Does exercise help with weight management?

The full deal

What is the issue here?

For those people familiar with the energy balance equation, simply stated as change in body size will equal the energy consumed from food minus the energy expended in activity, it seems obvious that exercise will influence body weight. If people consume the same number of calories and exercise more, they will loose weight. If they consume the same number of calories and exercise less, they will put on weight.

In practice it does not always appear to work like this with some researchers pointing to the benefits of exercise in weight management and others maintaining that it does not play a role at all. The latter view is the most controversial so let's start by looking at where it comes from and whether it is supported by the evidence.

Energy balance models

It seems that the energy balance equation is not so simple after all and three models have been proposed for energy balance in the body. The most simple is the additive model.

Additive model

This model starts with the energy required to run all the major organs in the body, the muscles and the immune system which is the basal energy expenditure and adds to it the energy required for physical activity. In this model if an individual exercises more their energy requirement will go up.

Performance model

Like the additive model the performance model separates the energy requirement for basal energy and the additional energy for physical activity, but according to this model, when an individual increases physical activity the basal energy requirement increases as well. This means that the energy requirement for a given amount of physical activity will be more in the performance model than the additive model.

Compensation model

The third model is the compensation model and it is the basis for the claims that physical activity does not help with weight loss. According to the compensation model there is a still a separation between basal energy and energy required for physical activity, but in this model, as the energy demands from physical activity increase there is a compensatory decrease in the energy required for basal activities so that there is no net increase in energy requirement. This means that the energy requirement for a given amount of physical activity will be less in the compensation model than in the additive model.

The energy compensation model was first proposed by Herman Pontzer (Pontzer et al. 2012) and came to general attention in his book, "Burn" (Pontzer, 2014). Pontzer is an anthropologist and the energy compensation model arose from his work with hunter gatherer populations and western populations. He found that the amount of activity undertaken per day has "almost no bearing" on the calories burned every day. He had anticipated greater total energy expenditure in the hunter gatherer populations than in the western population, but actually found the energy expenditure to

be similar, leading him to conclude that the hunter gatherers must be compensating for their greater activity by reducing their basal energy requirement. If this is correct it means that individuals in western populations that wish to lose weight will need to reduce their calorie intake, as increasing their physical activity will have a compensatory effect on the body's metabolism such that the energy requirement will not change.

There are some possible physiological explanations for an energy compensation mechanism, set out by Gonzalez et al. (2023). There is some evidence for gait and other movement becoming more efficient with practice, for dietary changes because metabolising carbohydrate is more efficient than metabolising fat and for increased efficiency of the mitochondria (the energy releasing organelles) in the muscles with high intensity training. Nevertheless, it is difficult to see how these explanations could compensate for all the increased energy requirement from physical activity.

Does the body really compensate for increased physical activity?

The energy compensation model is based on studies comparing the energy use of different populations, but when its advocates say that physical activity will not help with weight loss, it is being used to predict what will happen in individuals. The energy compensation model can be tested by measuring energy use in individuals undertaking increasing levels of physical activity. If the energy compensation model is correct then energy use should stay the same, despite the increase in physical activity. If the energy compensation model is incorrect the increased energy consumption associated with increased energy use should lead to a decrease in body weight provided the calorie intake from food stays the same. If the individual takes in more calories because the increased physical activity makes them hungrier, then according to the energy compensation model the increased activity would lead to increased body mass. If the model is wrong the individual would maintain a constant body mass because the increased energy intake would be balanced by the increased energy consumption as per the energy balance equation.

There is a lot of research in this area that has tried to find out what does happen with these changes in physical activity and diet. It's not straightforward and it seems that there is some evidence for energy compensation, but not to the extent that physical activity has no role to play in weight loss as some advocates (e.g. van Tulleken, 2023) of the energy compensation model propose.

The relationship between total energy expenditure and basal energy expenditure

Evidence for energy compensation comes from the work of Careau et al. (2021) in a study on energy compensation in which Pontzer was a co-author. In this study the focus was the total energy expenditure and basal energy expenditure using an existing data base, where these values had been recorded for many individuals. If the energy balance equation is correct, one would expect the basal energy requirement to increase linearly as the total energy requirement increased. In this investigation this did not happen, instead the basal energy requirement increased less than the total energy requirement indicating that there was a degree of compensation. The researchers calculated that the compensation effect reduced total energy requirement by 28%, far from 100%, but nevertheless a significant amount. The authors also found that the degree of compensation varied between individuals, with individuals with more body fat having a greater degree of compensation, which suggests that it will be more difficult for individuals with more body fat to lose weight through physical activity. The researchers were unable to determine whether this effect was because individuals who compensate more are more likely to make fat, or because an accumulation of fat results in more compensation.

