Physical activity in the treatment of the adulthood overweight and obesity: current evidence and research issues

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Abstract


Purpose: The purpose of this paper is to review the evidence on the role of physical activity in the treatment of adult overweight and obesity. Three specific questions are addressed: (1) Does exercise alone produce weight loss? (2) Does exercise in combination with diet produce greater weight loss than diet only? and (3) Does exercise in combination with diet produce better maintenance of weight loss than diet alone?

Methods: The literature initially identified by the Expert Panel on Clinical Guidelines for the Treatment of Obesity, three key meta analyses, and additional literature searches were used to identify randomized trials related to the three aforementioned topics. These articles were reviewed and tabulated.

Results: Six of 10 randomized studies found significantly greater weight loss in exercise alone versus no treatment controls. The magnitude of the effect averaged 1-2 kg. Only 2 of 13 studies found significant differences in initial weight loss for diet plus exercise versus diet only, although almost all studies pointed in this direction. Six studies were identified with maintenance periods of at least 1 yr. In two of the six there were significant long term differences favoring diet plus exercise, but in every study considered the direction of the difference favored diet plus exercise. Other strong evidence showing benefits of exercise for long-term weight loss comes from correlational analyses which consistently find that those individuals who report the greatest exercise have the best maintenance of weight loss.

Conclusions: Randomized trials consistently show benefits of exercise for weight loss, but the effects are often modest. This may result from small sample sizes, short study duration, and poor adherence to the exercise prescriptions. To better define the doses and types of exercise that will promote long-term weight loss, it is necessary to develop better ways to measure exercise and promote adherence to exercise.

The combination of diet plus exercise is recommended for obese patients desiring to lose weight. The purpose of this paper is to review the empirical literature supporting this recommendation. Specifically, this literature review will address three important questions:

- Does exercise alone produce weight loss?
- Does exercise in combination with diet produce greater weight loss than diet alone?
• Does exercise in combination with diet produce better maintenance of weight loss than diet alone?

The National Heart, Lung, and Blood Institute, in combination with the National Institute of Diabetes and Digestive and Kidney Disease, recently convened an Expert Panel on the Identification, Evaluation and Treatment of Overweight and Obesity in Adults (22). Since this panel addressed issues similar to the ones being addressed in this paper, their literature search was used extensively in preparing this report. The Expert Panel selected randomized controlled trials which involved 4 months or more of treatment regardless of the sample size involved. Thirteen articles were used for the comparison of exercise versus no treatment (2,4,8,9,12,13,16-18,27,33,37,42) and 15 for the comparison of diet plus exercise to diet alone (1,2,4,5,11-13,20,23,33-36,39,43). The Expert Panel based their conclusions on (a) the number of studies that favored exercise versus no exercise and (b) the mean differences between the two conditions. These articles were re-reviewed for the present paper, and a few other studies meeting the Expert Panel’s criteria were identified. The present review used a different criterion for evaluating the effect of exercise on weight loss, namely, the number of studies that showed significant differences favoring exercise. In addition three meta-analyses related to this topic were used in developing this paper (3,10,21).

DOES EXERCISE ALONE PRODUCE WEIGHT LOSS? TOP

The Expert Panel concluded that in 10 of the 12 studies that met their review criteria the exercise condition had larger weight losses than the control, with a mean difference in weight loss of 2.4 kg (or a BMI difference of 0.7 kg·m\(^{-2}\)). In the one meta-analysis that addressed this issue, Garrow and Sommerbell (10) reached a similar conclusion: that exercise produces a slight weight loss in men (net difference = 3.0 kg) and in women (net difference of 1.4 kg).

