success, the doctor will consider the possibility of increasing the prescription to 60 min of physical training 5 days a week (300 min week⁻¹). Each step may last for some weeks²⁶. A pyramid of physical activities for adults has been proposed by the Spanish Society for the Study of Obesity (Fig. 1)²⁷.

A long-term approach in order to change sedentary habits must be prepared, with an individual programme for each patient based on aerobic repetitive exercises. The limit for the individual session must not exceed 70–80% of the maximum heart rate corresponding to each

Table 1 Approximate energy expenditure for activity levels

| Activity | Energy as REE multiple | kcal min ⁻¹ |
|---|------------------------|------------------------|
| Rest | | |
| Sleep, lying down | REE × 1.0 | 1–1.2 |
| Very light | | |
| Sitting and standing, painting, driving, laboratory work, ironing, sewing | REE × 1.5 | Until 2.5 |
| Light | | |
| Walking about 4–5 km h ⁻¹ , working in the garage, carpentry, playing golf, sailing, playing ping-pong | REE × 2.5 | 2.5–4.9 |
| Moderate | | |
| Walking 5.6–6.4 km h ⁻¹ , working with hoe, carrying a load, riding a bicycle, skating and dancing | REE × 5.0 | 5.0–7.4 |
| Intense | | |
| Walking with a load uphill, cutting down trees, manual excavation, playing football or basketball | REE × 7.0 | 7.5–12.0 |

REE – resting energy expenditure.

Source: Food and Nutrition Board, National Research Council⁹.

Table 2 Different recommendations for doing physical activity

| Organisation/agency | Year of the recommendation | Minimum length of recommended physical activity | Minimum recommended intensity | Expected beneficial results |
|--|----------------------------|--|-------------------------------|---|
| Center for Disease Control and Prevention and American College of Sport Medicine ²² | 1995 | 30 min most days of the week | Moderate | General health improvement |
| Surgeon General's Report on Physical Activity and Health ¹⁴ | 1996 | 30 min most days of the week | Moderate | General health improvement |
| American College of Sports Medicine ²³ | 2001 | 150 min week ⁻¹ 200/300 min week ⁻¹ | Moderate Moderate | General health improvement Long-term maintenance of weight loss |
| Institute of Medicine ²⁴ | 2002 | 60 min day ⁻¹ | Moderate | Avoid putting on weight and add other benefits for health independently of weight |
| International Association for the Study of Obesity ²⁵ | 2003 | 45–60 min day ⁻¹ 60–90 min day ⁻¹ | Moderate Moderate | Prevent transition to overweight or obesity, avoid weight regain |

Modified from Jakicic²⁶.