Metabolism has become more efficient

Further evidence is support of the compensation model comes from studies of energy requirements in the population and how they have changed over time. In developed countries there has been an increase in the weight of the population such that there are more people who are overweight or obese. This has been attributed to the population eating more energy dense foods and taking in more calories, or being less active and using less calories, or both. Speakman et al. (2023) looked at changes in total, basal and active energy requirements in a large sample of people collected over a 30-year period. Because the overall Body Mass Index (BMI) in the sample increased over the sampling time, they corrected the data for BMI on the basis that bigger bodies have a bigger basal energy requirement. The corrected data showed that in males there was a significant decrease in basal energy requirement over the period of the study. The same effect was seen in females, but it did not reach significance. Without a compensatory increase in active energy expenditure this decrease in basal energy requirement, will lead to an increase in BMI in the population. The authors theorised that the decrease in basal energy requirement over time might be due to changes in the immune system, or to diet, particularly reduced consumption of saturated fats which have been show in mice to be associated with a higher metabolic rate. They considered and were not able to dismiss the idea that the observed decrease in basal energy requirement is due to measurement artefacts, because the equipment used to take samples changed over the 30 years of the study period.

These two studies (Careau et al. 2021 and Speakman et al. 2023) looked at energy expenditure at the population level. They therefore do not actually answer the question that public health professionals and individuals alike want answered, which is, will exercise help me lose weight or maintain a healthy weight, even if there is some degree of energy compensation?

There is a considerable body of evidence to support the energy balance equation prediction that increased physical activity will lead to weight loss, although the evidence shows that the weight loss is less than anticipated from a simple application of the energy balance model.

Exercise and weight loss

There is considerable evidence from high quality clinical trials that exercise leads to weight loss. A randomised controlled study (RCT) (Donnelly et al. 2013) was designed to look at the effects of exercise alone, and not diet and exercise together, on weight loss. Overweight or obese participants (141) were randomised to two different exercise programmes, or no exercise, and followed up for ten months without energy restriction. In other words, they were not asked to change their diet. The exercise programmes were intense, one was designed to use 400 Calories per session and the other 600 Calories per session, with the participants starting at lower levels and working up to these targets. Sessions took place five times a week and were supervised to ensure that the exercise took place. The results clearly demonstrated the benefits of exercise alone on weight loss with the 600 Calorie group loosing 5.7% of their body weight at the end of the ten-month trial period and the 400 Calorie group loosing 4.3% of their body weight. In contrast the body weight of the control group increased by 0.5%. These results are certainly convincing on the benefit of exercise on weight loss, but in practice it may be difficult to achieve the level of intensity and commitment to an exercise programme that was achieved in the study.

The Donnelly et al. (2013) study was a well conducted individual trial, but it makes sense to look at systematic reviews to take into account the findings of multiple studies in this area. A systematic review of different exercise patterns in obese adults aged 18-45 considered the results from 32 RCTs involving 1401 participants (Hao et al 2022). Most of the studies were short term of 4-12 weeks

duration, but five of the studies were longer than 12 weeks. They found that across all these studies. exercise led to weight loss compared to controls that did not exercise, and the weight loss was greater when the exercise group undertook vigorous aerobic exercise or moderate aerobic exercise combined with either low or moderate resistance training. From the trials reviewed they found that high intensity aerobic exercise was the best to reduce weight, but high intensity aerobic exercise combined with resistance training was the best to reduce BMI and body fat. Moderate intensity aerobic exercise combined with resistance training was the best to reduce waist circumference.