Table 1 shows the results of 10 randomized controlled trials comparing exercise interventions to no-treatment controls that were considered in the current review. The study by Bertram et al. (4) used a diet condition as the control group and thus this study has been excluded. Another study used by the Panel provided follow-up data from the King study (18); at the point of follow-up, the control group was no longer available. This study has also been excluded from the present review. The references by Wood (42), Frey-Hewitt (9), and Fortman (8) apparently all present results of the same study, and thus only the Wood study is used here. Finally, an additional study by Wood (41) was identified that met inclusion criteria. The exercise programs used in these studies stressed aerobic exercises such as brisk walking, but a few also included some resistance training. In general, subjects in these studies were men who were only slightly overweight.

Table 1. Weight loss in exercise alone vs no treatment control group.

<table>
<thead>
<tr>
<th>Study</th>
<th>Duration</th>
<th>N</th>
<th>Weight Loss</th>
<th>Study</th>
<th>N</th>
<th>Weight Loss</th>
<th>Signif.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderssen 1995 (2)</td>
<td>1 yr</td>
<td>49 M/F</td>
<td>-0.9 kg</td>
<td>43 M/F</td>
<td>+1.1 kg</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Hammer 1989 (12)</td>
<td>4 months</td>
<td>8 F</td>
<td>-6.7 kg</td>
<td>4 F</td>
<td>-5.8 kg</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Hellios 1993 (13)</td>
<td>6 months</td>
<td>39 M</td>
<td>-0.3 BMI</td>
<td>39 M</td>
<td>+0.3 BMI</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Katzef 1995 (16)</td>
<td>9 months</td>
<td>49 M</td>
<td>-1%</td>
<td>18 M</td>
<td>+0.5%</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>King* 1991 (17)</td>
<td>1 yr</td>
<td>29-35 F</td>
<td>-0.6 to +0.4 BMI</td>
<td>34 F</td>
<td>0 BMI</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Rönnea 1988 (27)</td>
<td>4 months</td>
<td>13 M/F</td>
<td>-2.0 kg</td>
<td>12 M/F</td>
<td>+0.5 kg</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Stefanik 1998 (33)</td>
<td>1 yr</td>
<td>43 F</td>
<td>-0.4 kg</td>
<td>45 F</td>
<td>+0.8 kg</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Verity 1989 (37)</td>
<td>4 months</td>
<td>5 F</td>
<td>-2.1 kg</td>
<td>5 F</td>
<td>-2.9 kg</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Warm 1983 (41)</td>
<td>1 yr</td>
<td>48 M</td>
<td>-1.9 kg</td>
<td>33 M</td>
<td>+0.6 kg</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>Wood 1988 (42)</td>
<td>1 yr</td>
<td>47 M</td>
<td>-4.0 kg</td>
<td>42 M</td>
<td>+0.6 kg</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

*a Significance of difference in weight loss for exercise vs control.

b Data interpreted from graph.

c This study included 3 exercise conditions: high intensity group based/high intensity home based/low intensity home based. None differed in weight loss from controls.

d Table 1. Weight loss in exercise alone vs no treatment control group.* Significance of difference in weight loss for exercise vs control.* Data interpreted from graph. This study included 3 exercise conditions: high intensity group based/high intensity home based/low intensity home based. None differed in weight loss from controls.

While the Expert Panel considered all these articles equally, it should be noted that the sample sizes in the studies by Verity (37) (N = 5 per condition), Rönnea (27) (N = 12-13 per condition), and Hammer (12) (N = 8 in exercise and 4 in control) seriously limit conclusions from these articles. The large weight losses in the Hammer study (12), even in the control group, suggest that these subjects were changing their diet. The Katzef study (16)
specifically asked patients not to lose weight and thus interpretation of the small weight loss that occurred is difficult.

Despite these concerns, the studies reviewed in Table 1 support the conclusion that exercise produces larger weight loss than the no-treatment control. In 6 of the 10 studies reviewed here, the differences were significant. However, in all cases except the Wood study (42), the effect of exercise was very modest.

