Paper

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Exercise for obesity – how much is enough?

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ABSTRACT Exercise is an important part of weight management, particularly in the long term. However, there is conflicting evidence about how much exercise obese subjects need to perform. Diet, genetic or other factors may contribute to the difference in weight between normal and obese subjects if physical activities are equal between groups. Obese subjects may therefore need to be more active and perform more exercise than their normal weight counterparts in order to lower or maintain their weight.

Regarding the amount of exercise, duration has a greater effect on weight loss than intensity. Moderate-intensity exercise is as beneficial as high-intensity exercise for weight loss and, as it appears to be more attractive to obese subjects, leads to a greater adherence to exercise programmes.

Preservation of lean body mass is greater when exercise is performed as part of a weight management programme. If diet only is used for weight loss, lean tissue is lost. Combining aerobic and resistance exercise appears to preserve lean tissue, so both types of exercise should be encouraged. Aerobic exercise has a greater effect on weight loss, but resistance exercise could potentially increase lean tissue. High-intensity exercise may spare more lean tissue than moderate exercise, but the benefits of greater adherence of subjects to moderate exercise outweigh those of high-intensity exercise.

When barriers to exercise exist, lifestyle changes combined with diet should be advised. In general, obese subjects should be encouraged to start off with low-intensity exercise and gradually progress to a higher level.

KEYWORDS Exercise, fitness, obesity, physical activities

LIST OF ABBREVIATIONS Basal metabolic rate (BMR), body mass index (BMI), excess post-exercise oxygen consumption (EPOC), energy expenditure (EE), free fatty acids (FFA), heart rate (HR), metabolic equivalent (MET), maximum volume of oxygen consumption ($VO_{2\,max}$)

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INTRODUCTION

Obesity rates in Britain are on the increase, with 22% of women and 23% of men currently obese. This is expected to rise to 28% of women and 33% of men by 2010.[1] While large numbers of people are attempting weight loss, levels of physical activity in the general population are low, implying many people attempt weight loss by diet alone. The *Allied Dunbar National Fitness Survey* of 1992 revealed 30–35% of respondents had undertaken fewer than four 20-minute periods of moderate activity in the previous month. These findings have led to initiatives such as the 10,000 steps a day programme to increase levels of physical activity.[2]

Those attempting weight loss are told to eat less and exercise more; however, current recommendations for exercise can be confusing, ranging from 15–60 minutes per day, at intensities between 45–90% and frequencies of 3–6 times a week.[3] Much of this variability is due to differences in the desired outcome. Exercise required to prevent weight gain is less than exercise required for weight loss, and exercise required for health benefits is different again.[3] Recommendations also vary according to the perceived compliance of the target population; some physical activity is better than none at all, so lower levels may be suggested as they are less daunting and can lead to a stepwise increase in activity.[4]

Obesity is often managed through commercial plans, such as Weight Watchers, or with help from GPs, but tends to focus on dietary interventions. Exercise has been shown to increase weight loss and to prevent weight regain, though there are many barriers to establishing an exercise regime, including poor physical health and patients' own perceptions. It is important to be aware of how various aspects of physical activity contribute to obesity management, as well as the best type of exercise to advise for weight loss.

TOTAL VOLUME OF EXERCISE

Total daily energy expenditure (EE) is the result of interaction between three processes – BMR, the thermogenic effect of food and physical activity.[5]

Basal metabolic rate is the energy expended when at rest and fasting, and is responsible for up to 75% of daily EE.[5]

The thermogenic effect of food is a rapid, transient increase in metabolic rate by 10–20%, and is responsible for 10% of daily EE. This effect is decreased in some obese patients. However, the resulting energy deficit is <25 kcal/day,[6] making it irrelevant in the treatment of obesity.

Physical activity alters the metabolic rate, even at low intensity; it is highly variable and responsible for as little as 20% or as much as 50% of the daily EE.[7]

The acute effect of exercise on metabolism is termed excess post-exercise oxygen consumption and accounts for up to 15%[8] of the EE of exercise. The length of this effect varies between 20 minutes and 12 hours[5] and depends on several factors, including increases in heart and respiratory rates, increased circulating catecholamines and raised body temperature.[8] Excess post-exercise oxygen consumption can be altered by varying the duration, frequency and intensity of exercise. Physical activity also affects the BMR.[9] Svendsen *et al.*[10] found adding exercise to a low-fat diet increased BMR from 0·26 kcal/kg/day to 2·65 kcal/kg/day. Furthermore, this effect continued as long as regular exercise was maintained.