A meta-analysis carried out by Lee and Lee (2021) looked at the effects of longer exercise interventions on body weight and composition. All the 16 RCTS included in the analysis involved overweight or obese adults. Exercise interventions were either aerobic, resistance training or a combination of the two. Across the studies the average exercise intervention time was 22 weeks, with exercise taking place on average four time a week for 50 minutes. Not all the studies reported on all the parameters, but the studies showed that exercise significantly reduced weight, BMI and visceral fat compared to non-exercising controls. Lean body mass increased, but the effect did not reach significance. The beneficial effect size of exercise varied across the studies. This finding is not unexpected because of differences in the type and duration of exercise, the length of time over which the exercise intervention was employed and the different ways of measuring fat in the study participants. There are limitations in this type of analysis. As the authors point out the studies did not control for physical activity carried out outside of the exercise intervention itself and diet was not controlled in either the exercise groups or the control groups.

An alternative approach to investigating the effect of exercise on body weight is to compare two groups, one of which exercises and one which does not. This was the approach employed by Kutac et al (2022) who compared groups of runners with sedentary groups in the Czeck Republic. They divided their population of 1,296 into groups by age and looked at the data for males and females separately. They were able to look at how body parameters changed over time by comparing the different age groups and how runners and non-runners differed. They found that both male and female runners of all age groups had lower BMI, body fat and visceral fat compared to non-runners. They found that visceral fat which is the biggest factor in the development of cardiovascular disease and type 2 diabetes increases, with age, but much more slowly in runners such that running took 20 years off the biological age of the older runners. These researchers concluded that fat levels were a more useful measure of health than BMI, because running increases lean body mass as well as reducing fat, attenuating the change in BMI. The limitation of this study as evidence of the health effects of exercise is that diet was not controlled. It is likely that individuals that adopt running as a healthy lifestyle behaviour also follow a healthy diet.

Exercise plus diet and weight loss

Many studies have tried to separate out the role of diet alone, exercise alone and the combination of diet and exercise on weight loss. Clark (2015) reviewed 66 RCTs, all of which had a minimum intervention period of four weeks. Whilst there were decreases in body weight with both exercise and diet interventions, the combination of diet and exercise was superior to either intervention alone. Looking specifically at the exercise interventions both endurance training and resistance training produced an energy imbalance, particularly at high levels of physical activity intensity. Diet plus endurance training was superior to diet alone in reducing body mass and diet plus resistance training was superior to diet alone in reducing fat mass. Clark (2015) also reported that exercise was more effective in reducing fasting insulin levels than diet which provides a metabolic advantage. Resistance training had the most favourable effect on blood lipids.

A review of 33 RCTs in overweight and obese adults with a follow up of at least a year found that immediately after the intervention, and at the one year follow up, diet and exercise were 20% better than diet alone in achieving and maintaining weight loss (Curioni and Lourenco, 2005). Is should be noted that both groups regained about half the weight loss in the 12 month follow up period.

Do exercisers compensate by eating more?

The observation that weight loss following exercise is less than predicted by the energy balance model may be explained by a different type of compensation, that of eating more. Individuals undertaking exercising may eat more to compensate for the increased activity undertaken such that they do not lose weight or, if they over compensate, actually increase in weight. Bosy-Westphal et al. (2021), conducted a review of the literature in this field and found that some energy increasing activities including physical activity favour weight loss whereas other activities that increase energy expenditure such as exposure to cold and lack of sleep lead to an over compensation in energy intake and weight gain. They also found that short term increases in energy expenditure are associated with weight gain, because when the energy expenditure drops back to the original level after that period of increase, there is no compensatory decrease in energy intake.

An earlier meta-analysis by Schubert et al (2013) had similar findings. The results showed minimal compensation in energy intake after exercise and that as a consequence, exercise does lead to an energy deficit. Nevertheless, the energy deficit was less than might be expected taking into account the exercise undertaken and the food consumed afterwards, indicating some degree of metabolic or other compensation. Barutcu et al (2020) took a wider view of compensation through increased calorie intake by looking at food intake before a planned exercise session as well as after. Their study was conducted in twenty healthy weight stable volunteers. From monitoring calorie intake at breakfast, lunch and dinner following a planned afternoon energy session they found that calorie intake at lunch increased by about 11% in anticipation of an exercise session whereas calorie intake at the other meals remained about the same. Despite this increase in energy intake the exercise itself did lead to an energy deficit, but the calorie increase at lunch may explain why the deficit was not as big as would be expected from a simple energy balance model.

Do exercisers compensate by resting more?