Thus, the conclusion from these studies is that exercise alone produces modest weight losses. (Evidence Category A). A key question raised by these data is whether it is really the exercise that produces the weight loss, or whether participants in such studies also change their intake, despite instructions to the contrary. Although not included in the Expert Panel’s review, a study by Bouchard et al. (6) on the long-term impact of significant amounts of exercise provides the best data on the effect of exercise independent of changes in diet. In this 100-d-long study conducted at a residential facility, the five male participants exercised twice a day, 6 d·wk⁻¹, at 55% of VO₂max and their intake was held constant. Subjects in this study lost 8 kg over the 100 d. This study is the clearest proof that exercise alone can produce weight loss.

DOES EXERCISE IN COMBINATION WITH DIET PRODUCE GREATER WEIGHT LOSS THAN DIET ALONE? TOP

The Expert Panel used 15 randomized trials to compare diet alone versus diet plus exercise. They concluded that 12 of the 15 articles showed a greater weight loss in the combined diet and exercise group (1.9 kg) and greater reduction in BMI (0.3 to 0.5) than in the diet only group. Ten of the 15 were reconsidered here; one of the studies used in the Expert Panel reported follow-up data (35) rather than being a separate study and was thus excluded; one could not be located (23); and three had only 3-month duration for the intervention (11,34,37). Three other studies not originally reviewed by the Expert Panel were identified (7,28,29). Thus, in the present review, the answer to this question is based on 13 studies.

The characteristics of the studies in Table 2 differed from those in Table 1 in that now the samples were predominantly female and the intervention phase in the majority of studies was shorter, lasting 4-6 months. Moreover, although not shown in the table, subjects in these studies were more overweight than in Table 1.

<table>
<thead>
<tr>
<th>Duration</th>
<th>N</th>
<th>Weight Loss</th>
<th>N</th>
<th>Weight Loss</th>
<th>Signif.</th>
<th>N</th>
<th>Weight Loss</th>
<th>Signif.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diet Only</td>
<td></td>
<td></td>
<td>Diet + Aerobic Exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diet + Resistance Exercise</td>
<td></td>
<td></td>
<td></td>
<td>Diet + Resistance Exercise</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Andersen 1995 (1)</td>
<td>1 yr</td>
<td>16 F</td>
<td>-12.9 kg</td>
<td>16 F</td>
<td>-13.4 kg</td>
<td>NS</td>
<td>18 F</td>
<td>-17.9 kg</td>
</tr>
<tr>
<td>Andersen 1995 (2)</td>
<td>1 yr</td>
<td>52 M/F</td>
<td>-4.0 kg</td>
<td>65 M/F</td>
<td>-5.6 kg</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bortman 1990 (4)</td>
<td>4 months</td>
<td>8 F</td>
<td>-9.3 kg</td>
<td>13 F</td>
<td>-7.0 kg</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blank 1994 (5)</td>
<td>6 months</td>
<td>26 M/F</td>
<td>-12.2 kg</td>
<td>27 M/F</td>
<td>-2.9 kg</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degen 1994 (7)</td>
<td>10 months</td>
<td>26 M</td>
<td>-9.3 kg</td>
<td>25 M</td>
<td>-8.1 kg</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hammer 1989 (12)</td>
<td>4 months</td>
<td>8 F</td>
<td>-11.5 kg</td>
<td>6 F</td>
<td>-12.9 kg</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hellmann 1993 (13)</td>
<td>6 months</td>
<td>40 M</td>
<td>-0.3 BMI</td>
<td>39 M</td>
<td>-0.6 BMI</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marks 1995 (20)</td>
<td>5 months</td>
<td>10 F</td>
<td>-3.7 kg</td>
<td>8 F</td>
<td>-4.5 kg</td>
<td>NS</td>
<td>11 F</td>
<td>-3.5 kg</td>
</tr>
<tr>
<td>Ross 1995 (28)</td>
<td>4 months</td>
<td>12 F</td>
<td>-10.0 kg</td>
<td>12 F</td>
<td>-11.7 kg</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ross 1996 (29)</td>
<td>4 months</td>
<td>11 M</td>
<td>-11.9 kg</td>
<td>11 M</td>
<td>-11.6 kg</td>
<td>NS</td>
<td>11 M</td>
<td>-13.2 kg</td>
</tr>
<tr>
<td>Stefanik 1993 (33)</td>
<td>1 yr</td>
<td>46 F</td>
<td>-2.7 kg</td>
<td>43 F</td>
<td>-3.1 kg</td>
<td>NS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood 1991 (43)</td>
<td>1 yr</td>
<td>40 M</td>
<td>-3.1 kg</td>
<td>39 M</td>
<td>-5.7 kg</td>
<td>*</td>
<td>10 F</td>
<td>-12 kg</td>
</tr>
</tbody>
</table>

