Exercise Is Not an Effective Weight Loss Modality in Women

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The excess caloric expenditure which results from physical activity should lead to weight loss if caloric expenditure at other times remains constant. Unfortunately, while there is good evidence for such an effect in men, there is little if any evidence for a similar effect in women. Weight loss with exercise does not readily occur in women unless accompanied by caloric restriction. Further, the role of exercise in maintaining resting metabolic rate while dieting has only marginal support. Potential reasons for the ineffectiveness of exercise in inducing weight loss in women include smaller body size and lower aerobic capacity, under-reporting of caloric intake, differences in body fat distribution and sensitivity to catecholamines, a different gonadal hormone milieu, and energy conservation resulting from evolutionary pressures. Nevertheless, regular exercise in women has many beneficial effects on lipids, glucose homeostasis and bone metabolism even if weight loss does not occur.

Abbreviations: FFA = free fatty acid(s), LPL = lipoprotein lipase, RMR = resting metabolic rate, $\dot{V}O_{2max}$ = maximum oxygen consumption, WHR = waist-to-hip ratio

At a time when exercise is believed to solve most problems for many people, it will not be popular to state that exercise is ineffective as a weight loss modality in women. Although similar arguments have been made about effects of exercise on weight loss regardless of gender [1], a more convincing case can be made against any significant effect in women. The reason behind the apparent violation of the energy balance equation in women is unknown. This review will first cite studies in which exercise failed to produce a weight loss in women and then explore possible reasons for these apparent contradictions to logic. I hasten to point out that the review does not indict benefits of exercise in general, as the literature is replete with reports of physical activity benefiting virtually every aspect of human health.

EVIDENCE AGAINST AN EFFECT OF EXERCISE

In a frequently cited study by Gwinup [2], 29 obese women were given an exercise program consisting primarily of walking. Eleven of these women lost an average of 22 lbs over 1 year. Women who did not exercise > 30 minutes/day failed to lose (n = 18), and in those who completed the exercise, weight loss occurred mainly when exercise was > 120 minutes/day. A failure rate of therapy (based on intention to treat) of 62% was experienced in this study.

College female athletes (swimmers and tennis players) experienced no weight loss in a 16-week season despite increased levels of physical activity compared to the off-season. More striking, weight was apparently maintained with no change in reported dietary intake (swimmers 2091 kcal/day at the beginning of the season and 2065 kcal/day at the end of the season, tennis players 1811 vs 1791 kcal/day) [3]. While training for a marathon, previously sedentary men and women also had weight changes and dietary intake monitored for 80 weeks. Both men and women experienced significant improvements in maximum oxygen consumption ($\dot{V}O_{2max}$). Women experienced no change in weight or body composition, whereas men lost both weight and fat mass. Men significantly increased

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their caloric intake, while there was no significant change in women [4]. Similarly, a study examining the hormonal reproductive axis of women during 1 year of new physical training found no change in body weight or reported dietary intake, even though the women had run an average of 790 miles during that year [5]. By my estimate, these 13 women should have lost about 8 kg if dietary intake did not change during the increased level of activity. Further, physical activity in obese Pima native Americans correlates to weight and fat changes in men but not in women studied for 1 year [6]. As final evidence for a lack of effect of exercise on the weight of women, the same controlled exercise program was imposed on men and women for 20 weeks by Tremblay et al [7], with no attempt to control diet. Men experienced statistically significant declines in body weight, fat mass, percent fat and the sum of skinfolds, while women experienced no such change.

Even though exercise should not be considered an isolated approach to weight loss in women, exercise, combined with caloric restriction, may be useful in helping to maintain lean body mass in the face of caloric restriction [8–10]. Nevertheless, the combination of exercise with caloric restriction is not likely to produce greater weight loss than is restriction alone [8–10], although one study suggests that exercise plus diet indeed may produce greater weight loss than exercise or diet alone [11].

POTENTIAL EXPLANATIONS

Why the equation for energy balance is disrupted in exercising women is unclear. If expenditure exceeds intake, how can body weight remain the same? A simple explanation is that our measurements or assumptions of expenditure and/or intake are either invalid or unreliable.