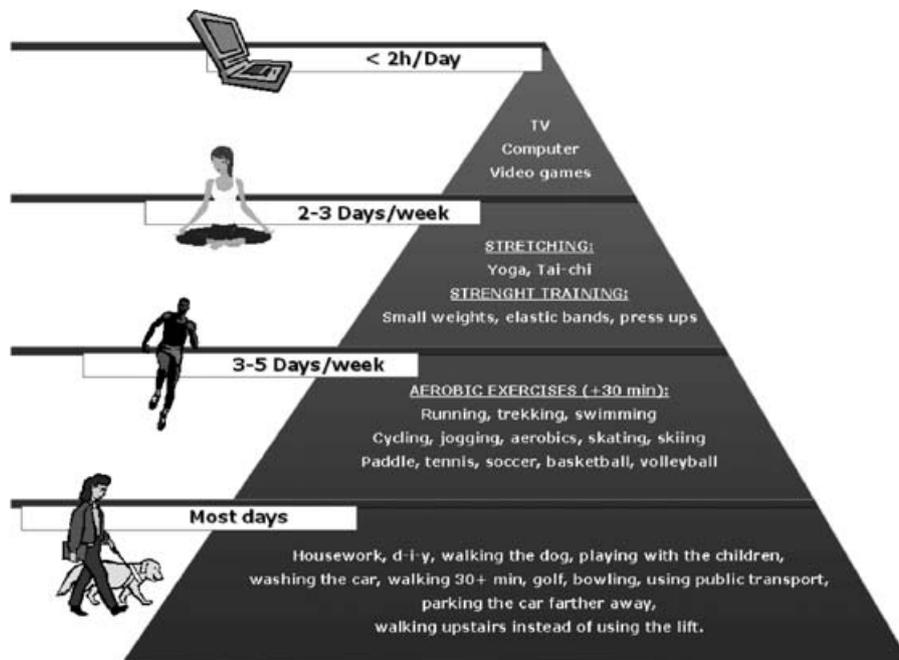


Fig. 1 Physical activity pyramid proposal for adults²⁷

individual according to his age (recommended maximum heart rate: 220 – patient age). Stretching, warm-up and cool-down exercises at the beginning and the end of sessions are essential²⁷.

Resistance exercises are also recommended 2–3 days per week. They consist of 8–10 different exercises, using the main muscle groups, with 10–15 repetitions for each type of programmed exercise. Increasing muscle mass has two results: First, increasing lean-mass that has more thermogenic activity may prevent weight regain. Second, increasing muscle strength can ameliorate usual life tasks, which is very important for elderly people²⁷.

Physical activity can be assessed by different techniques: questionnaires, log books, diaries and pedometers. Pedometers are cheap devices, placed in the inner part of

one of the legs at the waistline and registers the regular pace over the chosen period of time. The objective is to reach about 10 000 paces per day. This figure is associated with an improvement in the health of the obese patient²⁸. Sedentary people do not exceed 6000–7000 paces per day. The objective would be to increase the daily rate by 3000 paces. It is often difficult to motivate the patient to continue with such physical activity in order to reach the required aim and to maintain that routine in the long term²⁹.

Individualisation of physical activity prescription

Physical activity will be individualised according to individual ability and to the possible risk/benefit cost.

Patient attitude towards physical activity

This factor will, on many occasions, lead to a failure of treatment. In order of frequency lack of motivation (85%), too much work, lack of time, tiredness, laziness, all other kinds of inconveniences or lack of health (5%) are the main complaints of patients. Few people claim lack of health (less than 5%) in comparison with those who claim lack of motivation (more than 85%)¹². Some patients wait for a 'miracle cure'. They are not interested in changing physical or dietetic habits or perhaps are looking for a definitive weight reduction in a short time. This type of patient has visited countless doctors previously. Jakicic²⁶ proposes a kind of survey or an evaluation method of this predisposition step to behaviour change towards physical training, as shown in Table 3. According to the predisposition step where the patient is located, we shall project a different type of activity, and this will also influence the success rate. Setting up a programme of physical training always finds obstacles such as: 'I do not have time' and/or 'it is monotonous and boring'. To combat this, the professional must try to introduce an intermittent physical training programme or to incorporate some modifications in the patient style of life in order to increase the energy costs²⁴. Different routine activities may be useful for that purpose: walking up the stairs instead of taking the lift, parking the car farther away from the office and walking the rest of the way and so on can contribute to raise the caloric expense without changing the daily routine too much, thus increasing physical activity in those patients unwilling to start a programmed exercise plan. A guideline for intermittent activity would be to spread the programmed time for routine physical activity into several sessions or working periods through the day³⁰. Adapting the activities to the family and social environment

will increase the adherence to the programme. Other useful reinforcing techniques are group therapies, mailing, telephone and Internet contacts.

Patients with osteoarthritis

This is an especially difficult group. But with a slight weight loss, locomotive functional ability may improve. This will also improve the amount of physical activity, which, at the same time, will increase the weight loss and in this way shall break the tendency to gain weight. Low-impact exercises (walking, cycling and swimming) cause less stress on bones and joints, whereas high-impact exercises (running and aerobic dancing) cause repeated impact on the knees, ankles and feet. Studies indicate that the intensity and nature of impact of physical activity are the two most important factors in determining the frequency of injuries.

Patients with cardiac disease

In these patients, physical activity will be programmed according to the grade of his/her disease. This must always be individualised and supervised by qualified staff. The American College of Sport Medicine¹² has established practical categories to classify patients in relation to potential risks of any physical activity programme.