The total weekly increase in EE required for weight loss using exercise alone is ≥ 2,400 kcal,[11] the equivalent of 60–90 minutes of brisk walking per day. Bouchard *et al.*[12] were able to show weight loss of 8 kg over 100 days, 80% of which was fat mass, could occur using exercise alone. However, other studies[11] have not replicated this, showing subjects lose an average of 2·4 kg over six months.

The combination of diet with exercise gives a more achievable target, requiring increases of EE by 1,000 kcal/week,[11] equivalent of 30 minutes' moderate-intensity (15–20 minutes' high-intensity) activity per day. A meta-analysis study has also found that this method results in maintenance of weight loss for two years or more.[13]

These findings have led to the current recommendations requiring EE of ≥ 1,000 kcal/week alongside an energy-restricted diet to lose weight. Altering intensity, duration, frequency and type of exercise changes the manner in which the 1,000 kcal is achieved and may also affect metabolism and body composition independent of the total EE. These aspects of exercise need further consideration.

INTENSITY OF EXERCISE

The issue of intensity is quite variable among people and can be subjective. The level of intensity depends on the individual's resting metabolic rate, physical fitness and total energy expenditure. A low-intensity exercise level for an athlete can be regarded as a high-intensity exercise level by an obese person.

Energy for skeletal muscle activity is gained from oxidation of free fatty acids (FFA), utilisation of glycogen and triglyceride stores and metabolism of glucose. Carbohydrate oxidation provides the most energy per litre of oxygen; therefore at high intensities energy comes solely from this form of metabolism. At lower intensity oxidation, FFA is the preferred source of energy.[14]

Several studies have shown that fat oxidation occurs maximally at lower exercise intensities,[15–17] implying that low-intensity exercise is the more beneficial if fat loss is the aim. However, this has not translated to clinical findings: Ballor *et al.*[17] and Gutin *et al.*[18] found that when EE remained constant but intensity was altered there was no measurable difference in loss of fat mass between the groups.

Increasing intensity of exercise may not increase loss of fat mass but can lead to preservation of lean mass. Grediagin *et al.*[19] and Mougios *et al.*[20] both found moderate-intensity exercise resulted in a greater reduction in BMI than high-intensity exercise, and concluded that moderate-intensity activity does not result in preservation of lean mass. This may have negative implications in obesity by reducing the volume of metabolically active tissue; however, this should be balanced against the increased compliance due to the measurable changes in body mass and waist circumference.

Changes in metabolic rate also result from alterations in exercise intensity, acutely by affecting EPOC and longer term by affecting BMR.

One review[21] of the effect of exercise on EPOC found that raising the intensity of physical activity increased the magnitude or duration of EPOC, so high-intensity exercise results in a favourable acute response compared with moderate intensities. This response continues into the long term when regular high-intensity activity is carried on.[9,14]

Therefore, long-term high-intensity exercise may increase overall EE compared with moderate-intensity exercise, despite carrying out the same relative volume, resulting in greater weight loss. High-intensity exercise also has cardio-protective effects, increases bone mineral density, protects against colon and breast cancer and can have positive effects on eating behaviour.[22]

TABLE 1 Measuring intensity using the MET score

Frequency hour/week	MET score	Intensity
<1	0	Low
1–3	1–3	Medium
4–6	4–6	High
>7	7+	Very high

The effects of intensity of exercise on weight loss and health occur in a dose-response manner.[21] This should be balanced against patients' abilities: it is unrealistic to expect patients to exercise above 80% intensity for any significant duration, so current guidelines for weight loss recommend moderate- to high-intensity exercise at 60–80% $VO_{2\ max}$.[5]

VO_2 is related to respiratory rate: at $VO_{2\ max}$ the patient is at the maximum respiratory rate and is therefore exercising at 100% intensity. This is difficult to measure as it relies on breathlessness, which is often subjective.[23]

Other measures of intensity have been developed for use in place of % $VO_{2\ max}$. One of these is to assign activities a MET score. This is based on the average increase in metabolic rate achieved by a given activity. A wide variety of activities has been assigned MET scores, which are available in the literature.[24] An activity at 60–80% $VO_{2\ max}$ might be equivalent to a MET score of 4–6. This includes activities such as gardening, jogging, cycling and brisk walking.[24] This method is dependent on knowledge of the literature and may not be suitable for self-assessment of intensity.