Mansfeldt and Magkos (2023) report on another explanation for why the weight loss following physical activity is less than anticipated by the energy balance model. They argue that weight loss is not as much as expected because individuals compensate for the exercise sessions by reductions in non-exercise physical activity when they undertake an exercise programme. They reviewed 24 different studies covering a diverse range of exercise programmes. They found that 16 out of the 24 studies demonstrated this compensatory decrease in other physical activity, three in contrast found an increase in other physical activity and the remaining five showed no change. One explanation for this inconsistent finding was that age, sex and BMI all played a role in this compensatory finding and the studies covered different age groups, sex distribution and body sizes. Of particular note was the finding that when this compensatory decrease in other physical activity occurs it can be large enough to negate the beneficial effects of the exercise programme on energy balance. Mansfeldt and Magkos (2023) suggest that the mechanism behind this compensatory decrease in other physical activity could be either tiredness from the effort of the exercise programme, or individuals rewarding themselves with a rest after exercise.

Is body weight the best metric?

Another factor to take into account when looking at the effects of exercise on energy balance is that body weight might not be the best measure of the changes that are taking place in the body. Whilst BMI is correlated with morbidity and mortality, the association between mortality and morbidity is actually stronger with visceral adiposity. Exercise has an important role to play in reducing visceral adiposity and visceral adiposity can be reduced without reducing weight.

Verheggen et al. (2016) reviewed studies that looked at changes in BMI and adiposity in overweight and obese individuals. The studies included in the review covered both studies that looked at exercise alone and studies that examined the effects of both diet and exercise. The found that whilst both exercise and diet reduced visceral adiposity, exercise was better at decreasing visceral adiposity and diet better at decreasing weight. The explanation for this difference is that a calorie restricted diet leads to the loss of both muscle and fat mass, whereas exercise reduces fat mass but increases lean body mass and circulating plasma volume, attenuating the weight loss.

A more recent review by Bellicha et al. (2021) develops the idea of the role of different metrics and identifies four different targets namely, weight loss, fat loss, preservation of lean body mass and maintenance of weight loss. In a review of 12 controlled studies, they found that exercise contributed to weight loss and that for weight loss aerobic exercise was better than resistance training. They found that all types of exercise, except resistance training, contributed to the loss of visceral fat. Resistance training however, was particularly beneficial in preserving lean body mass, despite weight loss. In the studies reviewed there was no benefit of exercise on weight maintenance. There were some possible explanations for this last finding. It is difficult to know whether the study participants adhered to the exercise programmes, and it is not clear whether the exercise programmes themselves had sufficient energy demand to maintain weight. It is estimated that more than 250 minutes of exercise a week is required to prevent weight gain and participants in the studies reviewed may not have reached this threshold.

The importance of resting metabolic rate

Within total energy expenditure, resting metabolic rate is of particular significance because it represents the largest component of the body's energy expenditure. More energy in the form of resting metabolic rate is required to maintain larger body sizes, and there is a relationship between fat free mass and resting metabolic rate. Thus, if a weight reduction programme reduces fat free mass, then the resting metabolic rate should decrease as well. If an individual undertakes resistance training and maintains body weight, then the expectation would be an increase in fat free mass and resting metabolic rate. If as a result of the resistance training body mass is lost, resting metabolic rate would remain constant as fat free mass has been maintained. Whilst these relationships have been established for resistance training the relationship between aerobic exercise and resting metabolic rate is not so clear.

Yu et al (2021) set out to investigate the effects of aerobic exercise, resistance training and a combination of the two in overweight and obese adolescents when calorie consumption was not restricted. In the study there was a total of 140, 12–18 year-olds, divided into four groups; a control group, an aerobic exercise group, a resistance training group and a combined exercise group. All the exercising groups undertook three sessions of exercise for three to six months. Overall, there were no changes in resting metabolic rate, but there were interesting changes in body composition. Compared to the control group, all the exercise groups reduced visceral fat. The aerobic exercisers reduced body weight, both the aerobic and the resistance groups reduced fat mass, the combined exercise group increased fat free mass, and the resistance and combined exercise groups increased

skeletal muscle. This study refutes the idea that the body reduces resting metabolic rate in response to exercise and shows clearly the benefits of exercise on body composition with aerobic exercise having a beneficial effect on body weight. This benefit on body weight was not seen when aerobic exercise and resistance training were combined because resistance training increased skeletal muscle.

