

# Obesity and Physical Activity

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Some clinical manifestations of obesity include nonalcoholic fatty liver disease, type 2 diabetes, and cardiovascular disease. Calorie restriction may aid in weight loss in the short term. Exercise and physical activity are other means of weight loss. However, the efficacy of exercise and physical activity in weight reduction in obese populations is still unknown. In this review, we discuss the effects of exercise and physical activity in obese and overweight populations. We also discuss the effects of aerobic exercise and/or resistance training in weight loss and maintenance.

**Key words:** Obesity, Exercise, Physical activity, Weight loss, Weight maintenance

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## INTRODUCTION

In Korea, the prevalence of obesity has steadily increased from 28.7% in 2006 to 32.4% in 2015, as has the prevalence of abdominal obesity, from 18.3% in 2009 to 20.8% in 2015.<sup>1</sup> The clinical manifestations of obesity include nonalcoholic fatty liver disease<sup>2</sup>, type 2 diabetes<sup>3-5</sup>, and cardiovascular disease.<sup>6</sup> Obese individuals have an increased risk of all-cause mortality.<sup>7-9</sup> The American College of Cardiology/American Heart Association Task Force on Practice Guidelines and The Obesity Society (AHA/ACC/TOS) guidelines recommend a loss of 3-5% of initial body weight for the management of obesity in adults.<sup>10</sup> A negative energy balance is an important strategy in weight reduction.<sup>11</sup> Calorie restriction may aid in weight loss in the short term. However, physical activity is important for weight loss because physical activity increases the metabolic rate, which results in increased energy expenditure and

thus, negative energy balance.<sup>12</sup> Given the association between obesity and physical inactivity, the 2013 AHA/ACC/TOS guideline for the management of overweight and obesity in adults recommended an increased physical activity of  $\geq 150$  min/week.<sup>10</sup> However, the efficacy of exercise and physical activity in weight reduction in obese individuals is not yet established.

In this review, we will discuss the effects of various types of exercises and physical activities in obese and overweight populations.

### Aerobic exercise interventions without calorie restriction

Aerobic exercise (AE) is a popular intervention for the management of obesity and overweight. Several reviews and meta-analyses on effects of AE interventions on weight loss have been published. In a recent systematic review and meta-analysis, Thorogood et al.<sup>13</sup> evaluated the efficacy of AE in obese individuals. They pooled the results of the 6 months and 12 months programs. Six-month exer-

cise interventions effected a modest weight reduction of 1.6 kg (95% CI, 1.56 to 1.64). Twelve-month AE interventions resulted in a weight reduction of 1.7 kg (95% CI, 1.11 to 2.29) and a decrease in waist circumference of 1.95 cm (95% CI, 0.29 to 3.62). Furthermore, isolated moderate-intensity AE interventions yielded a modest improvement in blood pressure and lipid levels. Exercise methodology, intensity, and frequency varied across the included trials. However, the results of this meta-analysis showed that isolated moderate-intensity AE interventions of 6-12 months result in modest weight loss in obese and overweight populations.

Another randomized controlled trial conducted in Japan included obese participants who had two or more risk factors for cardiovascular disease.<sup>14</sup> All participants underwent a health counseling. The intervention group exercised 2-4 times a week for 6 months. This group showed significant reductions in body weight (-1.60 kg), waist circumference (-1.8 cm), triglyceride levels, and high-sensitivity C-reactive protein levels. Exercise interventions for 6 months also improved the cardiovascular risk profile of the participants. Our review of several studies suggests that AE interventions of 6-12 months without calorie restriction yield a 2-3% loss in initial body weight, a finding corroborated by several trials (Table 1). In fact, even a modest weight loss of less than 3%, when achieved via lifestyle-based strategies that include an increase in physical activity, have health benefits similar to greater weight loss without exercise.<sup>15</sup> The relationship between anaerobic exercise volume and the extent of weight loss is an important factor. Moderate AE of 6