Measuring the MET score can be done by asking the patient about the average time per week spent undertaking the following kinds of activities: walking, jogging/running, lap swimming, tennis or racquetball, bicycling or stationary biking, aerobics/callisthenics and dancing (see Table 1).

Another method of measuring intensity in clinical practice is heart rate (HR). This is easy to monitor and is related to respiratory rate. Although not suitable for monitoring low- or very high-intensity exercise (e.g. slow walking or fast running respectively), it can be used to measure exercise at levels of 60–80% $VO_{2\ max}$. This is equivalent to a 60–80% rise from the resting HR.[24]

The issue of the effect of physical activity on appetite remains controversial. Extreme exercise may cause tissue damage and increases metabolic rate. This probably leads to the release of cytokines and reduces appetite. Sustained moderate physical activity appears to allow re-setting of appetite to match metabolic need, perhaps by permitting transfer of plasma leptin across the blood-brain barrier.

DURATION AND CONTINUITY OF EXERCISE

To maintain an increase in EE ≥ 1,000 kcal/week, 30 minutes of exercise at 60–80% intensity must be carried out most days. This is difficult to incorporate into some lifestyles and can be daunting for previously sedentary individuals,[25] which has resulted in much interest into the effects of splitting exercise in smaller bouts.

Researchers have found that splitting exercise into several 10-minute sessions per day produces little difference in body mass compared with one 30-minute session,[27] though one study found that the shorter bouts gave an extra 0·8 kg of weight loss.[26]

Multiple short-duration exercise has been shown to significantly increase EPOC but does not appear to cause long-term changes in the BMR.[28–29] Therefore the contribution of this acute response to total weight loss is unknown.

Multiple short bouts of exercise are more likely to be carried out at the higher intensities[30] and increase compliance by fitting around other activities. They also produce similar weight loss as single longer sessions of exercise. Research has not been carried out into the effect of exercise bouts lasting <10 minutes; therefore guidelines suggest a total of ≥ 30 minutes' 60–80% intensity exercise should be carried out per day in sessions of ≥ 10 minutes.

FREQUENCY OF EXERCISE

There are no published data on weight loss when comparing bouts of one to two long sessions of exercise per week with daily 30-minute bouts. Lee *et al.*[31] compared mortality rates in those carrying out physical activity on most days of the week with patients doing longer bouts only at weekends, and found that several short sessions of exercise were best, but single longer sessions were still very beneficial in reducing mortality. Another study[32] found that adding a weekend game of golf to a previously sedentary lifestyle was associated with increased fitness and some weight loss. However, there was no comparison between those active only at weekends and those active on several days a week. One recent study[33] looked at the effects of one to two long bouts compared with several shorter bouts a week while keeping EE the same; it found no difference in weight loss between groups, though this was only an eight-week study of low power.

For a single bout of exercise to expend ≥ 1,000 kcal/week it must be either high-intensity, long duration or a combination of these. The most common activities for 'weekend warriors' were golf, gardening and tennis,[31] all of which are moderate intensity. They are also relatively time consuming, which is one of the main reasons given for not

exercising in population surveys.[25] Multiple shorter-bout exercise is easier to incorporate into people's lifestyles and allows exercise at higher intensities; therefore current guidelines recommend that exercise should be carried out for 30 minutes on most days of the week.

BODY COMPOSITION AND TYPE OF EXERCISE

Fat makes up 15% of male and 20% of female body mass in non-overweight subjects. Visceral and abdominal fat are of the greatest concern in obesity management as these distributions predispose to the development of obesity-related ill-health.[5]

In clinical practice, obesity is usually estimated by BMI. However, fat reduction can occur without subsequent BMI decreases, due to preservation or increase in lean mass. Some indication of fat distribution can be gained through waist circumference,[5] which may be more suitable for measuring weight loss when exercise is combined with diet.

Preservation of lean mass may help prevent the plateau effect commonly seen in calorie-restricted diets[5] due to its high metabolic activity. When lean mass is lost, weight regain is more likely to occur and this weight is more likely to be distributed as fat.[34]

Exercise has an effect on both preservation of lean mass[35–36] and reduction of abdominal and visceral fat[37] over the effects of diet alone, though studies in this area have tended to be small scale and requiring high-intensity exercise. One review focusing on trials with lower-intensity exercise failed to show significant fat loss resulting from increased physical activity,[38] implying that exercise has a minimal role in fat loss. However, a year-long study by Wood *et al.*[39] showed that, although patients using diet alone lost more weight than those using exercise alone, the diet-only group also had greater loss of lean mass. Therefore patients should be informed about the benefits of preserving lean mass and advised to monitor weight loss through waist circumference as well as BMI.