The Yu et al. (2021) study did not restrict participant calorie intake. When exercise and diet are combined the outcomes are different. Miller at al. (2018), examined the effects of resistance training and diet on body composition in 40 overweight or obese, pre-menopausal women. The participants were divided into four groups, a diet group, resistance training group, a combined group and a control group. The resistance training was two to three sessions per week for 16 weeks. Body weight decreased in the diet and combined groups, but not in the resistance training only group. The percentage body fat decreased in all three intervention groups as did total fat mass and the decrease in fat mass was most pronounced in the combined resistance training and diet group. As in the Yu et al. (2021) study, lean body mass increased in the resistance training group. Resting metabolic rate was unchanged. The authors were surprised that resting metabolic rate did not increase in response to the exercise interventions and suggested that a longer intervention period may lead to an increase in resting metabolic rate. This study shows the value pf physical activity in not only decreasing body weight, but in maintaining a healthy body composition, which is achieved with the combination of diet and resistance training.

Further support for the beneficial effects of exercise on body composition comes from a review of 58 studies all looking at the effect of resistance training, with or without dietary restriction or aerobic interventions, in healthy standard weight, overweight or obese people (a total of 2,058 participants) Wewege et al. (2021) found that both resistance training and aerobic exercise were beneficial additions to the diet intervention, with resistance training preserving lean body mass whilst diet and aerobic exercise resulted in a loss of lean body mass.

Exercise to prevent weight regain

There is a lot of interest in exercise as a mechanism to prevent weight regain after weight loss. There are many biological reasons to explain why weight is regained after weight loss including changes to the hormones which influence energy intake and energy expenditure. Exercise may have a positive impact on these biological changes thereby reducing the likelihood of regaining weight, but it is likely that a considerable amount of exercise will be required to overcome these changes (Washburn et al, 2021).

Washburn et al (2021) studied three different exercise levels in overweight and obese participants who had lost more than 5% of their body weight. The different exercise levels were along the spectrum from moderate to vigorous exercise at 150, 225 and 300 minutes of exercise per week. Interestingly this study did not show a relationship between weight regain and the exercise regime. The study found that overall, the participants had lost a total of 9.3Kg during the weight loss programme and on the exercise regimes they regained 2.4Kg over 12 months. Of particular note was the wide range of changes observed within this overall effect. 30% of the participants continued to lose weight, 30% regained less than 5% of the weight they had lost, 30% regained 5-10% of the weight they had lost and 10% regained more than 10% of the weight they had lost. This suggests that for most of the participants the exercise programme was helpful in either further reducing body weight or preventing rapid weight regain. It should be noted that the trial participants had the benefit of being enrolled in a weight maintenance programme which may have also contributed to their success in preventing weight regain.

This triggering of compensatory mechanism to restore body weight after weight loss is a natural mechanism to preserve body mass, but is unhelpful in individuals wishing to lose weight. Another review of studies in this area by van Baak and Mariman (2023) also found that the evidence for the benefits of exercise on weight maintenance is mixed, but that there appear to be some benefits. Even in those studies that had an overall negative result, there was evidence that individuals who exercise more were better at maintaining weight loss.

Exercise to influence behaviour

A different way at looking at the benefits of exercise on weight loss is to take a behavioural approach. The concept here is that taking part in a healthy activity like physical activity makes it more likely that people will stick to a healthy eating regime, by taking control of one area of their life they will be more likely to transfer that self-control to another behaviour. This was tested by Annesi and Sevene (2023) in 110 women divided into four groups according to the number of self-reported exercise sessions they took part in. All the women were on a weight reducing diet and although no association between exercise and weight loss was reported in the study, regular exercise led to a positive change in eating behaviours. In this study participating in physical activity was providing a psychological rather than a physiological benefit to the adoption of healthy eating behaviours in the participants.

In summary

The evidence shows that exercise is a valuable tool for people wishing to lose weight. The amount of weight that will be lost is likely to be less than anticipated by a simple energy balance model because there are some compensatory mechanisms at play. There is however no doubt that exercise has an important part to play as part of a weight loss programme, Exercise has benefits beyond weight loss in terms of body composition. Aerobic exercise is helpful for weight loss and for reducing body fate, whereas resistance training is helpful to build lean body mass.

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