Variations in physical activity habits and body composition

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Introduction

Over the past twenty years scientists and clinicians have become increasingly aware of the importance of physical activity in the regulation of body mass and composition. It is now recognized that the total number of calories expended by intentionally increasing levels of physical activity can be substantial. Further, increasing physical activity levels can depress, maintain, or increase caloric intake. These facts should not be surprising as farmers and ranchers have known for years that to fatten cattle or pigs for market requires an unlimited availability of food and a small pen that greatly restricts activity.

The purpose of this paper is to investigate the effect of increasing physical activity on altering body mass and composition through a review of the existing literature. Factors affecting our interpretation and understanding of this literature will then be discussed. Finally, we will conclude with some observations about the potential role of exercise in the prevention and treatment of overweight and obesity. This review and discussion will be limited to the direct effects of physical activity independent of changes in dietary energy restriction, as the interaction of physical activity and energy restriction will be the focus of another paper.¹

Physical Activity and Alterations in Body Mass and Composition

A number of excellent review articles have been published within the past fifteen years directly addressing alterations in body mass and composition consequent to exercise training.²⁻¹² Before discussing these, however, it is important to understand the great variation in results of individual research studies. Reviews, like averages or mean data, tend to focus on trends to the exclusion of a critical analysis of the extremes. In this brief review, we will start with the extremes and then concentrate on the overall trends.

Several individual studies have reported rather remarkable alterations in body mass and composition with physical activity intervention. Hadjiova et al.¹² trained 32 obese women for a period of 45 days, using a variety of activities for a period of approximately 10 hours per day. Diet was maintained "normocaloric." At the end of the 45 day training period, there was a mean body mass loss of 12.4 kg (-1.93 kg/week) and a mean fat loss of 11.0 kg (-1.71 kg/week).

Lee et al.¹³ have recently reported on the changes in body mass and composition of 197 obese male recruits who were placed in a 5-month program of basic military training. There were a total of 976 one-hour training periods during the 5-month period, 57% of which were considered to be physically intensive for obese subjects. Intensity and duration of activity were adjusted to provide a progressive increase in physical activity over the 20 week period. No dietary restrictions were imposed. At the end of the 20 weeks of training, there was a 12.5 kg loss in total body mass (-0.63 kg/week) and a 11.9 kg loss in fat mass (-0.60 kg/week).

Finally, Leonardo et al.¹⁴ had six previously sedentary young men walk on a treadmill at 3.2 mph, 10% grade for 90 minutes/day, 5 days/week. No dietary restrictions were imposed. Following 16 weeks of training, the subjects experienced a 5.7 kg loss of body mass (-0.36 kg/week) and a 5.9 kg loss of fat mass (-0.37 kg/week).

In contrast, several studies have found no change in body mass or composition with a program of physical training. Hagan et al.¹⁵ compared the effects of aerobic conditioning and/or caloric restriction on body mass and composition in overweight men (n=48) and women (n=48). Subjects were assigned to one of four groups: sedentary control; exercise only; diet only; exercise + diet. The exercise intervention consisted of walking and running for 30 minutes/day, 5 days/week. At the end of the 12 week intervention period, body mass loss in the exercise group was only 0.3 kg (-0.03 kg/week) for men and 0.6 kg (-0.05 kg/week) for women. Fat loss was 0.2 kg (-0.02 kg/week) in the men and 1.2 kg (-0.10 kg/week) in the women. There were no significant changes in either mass or composition in the exercise group when compared to the control group.

Hardman et al.¹⁶ studied 28 women enrolled in a 12-month brisk walking program, starting at 100 minutes/week and increasing to 175 minutes/week at the end of the third month. An additional 16 women served as non-exercising controls. Training sessions had to be at least 20 minutes in duration, and at least three sessions had to be performed per week. At the end of
the 12 month program, the brisk walkers had a net body mass gain of 0.3 kg (+0.01 kg/week) and a net gain in fat of 1.0 kg (+0.02 kg/week). There were no significant differences in body mass or composition changes between the brisk walkers and controls. In contrast to the previous studies cited earlier, this group of women were relatively lean at the start of the study (relative fat: 23.7% in brisk walkers and 21.9% in controls).