Studies into aerobic exercise form the majority of literature on obesity management, and it is the exercise type most often recommended. Aerobic exercise is defined as the continuous rhythmic movement of larger muscle groups,[5] and includes walking, jogging, cycling and dancing. Aerobic exercise is also easily adaptable for intensity, duration and frequency and does not usually require special equipment.

It is commonly accepted that total EE is more important than the type of exercise, though some studies have found that different types of aerobic activity produce differences in weight loss. Gwinup[40] found cycling was most effective for weight loss, followed by brisk walking, while swimming had no effect on weight, though other studies[41] have found no differences in weight loss between water- and land-based exercise. Dance has also been found to result in weight loss,[42] causing similar reductions as cycling and jogging.[43]

There is growing interest in the role of strength-training (resistance) exercise, such as muscle building in weight management. This increases muscle mass, resulting in greater exercise endurance and EE. There have been suggestions that strength training may increase BMR due to the high metabolic rate of muscle. Several studies have investigated this possibility, but so far no effect on BMR has been found.[3]

Strength training's main benefit is in the preservation of lean mass. Up to 29% of mass lost through dieting is lean tissue,[44] but this can be counteracted with regular physical activity. Comparisons of diet alone, diet and aerobic exercise and diet with aerobic and strength exercises resulted in similar overall weight loss, but the percentage of lean mass lost was 31%, 22% and 3% respectively.[12]

Total EE is more of a factor in weight loss than exercise type. However, swimming appears to be the least beneficial activity, possibly due to its relatively low intensity. If the primary aim is weight loss, the addition of strength training has little visible benefit. However, since it prevents lean mass loss, a combination of aerobic activity and strength training is recommended for weight loss.

BARRIERS TO EXERCISE

The health behaviours and beliefs of the population, common barriers to exercise and methods of increasing compliance also need to be considered when advising exercise.

Obese subjects have difficulty maintaining intensities of greater than 60% for any significant length of time,[45] though this effect can be reduced by steadily increasing the intensity of activity at each session; this method also leads to longer maintenance of lower body weight.[46] There is evidence that relative intensity is as important as absolute intensity, so advising patients to exercise until breathless is a suitable alternative to giving a set goal such as a 60% increase in resting heart rate.

Since obesity is higher in lower socioeconomic groups, barriers to exercise are also likely to be higher in these groups due to financial considerations – access to facilities, unsafe neighbourhoods for walking, and so on.

Lack of desire, time constraints, poor facilities and embarrassment are all reasons given for not exercising. The most commonly cited reason is low self-efficacy,[47] patients perceiving themselves as unable to carry out exercise due to disability, poor fitness and low self-confidence. These issues can be addressed to some

extent through promoting lifestyle activity, though its contribution to weight loss is not always clear. Most studies have found lifestyle activity does not produce as much weight loss as structured exercise, but may result in longer maintenance of weight loss as it improves physical fitness and is easier to implement.[48, 49]

Time constraints can also be addressed by lifestyle activity. However, short-bout exercise may be more effective. Splitting the 30 minutes a day into 10-minute bouts increases compliance and weight maintenance without reducing initial weight loss.[50, 51]

Location can have an impact on compliance with an exercise programme. The use of home exercise equipment is shown to increase weight loss and maintenance over the use of leisure centres.[30, 52] Cheap and easy access to facilities is considered an important incentive to exercise by patients.[52] However, when such access is available, exercise uptake does not necessarily improve.[53] This may be due to the dislike of exercising in leisure centres expressed by many obese patients.[47] Access to footpaths, walking tracks and safe outdoor environments has been found to increase exercise such as walking.[52] This is especially important as walking is the favoured exercise of most patients.[47]

Participation in exercise and weight loss can be increased when exercise programmes are carried out with friends,[54] relatives[55] or the patient's partner.[56] But if support is not available then the reverse is true: patients report preferring solitary exercise and have increased adherence and weight loss on these types of programmes.[47, 57]

Altered perceptions of intensity in obesity can make monitoring EE difficult.[23] In these circumstances pedometers may be useful in self-monitoring and have the added benefit of increasing self-efficacy.[46]

The most common exercise carried out is walking (44·1%), followed by gardening (29·4%), stretching (25·5%), cycling (15·4%), strength training (14·1%), stair climbing (10·8%), jogging (9·1%), aerobics (7·1%) and swimming (6·5%).[47] Thus recommendations suggesting walking, stair climbing or physical housework are likely to be well tolerated, though there is a risk that patients will not reach 60–80% intensity.[2]

Patients should start off at low–moderate intensity, gradually increasing to 30 minutes per day at 60–80% intensity. Local facilities should be taken into account and exercise with family or friends should be encouraged. Most barriers to physical exercise can be reduced with lifestyle advice, and result in some weight loss when combined with diet.