* Significance of difference between diet plus exercise vs diet only.
* This study compared diet only to diet plus exercise plus behavior modification.
* Data interpreted from graph.

Table 2. Weight loss in diet only vs. diet plus exercise.* Significance of difference between diet plus exercise vs diet only.* This study compared diet only to diet plus exercise plus behavior modification.* Data interpreted from graph.

Only two of the 13 studies showed a statistically significant difference in the weight loss obtained in the diet plus exercise condition compared with the diet alone condition (39,43), with the Wood et al. (43) study finding the significant difference in men only. While the direction of results very consistently favors diet plus exercise, as noted by the Expert Panel, the magnitude of the difference is small and rarely reaches statistical significance.
This may result in part from the small number of subjects and short treatment period used in many of these studies (however, the Stefanik study (33) which had the largest sample and lasted a full year failed to show a statistically significant difference between conditions).

Interestingly, four studies also included a diet plus resistance training condition (1,20,36). Again, these studies showed no significant differences in weight loss between the diet only group and the diet plus resistance exercise condition.

A larger number of studies were used in the meta-analyses, but the conclusions appear similar to those reported here. Miller (21) reported that average weight losses in diet alone and diet plus exercise were similar (10.7 kg and 11.0 kg, respectively). Ballor and Poehlman (3) reported no difference in weight loss (mean = 10 kg).

Thus, the conclusion to this question is that in most studies exercise does not significantly increase initial weight loss over and above that obtained with diet only. However, in almost all studies the diet plus exercise group lost somewhat more weight than the diet alone condition (Evidence Category A).

These studies raise several key questions for discussion. Most important is the question of why the effect of exercise on weight loss is so modest. Perhaps this is caused in part by the short duration of many of the studies. If participants are asked to increase their exercise by 1000 kcal·wk⁻¹, and the study lasts only 4-6 months, then differences in weight loss of only 2-3 kg would be expected. In many of the studies cited, this is close to the magnitude of the difference that is observed. It is also possible that individuals in diet plus exercise programs compensate for the energy expended in exercise by reducing physical activity at other times in the day or by eating somewhat more.

A second question relates to the interaction between the severity of the dietary restriction and the effect of exercise. A review of the studies in Table 2 suggests that programs with more severe dietary restriction (and hence larger weight losses) are less likely to observe an effect of exercise. For example, Andersen (1) used a 925-kcal diet for 16 wk with four servings of liquid formula per day and a frozen entree for dinner. This study produced the largest weight losses in Table 2, but no effect of exercise was seen over and above the effect of the diet.

Issues related to possible gender differences and ethnic differences cannot be resolved based on these studies.

**DOES EXERCISE IN COMBINATION WITH DIET PRODUCE BETTER MAINTENANCE OF WEIGHT LOSS? TOP**

The Expert Panel discussed three studies of diet plus exercise that included follow-up periods (1,35,39). They noted that at follow-up all three found 1.5-3 kg greater weight losses in the combined diet plus exercise condition.