With this as a background, we can look at the results of several of the reviews that have been conducted which have attempted to synthesize the results of individual studies that have been conducted through 1990. In 1980, Epstein and Wing conducted a meta-analysis of all studies investigating aerobic exercise and body mass loss conducted up to that time which met a set of inclusion criteria. The inclusion criteria included: at least 5 subjects/group; pre- and post-weights were available; exercise parameters were specified allowing calculation of energy expenditures; subjects were sedentary prior to the intervention; and subjects were not on planned diets. A total of 13 studies on males and three studies on females were included in this analysis. They reported a mean body mass change of +0.02 kg/week for the control groups and -0.09 kg/week for the exercising groups. Dividing the subjects into heavy and thin, they found that heavy exercising subjects lost significantly more mass than thin subjects. Also, the magnitude of body mass loss was directly a function of the number of exercise sessions per week. Relative body fat losses averaged -0.09%/week in the exercising groups and +0.02% in the control groups. Absolute body fat changes were not reported. Heavier subjects tended to have greater relative fat losses.

In 1983, Wilmore reviewed 46 studies, including 59 different training groups, that had investigated changes in body mass and composition with exercise training in adult populations. Training programs varied widely by activity, duration of program, and intensity of training. With an average program duration of 16.3 weeks, relative fat decreased by an average of only 1.6% (-0.10%/week), the average loss in total mass was 1.0 kg (-0.06 kg/week), and the decrease in absolute fat averaged 1.6 kg (-0.13 kg/week).

In 1991, Bailer and Keesey reported the results of a meta-analysis of the factors affecting changes in total mass, fat mass, and fat-free mass consequent to exercise training. To be included in this analysis a study had to meet the following criteria: at least five subjects per group, with no mixing of sexes within group means; reported pre- and post-intervention body mass and relative body fat; reported sufficient information to estimate exercise energy expenditure, with the exception of weight training; used subjects that were previously sedentary; used subjects that were not on weight reduction programs; specified clearly the type of exercise and did not mix modes of training; did not exceed an exercise duration of 60 minutes/session; and, did not exceed a training period of 36 weeks. Approximately 500 published studies were reviewed. A total of 53 studies met the selection criteria and were included in this analysis.

The analysis was broken down by gender and by activity, including run/walk, cycling, and weight training. For males, the mean change in body mass per week was -0.08 [-0.05] kg/week for walking/running, -0.06 [-0.02] kg/week for cycling, and -0.13 kg/week for weight training. Mean fat mass changes for males were -0.10 [-0.16] kg/week for walking/running, -0.10 [-0.05] kg/week for cycling, and -0.10 kg/week for weight training. Mean relative fat changes for males were -0.13 [-0.13] %/week for walking/running, -0.13 [-0.10] %/week for cycling, and -0.16 for weight training. These data expressed as mean change per week were calculated by dividing the mean changes for each variable by the average duration of the training programs. The resulting mean weekly changes are not in total agreement with what the authors presented in the text for males. There is no obvious explanation for the differences in calculated values between the present paper and the original paper.

Table 1 summarizes the changes in body mass and composition for those individual studies and reviews presented in this section. From this table, it is apparent that there is reasonable agreement across the three review articles as to the magnitude of weekly change despite the substantial differences in results from the individual studies cited. Overall, from these results it must be concluded that formal exercise training, in the absence of changes in diet, results in relatively small alterations in both body mass and composition. Using average values of change across these three reviews, a six month period of training would result in a loss of 1.0 kg of body mass, a loss of 2.6 kg of fat mass, a gain of 1.0 kg of fat-free mass, and a loss of 2.9% relative fat. Why doesn’t formal exercise training play a more substantial role in inducing body mass and composition changes?