Dietary Intake Reporting

In the studies cited above, caloric intake was usually acquired through 3- or 7-day diaries. Sources of error in this measurement include intended omissions, forgetfulness, and lack of proper identification of serving size. At least some of the discrepancies found between expenditure and intake must reside in the source of reporting.

In a study of female runners, Myerson et al [12] found that amenorrheic runners scored higher on a scale of aberrant eating patterns than did sedentary and eumenorrheic runners. As a group, however, the eumenorrheic runners had the greatest descrepancy between reported intake and expenditure [12]. Using doubly labeled water for measuring energy expenditure, Schulz et al [13] demonstrated an average 9% error in the energy balance equation of elite female runners, attributable perhaps to under-reporting of food intake (Fig. 1). Nevertheless, in a study by Janssen et al [4], men lost weight while training and reported increased intake, but women did not change in either parameter. This would suggest that if under-reporting occurred, it would have been of a much greater degree in women than in men.

Body Size and Fitness

It is well known that the average man is both taller and heavier than the average woman. Size differences alone dictate that a man will use more energy to walk or run the same distance as a woman (Fig. 2). In addition, men have a greater proportion of body weight as lean body mass, even if they are equally trained. Basic differences in body composition and hemoglobin levels are likely to contribute to the observed differences in $\dot{V}O_{2max}$ noted between the average man and woman [14]. Considering these facts, if men and women exercise at the same percentage of $\dot{V}O_{2max}$ for the same time, arithmetic proves that men should lose more weight through exercise than women (Table 1). Participation in the same aerobics class or running or biking the same distance will require more oxygen from the average man than the average woman. What amounts to about a 40% difference from the computations in Table 1 will also make under-reporting in men less significant than in women.

Catecholamines and Adipocytes

It is known that fat cells have both alpha and beta adrenergic receptors on cell surfaces. Alpha receptors are antilipolytic, while beta promote lipolysis. In addition, physical training has a pronounced effect on the rate of lipolysis. Beta agonists, when infused into the body, will elevate free fatty acid (FFA) levels, indicating that lipolysis

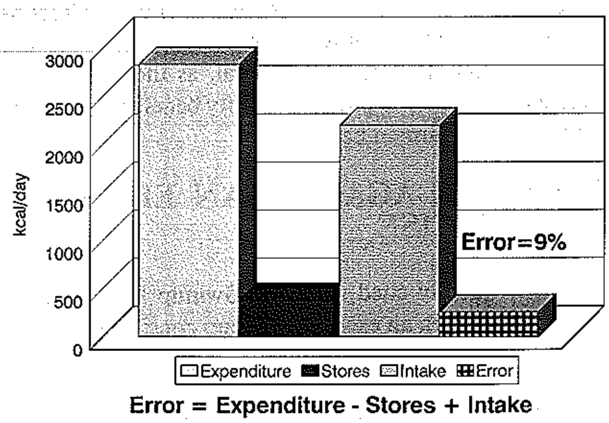

Fig. 1. Bar graphs are based on the data of Schulz et al [13] in female runners. Energy expenditure was measured by doubly labeled water, intake was by diary, and stores were based on weight loss over the observed time period. The error bar is presumably a function of under-reporting intake.

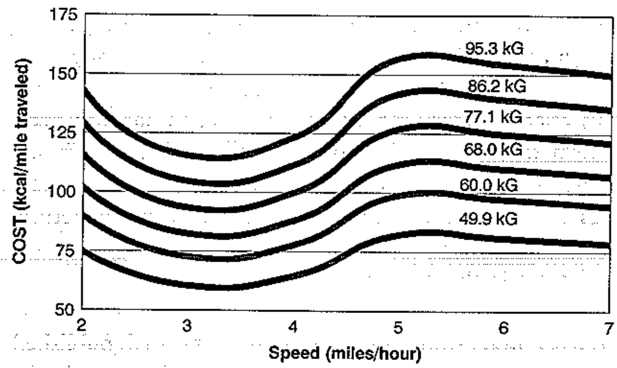

Fig. 2. Lines with body weights above them represent caloric costs of covering 1 mile at the speeds designated on the abscissa. This graph demonstrates that caloric expenditure for ambulation is very dependent on body weight (weight loss decreases cost). Because of lower body weights, women rarely attain the much quoted 100 kcal/mile. (Body weights are 110–210 lbs in 20-lb increments.)