months without calorie restriction typically showed a 2-3% weight loss.<sup>14,16</sup> However, high intensity and frequent exercise seem to predict a greater weight loss outcome. For example, in the studies conducted by Nishijima et al.<sup>14</sup> and Alves et al.<sup>16</sup>, the intervention groups performed a moderate intensity exercise intervention lasting for 40 min/day at a frequency of 2-4 times a week. The mean weight loss was 1.59 and 1.69 kg, respectively. In the Midwest exercise trial<sup>217</sup>, a weight loss of > 5% was achieved (Table 1). This randomized, controlled trial compared the effects of three different volumes of AE without calorie restriction. All participants in the exercise intervention groups attended exercise at a frequency of five times a week. The 400 and 600 kcal/day exercise groups showed weight reductions of 4.3 and 5.7%, respectively. Lee et al.<sup>18</sup> reported that an extremely high intensity exercise intervention lasting 20 weeks resulted in a 12.5 kg weight loss in young men (aged 17-19 years). We suggest a dose-dependent relationship between AE intensity and weight loss.

### Resistance exercise interventions without calorie restriction

AE reduces fat mass but has little effect on maintenance of fat-free mass.<sup>19-22</sup> Resistance training (RT), which yields fat-free mass gain, increases resting energy expenditure.<sup>23-25</sup> However, studies on the effect of RT in weight loss are lacking. In 2008, Willis et al.<sup>26</sup>, in their randomized trial, reported the effects of aerobic and/or resistance exercise on body and fat mass. They compared the effects of AE, RT, and a combination of AE and RT (AE/RT) in weight loss and weight maintenance. Participants were randomized into three groups (AE, RT, and AE/RT), and the interventions were performed for 8 months. Significant weight loss was seen in both AE and AE/RT groups; in contrast, weight gain was seen in the RT group (Table 1). All groups had significant reductions in waist circumference and fat mass and significant increases in VO<sub>2</sub> max. The RT and AE/RT groups showed significant increases in fat-free mass and thigh muscle compared with the baseline. Only the RT group did not achieve weight loss. In another trial<sup>27</sup>, participants (mean body mass index [BMI] 31.4 kg/m<sup>2</sup>, mean age 22 years) were randomized into RT and control groups. After 12 weeks of intervention, the RT group had a mean body weight gain compared with the baseline (Table 1). The RT group participants also had in-

**Table 1.** Comparisons of the effects of exercise and physical activity in weight management

	Duration of intervention (month)	Weight change (%)	Waist (cm)	Body fat (%)	Lean mass (%)
AE without CR	6-12	2-3% ↓ (moderate intensity AE) >5% ↓ (high intensity AE)	↓	↓	
RT without CR	6-12	NC, ↑	↓	↓	↑
CR with PA	6-12	3-5% ↓ (moderate intensity interventions) >5% ↓ (high intensity interventions)	↓	↓	

AE, aerobic exercise; RT, resistance training; CR, calorie restriction; NC, no change; PA, physical activity.

creased muscle strength and fat-free mass and decreased total and trunk fat mass compared with the baseline. RT without calorie restriction improves body composition, but may not yield weight loss (Table 1). Moghadasi et al.<sup>28</sup> conducted a randomized trial to examine the effect of RT in obese men. Participants were randomized to RT or control groups. After 8 weeks of intervention, the RT group had improved body composition, but no weight loss. The RT group showed significant body fat loss and improvement in biomarkers related to glucose metabolism. In a systematic review on the effect of RT in obese populations, authors reported that RT alone does not cause significant weight loss, but RT with dietary calorie restriction may reduce weight by 4.775 kg.<sup>29</sup> In summary, RT without calorie restriction may not yield significant weight loss. However, RT, by improving body composition, results in many health benefits.

### Combined calorie restriction and physical activity interventions

Calorie restriction and exercise intervention are common strategies for weight loss in obese individuals. However, optimal lifestyle habits in interventions are debated. Calorie restriction can result in a negative energy balance and thus weight loss. Various diet regimens such as low-calorie and calorie-restricted diets and low-carbohydrate diets are used for weight loss. In general, in various diet and exercise studies, energy intake was 500 kcal or more less than estimated energy need and fat intake was less than 30% of total energy intake. Franz et al.<sup>30</sup> conducted a meta-analysis of randomized controlled trials including obese and overweight participants who underwent one of several weight loss interventions (diet alone, diet and exercise, exercise alone, meal replacements, very-low-energy diets, weight-loss medications, and advice alone). Pooled mean weight loss in the combined diet + exercise group was  $7.8 \pm 5.2$  kg. However, the mean weight loss was  $3.7 \pm 4.3$  kg in the diet-only control group.<sup>30</sup> In 2009, Wu et al.<sup>31</sup> conducted another meta-analysis which systematically reviewed the effect of 6-12 months combined diet + exercise interventions and diet-only interventions on weight loss in obese individuals. The combined diet + exercise intervention showed a greater long-term weight loss than the diet-only intervention. In a pooled analysis of 10 randomized trials, the diet-only intervention yielded a weight loss of 1.78 kg, while the diet + exercise combined intervention yielded a weight loss of 3.6