DELIVERING THE MESSAGE

The National Health Survey of England and Wales, 1995, found only 35% of patients were advised about increasing exercise when visiting their GP,[4] despite evidence that advice by doctors resulted in increased exercise uptake.[2] This may be due to time constraints, physicians' unawareness of the best exercise to advise and doubts about patient compliance.[4]

Detailed advice and long-term follow-up maximise exercise uptake, aid weight loss and prevent weight regain.[2, 58] However, this level of intervention is often not practical and community-wide methods need to be developed to promote exercise.

Simply telling people to exercise more is ineffective[59] as it fails to address exercise barriers, raise motivation or educate patients about appropriate exercises, all of which are essential to increase exercise.[47] Similarly, mass media interventions do little to increase exercise; patients retain the message, but motivation levels do not rise.[60] There is some evidence that initiatives such as 10,000 steps a day, where easily achievable goals are set and monitored, can increase exercise levels, though their effect on weight loss is not yet known.[61] Written advice such as leaflets or exercise prescriptions can help to increase exercise when tailored towards specific groups of patients.[62] This provides education on both the benefits and types of exercise available and addresses some of the common barriers to exercise without requiring specialist clinic input or taking up large amounts of physicians' time.

Finally, the addition of an exercise programme to diet should be encouraged. Avenell and colleagues found in their systematic review of the long-term outcomes of the treatment of obesity that this enhances weight loss and reduce risk factors for at least one year.[63]

CONCLUSION

The total volume of exercise has a greater role in weight loss than the intensity, duration and frequency. This should be ≥ 2,400 kcal/week when using exercise alone or ≥ 1,000 kcal/week when combining a diet with exercise.

Moderate- and low-intensity exercise does not preferentially reduce fat mass; therefore patients should be encouraged to exercise at higher intensity, around 60–80%, though reaching this level may not be tolerable or practical for some. At this intensity, 150 mins/week of exercise need to be accumulated to expend ≥ 1,000 kcal/week.

Alterations in the duration and frequency make little difference to overall weight loss, but shorter bouts of exercise increase long-term compliance and make it easier for patients to reach higher intensities. Therefore exercise

should be carried out in sessions of ≥ 10 minutes for a total of 30 minutes a day on most days of the week.

Aerobic exercise such as walking is well tolerated and popular. It also yields better results than water-based exercise and should therefore form the basis of an exercise prescription. It should be combined with strength training to minimise the loss of lean mass.

Commonly encountered barriers to exercise include cost, time, embarrassment and poor self-confidence. These can be addressed to some extent by promoting lifestyle activity and advising initially low levels of exercise, which can be then increased up to the 'therapeutic' dose of 60–80% intensity, 30 minutes per day, most days of the week.

Multidisciplinary team interventions result in the most weight loss. However, it is not practical to expect this in many cases. Written exercise advice, such as exercise prescriptions, are the next most effective intervention and play an important role in community-wide exercise promotion.

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PAST PRESIDENTS

David Craigie (1793–1866)

Little is known of David Craigie's clinical work or his presidency.

His name is most commonly associated with writing, publishing and celebrating the life of William Cullen.

Born in 1793 near Edinburgh, Craigie trained in medicine at Edinburgh University, eventually becoming a Fellow of the College. From 1861–3 he was its president.

In 1828, not long after qualifying, Craigie wrote *Elements of general and pathological anatomy* (a second edition came out 20 years later).

About that same time he was appointed a physician to the Royal Infirmary of Edinburgh and became the owner (and editor) of the *Edinburgh Medical and Surgical Journal*.

The following year Craigie published his book *Elements of anatomy – general, special and comparative,* and in 1836 *Elements of the practice of physic*.

However, the work for which he is most likely to be remembered is *An account of the life, lectures and writings of William Cullen (two volumes)* by John Thomson, with whom Craigie collaborated.

Several of Craigie's papers – he wrote more than 30 – and letters are to be found in the University of Glasgow and our College Library.

After a long period of ill health he died in 1866.

Derek Doyle
Obituaries Editor, The Journal, RCPE