is occurring. Similarly, isolated fat cells will liberate glycerol, indicating an increase in the rate of lipolysis. The effect of physical training on the augmented response of lipolysis to epinephrine, however, is not long lasting. In chronically trained men runners, 4 days of detraining resulted in significant declines in FFA that had been elevated by epinephrine [15]. Consequently, enhanced mobilization of FFA may be very dependent on the last exercise bout and may disappear rapidly with even short periods of detraining.

It has been questioned whether training or the degree of fatness influences the rate of lipolysis induced by beta agonists. Equally lean male marathoners and sedentary controls were selected to have similar percentages of body fat and fat cell diameter. In this condition, the degree of glycerol liberation from isolated fat cells was shown to be no different between the two groups [16]. These results suggest that the degree of fatness dictates the enhanced lipolysis, not degree of training.

Adipose tissue from women may be more resistant to lipolytic actions of catecholamines than are tissues of men. Following 30 minutes of submaximum exercise, gluteal adipocytes from men and women responded similarly to a pure beta agonist (isoproterenol). Norepinephrine, with both alpha and beta agonist properties, produced significant increases in lipolysis from male but not female adipocytes, suggesting enhanced alpha (inhibitory) activity in women [17].

Trained women were demonstrated to have decreased alpha receptor responsiveness compared to untrained women. Trained men did not have decreased alpha receptor responsiveness compared to untrained men. Both trained men and women had enhanced beta agonist activity, but trained women still had greater alpha agonist activity than did trained men [18]. These authors concluded that training would have a greater influence on women than men, since alpha agonist activity was only affected by training in the women. In obese men it has been suggested that abdominal alpha receptor activity is enhanced compared to in obese women [19].

In contrast to these findings, Despres et al [20] showed that basal- and epinephrine-induced lipolysis was improved more in men than in women following identical training. Supra-iliac fat cells were obtained, and while decreases in skinfolds were noted from many sites in men, none were noted for women.

Body Fat Distribution

Body fat deposition differs between men and women. Women tend to have primary fat stores in the gluteal and femoral regions, while men have primary fat stores in the abdominal region. The waist-to-hip ratio (WHR) is therefore smaller in women. Using this measurement women can be classified into two basic fat distribution types: gynoid with a small WHR and android with a large WHR [21]. It has been shown that WHR is positively correlated with endogenous levels of free testerone in normal premenopausal women [22].

Sexual dimorphism in fat distribution is not without significance in terms of the actions of catecholamines on adipocytes. Smith et al [23] demonstrated that while basal lipolysis was greater in femoral than abdominal fat, norepinephrine-stimulated lipolysis in abdominal fat was more than in femoral fat. In review, Smith [24] concluded that basal femoral lipolysis is greatest due to increased size of adipocytes at this location and that the difference in norepinephrine's effect on femoral, gluteal and abdominal fat is due to the presence of increased alpha receptors on femoral and gluteal fat cells.

Table 1. Projected Weight Losses in an Average Man and Woman from Exercise

	Man	Women
Height	179 cM	166 cM
Weight	77 kG	57 kG
Lean body mass	65 kG	44 kG
Maximum oxygen consumption	3.386 L/min	2.541 L/min
75% of maximum	2.541 L/min	1.624 L/min
16-week weight loss	4.7 kG	2.9 kG

The above computations are based on values for average, middle-aged men and women. Body fat is assumed to be 15% for the male and 23% for the female. Exercise is assumed to be 4 times/week, 45 minutes/session and to cost 7717 kcal/kg, with a caloric equivalent of 4.8 kcal/L of oxygen.