kg. However, partial weight regain was seen in both diet-only and diet + exercise groups. Because of weight regain, prolonged diet and exercise interventions may be important. In another study, a combined diet+exercise intervention resulted in greater weight loss than a diet-only intervention in obese postmenopausal women.<sup>32</sup> This study compared the effects of lifestyle interventions on body weight and composition in overweight to obese postmenopausal women; 439 participants were randomized into four groups (moderate to high intensity aerobic exercise, dietary calorie restriction, both interventions combined, and no lifestyle change). All intervention groups had significant weight losses. The mean weight loss in the diet group, exercise group, and diet + exercise groups was 7.1 kg, 2.0 kg, and 8.9 kg, respectively. Moreover, over a 1-year period, all interventions improved adiposity (Table 1), with greatest improvement seen in the diet + exercise intervention. In almost all studies, the diet + exercise combined intervention resulted in at least at 3-5% or higher weight loss (Table 1). The MONET study however showed contrasting results.<sup>33</sup> This study also targeted postmenopausal women ( $n = 173$ ). Participants were divided into two groups (only diet vs diet + RT). This study found equivalent weight loss between the groups. Depending on the type of exercise intervention, the effect on weight may differ. Unlike diet alone, exercise helps maintaining lean body mass, and this could have important implications in older individuals who are at increased risk of sarcopenia. Greater adherence to lifestyle intervention has been shown to reduce weight and improve body composition. Greater adherence to the exercise interventions in both the DPP and the Look AHEAD trials was associated with higher rates of achieving weight loss.<sup>34,35</sup> Alhassan et al.<sup>36</sup> reported that adherence to diet was a key correlate of weight loss across various diet regimens.

Nevertheless, the combined diet + exercise interventions were found to be superior to diet-only interventions in weight reduction. However, both diet-only and diet + exercise combined interventions are associated with long-term weight regain, and future trials should explore better interventions to limit weight regain and induce greater weight loss.

### Increasing physical activity in daily life

Due to westernization of diet and lack of physical activity, the prevalence of obesity is continuously increasing.<sup>37</sup> In order to im-

prove obesity, it is very important to reduce the amount of energy intake and increase the amount of energy expenditure, and it is very difficult for busy adults to exercise regularly. Therefore, we would like to introduce “Non Exercise Activity Thermogenesis” (NEAT) that can be induced energy consumption in daily life. Physical activity refers to all movements caused by skeletal muscles that cause energy consumption and it is classified into occupational physical activity and leisure physical activity. Exercise is a sub-concept of this physical activity and is included in leisure physical activity and it is defined as a structured activity that is planned and repeated.<sup>38</sup> The total daily energy expenditure of humans consists of basic metabolic rate (BMR), thermogenic effect of food (TEF), and activity thermogenesis (AT). BMR accounts for 60% of total daily energy expenditure, and TEF accounts for 10% of total daily energy expenditure. AT varies greatly between individuals, from about 15% for static individuals to 50% for dynamic individuals.<sup>39</sup> AT is divided into exercise activity thermogenesis (EAT) and NEAT. NEAT is energy consumed through physical activities such as sitting, standing, walking, speaking, and restlessness, which are unlike planned and structured EAT.<sup>40</sup> As a result of the analysis of the NEAT of obese and lean people, sitting time was 571 minutes for the obese people and longer than 407 minutes for the lean people. Walking time was shorter in obese people. It is 269-477 kcal per day converting the difference to calories. Therefore, it is assumed that the daily intake is maintained at the same level, and if the posture and the gait pattern of the lean people are applied to the obese people, additive energy consumption of about 350 kcal per day may occur and prevent body weight gain.<sup>41,42</sup> NEAT as moving the body, walking, climbing stairs was more than 100 times higher than energy expenditure of resting. In another study, the participants had to do dishes themselves, walk to work, walk up the stairs instead of the elevator, resulting in a consumption of about 120 kcal per day.<sup>43</sup> Increasing NEAT and lifestyle change will prevent further weight gain, even if there is not much weight loss. Increasing physical activity in daily life can be effective in managing weight as much as regular exercise.