1. Patients with low risk: asymptomatic from a cardiovascular, pulmonary or metabolic disease viewpoint. Not more than one risk factor (the American Heart Association includes children and adolescents here).
2. Patients with moderate risk: men older than 45 years, women older than 55 years; at least two cardiovascular risk factors.

Table 3 Method of evaluating the predisposition to a change in the behaviour towards physical activity

Instructions for the patient:

Please read the following affirmations and select the one that with best accuracy reflects your real level of participation in a physical activity.

1. At the moment I do not want to do any physical activity and I am not considering starting a physical training programme.
2. At the moment I do not want to do any physical activity although I am considering starting a physical training programme.
3. At the moment I do not want to do any physical activity although I am making the arrangements to start a physical training programme in the new future.
4. At the moment I do physical activity. Nevertheless, I do it less than 150 min a week.
5. At the moment I do physical activity for at least 150 min a week, although I have so far spent less than 6 months on it.
6. At the moment I do physical activity for at least 150 min a week and I have spent more than 6 months on it.

The doctor classifies the patient in one of these predisposition phases considering the behaviour towards physical activity using the following categories:

| Selected patient class | Classification of predisposition phases considering the behaviour towards physical activity |
|------------------------|---|
| Class 1 | Precontemplation phase |
| Class 2 | Contemplation phase |
| Class 3 | Preparation phase |
| Class 4 | Transition of preparation phase to action phase |
| Class 5 | Action phase |
| Class 6 | Maintenance phase |

Physical activity is defined as a voluntary activity of intensity similar to one quick walk. Modified from Jakicic²⁶.

Table 4 Risk classification for physical training. Class A: apparently healthy individuals

This classification includes:

1. Children, adolescents, men <45 years and women <55 years who have no symptoms or known presence of heart disease or major coronary risk factors.
2. Men ≥ 45 years and women ≥ 55 years who have no symptoms or known presence of heart disease and with <2 major cardiovascular risk factors.
3. Men ≥ 45 years and women ≥ 55 years who have no symptoms or known presence of heart disease and with ≥ 2 major cardiovascular risk factors.

Activity guidelines: no restrictions other than basic guidelines.

Supervision required: none*.

ECG and blood pressure monitoring: not required.

ECG – electrocardiography.

*It is suggested that people classified as Class A-2 and, particularly, Class A-3 undergo a medical examination and possibly a medically supervised exercise test before engaging in vigorous physical training.

Source: Fletcher *et al.*³¹.

3. Patients with high risk: signs/ symptoms of known cardiovascular, pulmonary or metabolic disease.

A statement by the American Heart Association (AHA) grades cardiovascular risk according to different criteria such as age of the patient, presence or absence of a known pathology and associated comorbidities. Some apparently healthy individuals may be prone to cardiological problems when they begin an exercise programme (class A, Table 4). People with known cardiac disease are graded in classes B, C and D according to low, moderate or high risk when exercising. This statement provides standards and guidelines for the testing and training of all individuals. Followed carefully, it will allow the impact of physical training to improve their health without increasing the risk of a cardiac event³¹.

Ageing

Physical activity is particularly beneficial for elderly people. Besides the same effects cited before, quality of life and muscle strength are improved. Thus, it is important to recommend activities that require low-level energy expenditure, particularly during the first few weeks of the programme, and to prescribe mild increases at any time when progression of activity is made. In these instances, however, participants are encouraged to increase the frequency of exercise (for shorter duration), even to perhaps three or four times per day. They may require longer warm-up and cool-down periods, perhaps 10–15 min, and gradually taper exercise^{31,32}.

Summary

1. A low level of physical activity is related to weight gain, and decreases in physical activity over time were associated with greater weight gain. Physical activity may provide an opportunity to increase energy expenditure.
2. Increasing physical activity alone without a meal plan is not very effective in treating obesity, but

exercise in combination with diet produces a greater weight loss than diet alone, and it has many benefits to health.

3. A physical training programme should be developed according to the individual characteristics of the patient, in relation to his/her general health state, age, attitude and capacity to carry it out.
4. It will be essential to consider the ‘invaluable collaboration’ of the person and we shall have to encourage and stimulate him not to lose motivation in the development of the programme, and so it will be essential to explain the potential benefits he gains from doing it properly.

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