Fat distribution, regardless of gender, may have some impact on what can be expected from the effects of exercise on fat loss. In a 3-month conditioning study of obese men and women, Krotkiewski and Bjorntorp [25] divided the group into gynoid and android types based on WHR $\leq$ or $>$ 0.82, respectively. Gynoid obesity was associated with a significant weight gain, while the android group experienced no change or a slight loss.

Sex Steroids

The role of gonadal steroids on fat metabolism is also important. In a review, Campaign [26] noted that prolactin has an important impact on the activity of lipoprotein lipase (LPL). Increased LPL activity is inversely related to lipolytic responsiveness, and prolactin appears to play an important role in regulation of femoral fat cells in particular, making them virtually unresponsive to the effects of norepinephrine.

In another review, Wade and Gray [27] summarized the diverse effects on weight gain and fat cell metabolism by estrogen and progesterone. In gonadally intact female rats, progesterone causes a weight gain which occurs unless an 80% food restriction is imposed. Estrogen and progesterone receptors exist on fat cells and the former increases the number of receptors for the latter. While estrogen increases lipolysis, progesterone increases the rate of lipogenesis [27]. The eumenorrheic female, therefore, may have hormonal mechanisms which specifically prevent loss of body fat in the hip region. Alternatively, men have a more constant gonadal hormone milieu, and androgens are more potent anabolic stimulators in skeletal muscle than are female sex steroids. The precise role of the gonadal steroid effects on weight loss from exercise remains to be elucidated.

Energy Conservation

The defense of body fat undoubtedly has a long genetic basis in the evolution of our species, when the ability to conserve energy was of paramount importance in determining whether or not our ancestors survived to their next meal. In the female, preservation of body fat undoubtedly played a role in determining her ability to produce offspring by maintaining a normal gonadal hormone reproductive axis as well. What we now view as an unfortunate consequence of weight loss, i.e., a decrease in metabolic rate with weight reduction, was likely to be responsible for allowing modern man the luxury of such lamentations.

Very-low-calorie diets produce declines in metabolic rate, especially following a meal [28, 29]. Some of these declines may be due to changes in sympathetic nervous system activity and, somewhat less likely, in thyroid function [29]. The combination of exercise with diet has met with mixed results as a means of preventing the decline in resting metabolic rate (RMR). Lennon et al [30] showed that RMR did not decline in one of two groups who exercised and lost weight compared to a control group, whereas others [8, 10, 31] have not been able to reproduce this effect. Dietary-induced thermogenesis has also been shown to be reduced in trained compared to untrained subjects [32]. Another cross-sectional study [33] in runners was unable to show declines of either RMR or the thermic effects of a meal, although statistical power to detect a difference in the latter measure may have been limited by sample size. Values for the oxygen cost of running in these athletes were some 25% lower than normal published values for the speeds measured, a fact not discussed in the paper.

Finally, if exercise does not change RMR during weight reduction, it certainly has been repeatedly shown to improve the metabolic profile of women. Following 15 months of dieting and exercise training, significant declines in insulin, total cholesterol, apo-lipoprotein B and low-density lipoprotein cholesterol were observed in obese women who could still be considered overweight [34]. In a cross-sectional study, active women were shown to have significantly elevated high-density lipoprotein cholesterol levels when compared to sedentary women [35].

CONCLUSIONS

Unquestionably, exercise does provide certain benefits in women. As an isolated weight loss modality, however, exercise should not be counted on to produce desired weight reductions unless the woman is committed to many hours of exercise a day. Why women do not lose weight from exercise to the same extent as men is not known. Size, body composition, aerobic capacity, body fat distribution, fat cell sensitivity to catecholamines, and differences in gonadal steroid production and action are all possible explanations. Inability to properly measure dietary intake may also play an important role in the contradiction which emerges in the energy balance equation of physically active women.

At this point, it is not prudent to tell a woman that she will lose weight if she exercises. Alternatively, all women should be encouraged to exercise for its known effects on improving cardiovascular and respiratory efficiency, metabolic profiles, and possible benefits in countering osteoporosis.

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