Potential Factors Affecting Alterations in Body Mass and Composition with Training

While there are many potential factors that could affect the body mass and composition response to exercise training, due to space limitations this discussion will focus on only several that could play a critical role.

Genetic basis of individual variability

It has been well established from previous research that there is considerable individual variability in the response to a given intervention. The genetic basis of this variability has been recently demonstrated by Bouchard and his associates. Seven pairs of young adult male identical twins exercised on a cycle ergometer twice a day, nine out of every ten days, over a period of 93 days. Prior to initiating the exercise program, a 17H2
was individually prescribed to produce a net energy deficit of 4.2 MJ/day (1,000 kcal/day). The total energy deficit over the course of the study was 244±9.8 MJ (mean±SEM).

Mean body mass loss was 5.0 kg (0.38 kg/week), with a mean fat mass loss of 4.9 kg (0.37 kg/week). Relative body fat decreased from 23.6% to 18.8%, a total loss of 4.8%, or 0.36 %/week. There was reasonably close agreement in the amount of body mass lost within a given twin pair, but there was nearly a fourfold difference between the twin pair that lost the most compared to the twin pair that lost the least. At the extremes, for the same energy deficit of 4.2 MJ/day, one subject lost −1 kg and another lost −8 kg. This illustrates that for a given intervention, the variation in response can be considerable.

Composition of the subject's diet
The composition of the diet consumed by the subject at the time of the exercise intervention is now recognized as an important factor that could possibly alter the magnitude of change in body mass and composition. Tremblay et al.18 exercised nine healthy male subjects

Table 1  Mean weekly changes in body mass, fat mass, and relative body fat from selected studies and several reviews

<table>
<thead>
<tr>
<th>Study</th>
<th>Mean Change in Body Mass, kg/week</th>
<th>Mean Change in Fat Mass, kg/week</th>
<th>Mean Change in Relative Fat, %/week</th>
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<tr>
<td>Adigio (12)</td>
<td>-1.93</td>
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<td>-1.17</td>
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<tr>
<td>Son (14)</td>
<td>-0.36</td>
<td>-0.37</td>
<td>-0.31</td>
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<tr>
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<td></td>
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<tr>
<td>Agan (15)</td>
<td>-0.03 (M)</td>
<td>-0.02 (M)</td>
<td>-0.01 (M)</td>
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<tr>
<td>Individual study</td>
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<tr>
<td>Ardmann (16)</td>
<td>-0.05 (F)</td>
<td>-0.12 (F)</td>
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<td>Individual study</td>
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<tr>
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<tr>
<td>Bilemore (4)</td>
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<td>-0.13</td>
<td>-0.10</td>
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<td>View</td>
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<td>Stor &amp; Keese (8)</td>
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<td>View</td>
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<tr>
<td>Walking/jogging</td>
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<td>-0.10 (M)</td>
<td>-0.09 (M)</td>
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<tr>
<td>Telting</td>
<td>-0.05 (F)</td>
<td>-0.10 (F)</td>
<td>-0.13 (F)</td>
</tr>
<tr>
<td>Relting</td>
<td>-0.06 (M)</td>
<td>-0.11 (M)</td>
<td>-0.13 (M)</td>
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<tr>
<td>Surfing</td>
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<td>-0.05 (F)</td>
<td>-0.10 (F)</td>
</tr>
<tr>
<td>Right Training</td>
<td>+0.13 (M)</td>
<td>-0.10 (M)</td>
<td>-0.16 (M)</td>
</tr>
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</table>
The nature of the exercise intervention and total physical activity
It is important to recognize that the extent or magnitude of change in body mass and composition with exercise training can be greatly affected by the nature of the exercise intervention. The mode of activity might be a source of variation in response. This is not clearly demonstrated in Table 1 when comparing walking/running, cycling, and weight training. The results across these three modes appear to be similar. However, in recent unpublished research in our laboratory, we have observed greater decreases in fat mass and increases in fat-free mass consequent to resistance training compared to standard forms of aerobic training such as cycle ergometry, walking and running. Further, there have been several unpublished reports and one published report\textsuperscript{21} that suggest that the changes in body mass and composition are not as great with swimming when compared to walking and jogging. However, this certainly was not supported by the results of a well-controlled study by Lieber et al.\textsuperscript{22} who found comparable reductions in relative and absolute body fat in a group of sedentary males assigned to an 11.5 week program of either swimming or running compared to no changes in non-trained controls.