The meta-analysis by Miller (21) noted that at 1-yr follow-up patients in the diet only group maintained a weight loss of 6.6 kg, whereas those in the diet plus exercise group maintained a weight loss of 8.6 kg. Neither this overall weight loss nor the percent of weight loss retained differed significantly between conditions, although the abstract notes that at 1-yr follow-up the diet plus exercise programs tended to be superior.

In the current review a criterion of 1 yr or more for follow-up was used; since the study by Svendsen (35) had only a 6-month follow-up, it was omitted, but several other appropriate studies were identified (Table 3). Again, using statistical significance as the criterion, it was found that two of the six studies (24,39) had a significantly greater weight loss at follow-up in the diet plus exercise group than in the diet group; in the other studies (31,32,38,40) there were no significant differences at follow-up. However, it should be noted that in every study the direction of the difference favored diet plus exercise.
It is important to point out that in these studies with longer follow-up, participants who were initially randomized to diet only may have begun to exercise whereas those in diet plus exercise frequently fail to continue to exercise. Thus, while failing to find a significant difference with the intent-to-treat analysis, some studies find that those individuals who continue to exercise have the best weight losses. For example, although Wadden et al. (38) found no differences in long-term weight loss for subjects randomized to diet only versus diet and exercise, there was a strong association between self-reported level of exercise at follow-up and long-term weight loss. Subjects who reported regular exercise at follow-up maintained a weight loss of 12.1 kg versus 6.1 kg in the nonexercisers.

There are also many correlational studies that show a strong association between exercise at follow-up and maintenance of weight loss (26). From such data, one cannot determine whether it is the exercise per se that promotes weight loss maintenance or whether exercise is just part of a constellation of weight controlling behaviors (or a marker for this constellation). However, the correlational analyses support the possibility that the failure to see a significant effect of exercise in the randomized trials described in Table 3 may be related to poor long-term adherence to exercise in those assigned to the diet plus exercise condition or to adoption of exercise in the diet only condition.

Thus correlational data clearly show that continued exercise is associated with long-term maintenance of weight loss. Randomized trials support this finding. In all of the long-term randomized trials reviewed, weight losses at follow-up were greater in diet plus exercise than in diet only. However, the difference was statistically significant in only two of the six randomized controlled trials. (Evidence Category B)

**RESEARCH ISSUES**

The goal of weight loss intervention is to produce long-term sustained weight loss. The most important question to be addressed is thus whether there is a type or amount of exercise that will really improve maintenance of weight loss. To answer this question, we must be able to ensure that subjects who are randomly assigned to exercise complete the prescribed exercise. To accomplish this, we must first tackle several preliminary issues.

1. **Better Assessment of Physical Activity**

   It is important that we first find a way to more accurately quantify physical activity. At present, doubly labeled water is the gold standard, but this approach is too expensive for most intervention studies (with large sample sizes and multiple measurement intervals) and does not provide information about the type or pattern of physical activity. The alternative assessment approaches that are currently available, including mechanical devices and self-report, have problems related to validity and reliability. Thus a major goal for the field should be to develop a better way to measure physical activity. Similarly, if we are going to really understand the role of exercise in...
promoting long-term weight loss, it is important to be able to more accurately determine how much and what type of food the participants are consuming.

2. TOP

How Can We Improve Adherence to Exercise in Overweight Participants?

Secondly, if we are going to evaluate the effects of exercise on long-term weight loss maintenance, we need to be able to get overweight individuals to adhere to exercise long term. Overweight individuals typically have low levels of adherence to exercise, and exercise can improve weight loss only if the exercise is actually performed. Thus, we need to develop new approaches to promoting exercise adherence in obese individuals. For example, there have been several studies comparing home-based and supervised exercise. King et al. (17) found that men and women ages 50-65, adhered better to exercise programs they could complete at home rather than in supervised group settings. Likewise, Perri et al. (25) compared the effects of a supervised group exercise program versus a home-based program on exercise adherence and weight loss. At 12 months, the subjects who had been randomly assigned to the home-based programs had better exercise adherence and weight loss. Thus, home-based exercise appears to improve long-term exercise adherence, but makes documentation of the prescribed exercise more difficult.