### Effects on maintenance of weight loss of physical activity

Most obese individuals do not maintain weight loss for long periods.<sup>44,45</sup> Weight changes are affected by energy balance.<sup>46</sup> If the energy expenditure remains low, weight gain will occur. Several

studies have reported that declines in physical activity both in occupation and leisure may have an important role in the increase in obesity rates in the recent years.<sup>47,48</sup> Furthermore, many studies suggest that physical activity has an important role in weight gain.<sup>49,50</sup> High physical activity levels is inversely associated with cardiovascular disease, type 2 diabetes and all-cause mortality regardless of weight loss<sup>51,52</sup> and strongly associated with no weight regain over 1 year.<sup>53,54</sup> The American College of Sports Medicine recommended 200-300 min/week of moderate physical activity to prevent weight regain after weight loss.<sup>51</sup> Saris et al.<sup>55</sup> recommended that physical activity levels of 225-300 min/week were necessary to prevent the transition from normal weight to obese. The recommended physical activity time to prevent weight regain is more than the recommended time for improving health.<sup>51</sup> Hunter et al.<sup>56</sup> reported a randomized trial to evaluate the effect of exercise on weight loss maintenance. In this trial, 208 women (BMI range, 27 to 30 kg/m<sup>2</sup>) were recruited. During the weight loss phase, all subjects were instructed to remain on the 800 kcal/day diet until a BMI of < 25 kg/m<sup>2</sup> was achieved. In addition, the subjects were randomly assigned to three groups: AE with diet, RT with diet and diet only (non-exercise group). The subjects were followed-up after one year. Weight gain among the adherers in both the AE and RT groups was significantly less compared with that among the AE non-adherers, RT non-adherers and the non-exercise group. Weight gains among the adherers in the AE and RT groups were 3.1 kg and 3.9 kg, respectively. No significant differences were observed between the AE and RT groups. Weight gain in non-exercise group was 6.4 kg. In addition, in the AE and RT groups visceral fat did not significantly increase (< 0.8%) as compared with that in the non-exercise group (38%). This study suggests that the AE and RT interventions may prevent weight regain during weight maintenance phase and prevent regain of harmful visceral fat. Individuals who lose weight below expectations based on energy expenditure have been termed “weight compensator.” Several studies examined weight compensation after aerobic exercise training.<sup>57,58</sup> In a large exercise intervention trial among postmenopausal women, the difference between actual weight loss and predicted weight loss (compensation) increased with exercise dose.<sup>57</sup> Weight maintenance may be affected by weight compensation. This explains individual differences in weight loss or weight maintenance.

In summary, most obese individuals do not maintain the loss for long periods. The recommendations for physical activity to prevent weight regain after weight loss was 200-300 min/week of moderate physical activity. Not only AE but also RT may hinder weight regain during weight maintenance. In addition, we need to consider “weight compensation” to explain the individual differences in weight loss or weight maintenance.

## CONCLUSION

Our literature review suggests that AE interventions of 6-12 months without diet intervention yield a 2-3% loss in initial body weight and a dose-response relationship exists between AE intensity and weight loss. RT without dietary calorie restriction may not yield significant weight loss. However, RT improves body composition and thus yields many health benefits, and RT combined with a dietary calorie restriction can induce weight loss. The diet + exercise combined intervention is superior to diet-only interventions in inducing weight loss. However, most obese individuals do not maintain weight loss for long periods and both diet-only and diet + exercise combined interventions are associated with long-term weight regain. Moderate physical activity prevents weight regain after weight loss. Not only AE but also RT may hinder weight regain. Increasing physical activity in daily life can be effective in managing weight as much as regular exercise. Future trials should explore better interventions to limit weight regain and induce greater weight loss.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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