The magnitude of change in body mass and composition is also highly dependent on the duration, frequency and intensity of the training program. It is possible that there might be a threshold which must be exceeded before substantial alterations in body mass and composition can occur. There has also been speculation that low intensity exercise produces greater losses in fat mass compared to high intensity exercise due to a higher percentage of the substrate coming from fat. However, while the respiratory exchange ratio is significantly lower, indicating greater fat utilization, the rate of energy expenditure is also considerably lower, so the net effect on the total grams of fat utilized is negated, i.e., there is little or no difference in the total grams of fat utilized per unit of time.\textsuperscript{25}

Finally, it has been shown that elderly subjects who participate in an exercise training program will spontaneously reduce normal activity throughout the remainder of the day.\textsuperscript{26} However, Meyer et al.\textsuperscript{27} reported either no change or an increase in physical activity the rest of the day as a result of training. These results have been replicated in lean and obese women, obese boys, and lean men.

Characteristics of the subject population
As reported earlier, in the review of Epstein and Wing,\textsuperscript{2} those subjects who were heavier experienced greater losses of both body mass and fat mass as a result of a training program. However, Krotkiewski et al.\textsuperscript{28} first reported in 1978 that there is a difference in the response to exercise between patients with hypertrophic and hyperplastic obesity. Those with hypertrophic obesity had significant fat losses with physical training whereas those with hyperplastic training did not. This has been confirmed by subsequent studies by these same authors and others.

While the review of Ballor and Keesey\textsuperscript{4} would indicate that there are no differences in the body mass and composition responses of males and females to exercise training, a study by Andersson et al.\textsuperscript{27} suggests that there may be differences. They found that men, like male rats, become leaner during physical training due to a lack of energy intake compensation, while women with similar body fat mass, like female rats, may increase their energy intake to protect their levels of body fat.

Prevention of Overweight/Obesity Versus Treatment
The relatively small changes that have been reported in body mass and composition with exercise training seem inconsistent with expectations. Physical activity constitutes a major source of daily energy expenditure. Yet, the body appears to partially compensate for the energy deficit created by exercise training with increases in energy intake or decreases in energy expenditure outside the formal exercise time.

It is quite possible that physical activity and formal exercise training may have their greatest impact on the prevention of overweight and obesity. While the literature is just evolving in this area, there are several studies which suggest that those who are active weigh less and have a lower fat mass than those who are not active. Williamson et al.,\textsuperscript{29} in their review of the NHANES-I Epidemiologic Follow-up Study data (1971-1975 compared to 1982-1984), reported from their cross-sectional analysis at both baseline and follow-up surveys that recreational activity was inversely related to body weight. Low recreational activity reported at the follow-up survey was strongly related to a major weight gain (>13 kg) that had occurred over the preceding ten years. The estimated relative risk of major weight gain for those in the low activity level at the follow-up survey compared to those in the high activity level was 3.1 for men and 3.8 for women.

Tremblay et al.,\textsuperscript{29} in their analysis of the 1981 Canada Fitness Survey, reported that those practicing vigorous activities on a regular basis had lower subcutaneous skinfold thicknesses and lower waist-to-hip ratios than those not performing these activities. Blair,\textsuperscript{30} in an analysis of the data on the participants in the Multiple Risk Factor Intervention Trial (MRFIT), found that high baseline physical activity status and an increase in physical activity during the trial were both inversely associated with weight gain. It is possible that physical activity might have its most significant affect
on the prevention of, rather than in the treatment of, overweight and obesity.

References