Since lack of time is the primary barrier cited for exercise, Jakicic (14) has examined the effect of prescribing exercise in multiple short bouts (four 10-min bouts) rather than longer bouts (one 40-min bout). Adherence to exercise and initial weight loss were both improved by the multiple bout regimens. Improvements in fitness were comparable in the two conditions. Currently, Jakicic is replicating and extending this study and investigating whether providing home exercise equipment promotes adherence and weight loss.

These are provided as examples of the type of research that is needed on adherence. Other variables deserving attention include the effect of social support on exercise adherence, reinforcement for exercise, and ways to prompt exercise by phone or mail. Research is needed to determine whether these adherence strategies are effective for individuals of different races, genders, or age groups.

3. TOP

How Should Exercise be Prescribed to Improve Long-Term Weight Loss Maintenance?

If we could measure physical activity and produce better adherence to our exercise prescriptions, we could then begin to determine how exercise should be prescribed to promote long-term weight loss. Typically in behavioral weight loss programs, individuals are taught to gradually increase their physical activity to a level of 1000 kcal·wk$^{-1}$ with the emphasis on aerobic activities (primarily brisk walking). This goal is similar to the recommendations made by the CDC to accumulate 30 min of exercise on most days in the week. However, there has been little empirical investigation of this exercise prescription. There are several questions that need to be answered regarding this topic:

**How much total exercise is needed?**

Recent data suggest that 1000 kcal·wk$^{-1}$ may not be sufficient to produce maintenance of weight loss, and that levels of approximately 2500 kcal·wk$^{-1}$ are associated with weight loss maintenance. Schoeller et al. (30) concluded that the threshold of physical activity for weight maintenance was 47 kJ·kg$^{-1}$·body·weight·d$^{-1}$. This translated to an average of 80 min·d$^{-1}$ of moderate activity or 35 min·d$^{-1}$ of vigorous activity. Similarly in the National Weight Control Registry successful weight losers report expending approximately 2800 kcal·wk$^{-1}$ in physical activity (19).

**Does the intensity of exercise matter or is it the total calorie expenditure?**

The premise of behavioral weight loss programs has been that it is the total calorie expenditure that affects weight loss, not the intensity. However, there do not appear to be any long-term randomized trials that have
specifically tested this hypothesis. In the National Weight Control Registry, individuals who have lost weight and maintained their weight loss report expending over 800 calories wk$^{-1}$ in high intensity exercises such as running or aerobic dance. Similarly, Jeffery et al. (19) found that the best maintainers of weight loss were those in the top quartile of physical activity level at study end (month 18). These individuals had a median level of activity of 2550 kcal wk$^{-1}$, with again approximately 800 calories wk$^{-1}$ in high intensity activity. Such high intensity exercise may help individuals attain the large overall energy expenditure (without such exercise requiring inordinate amounts of time) or alternatively such high intensity exercise may differentially affect appetite, mood, or other factors associated with weight loss maintenance.

Does the type of exercise matter?.

To date, few studies have examined the effect of resistance training versus aerobic exercise on weight loss and maintenance. Because resistance training increases lean body mass, this form of exercise may be particularly beneficial for weight loss. Although initial studies have not shown such benefits, further research on this question is needed.

4. Why Does Exercise Improve Maintenance?

Finally, if we better understood the way in which physical activity might improve maintenance of weight loss, we would be better able to prescribe exercise for this purpose. Specifically, it is unclear whether in those studies where exercise has positive effects on weight loss maintenance, it is because exercise burns calories or because of other physiological, psychological, or behavioral effects of exercise. A better understanding of the mechanism would help us to determine the type of exercise to prescribe.

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REFERENCES

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Keywords:

WEIGHT LOSS MAINTENANCE; EXERCISE; PHYSICAL ACTIVITY; OBESITY