12 Weeks of Combined Exercise Is Better Than Aerobic Exercise for Increasing Growth Hormone in Middle-Aged Women

Dong-Il Seo, Tae-Won Jun, Kae-Soon Park, Hyukki Chang, Wi-Young So, and Wook Song

**Background:** The purpose of this study was to examine the effects of combined exercise training on growth hormone (GH), insulin-like growth factor-1 (IGF-1), and metabolic-syndrome factors and determine whether the changes in GH and/or IGF-1 induced by exercise correlate to the metabolic-syndrome factors in healthy middle-aged women (50–65 years of age). **Methods:** The participants were randomly assigned into an aerobic-exercise training (walking + aerobics) group (AEG; n = 7), a combined-exercise training (walking + resistance training) group (CEG; n = 8), or a control group (CG; n = 7). Exercise sessions were performed 3 times per wk for 12 wk. The aerobic-exercise training consisted of walking and aerobics at 60–80% of heart-rate reserve, and the combined-exercise training consisted of walking and resistance exercise at 50–70% of 1-repetition maximum. **Results:** GH, percentage body fat, fasting glucose, systolic blood pressure, and waist circumference were significantly improved in CEG (p < .05). However, GH induced by exercise training showed no correlation with metabolic-syndrome factors. IGF-1 was not significantly increased in either AEG or CEG compared with CG. **Conclusion:** These results indicate that the combined-exercise training produced more enhancement of GH, body composition, and metabolic-syndrome factors than did aerobic-exercise training. **Keywords:** growth hormone, insulin-like growth factor-1, metabolic syndrome

The aging process results in many adverse changes in body composition, muscle strength, health status, and, ultimately, functional capacity. These changes coincide with significant alterations in endocrine such as growth hormone (GH) and insulin-like growth factor-1 (IGF-1), and it may be associated with many of the symptoms of aging. The GH and IGF-1 axis plays an important role in the balance of normal insulin sensitivity and the development of insulin resistance and the development of insulin resistance (Johansson, Fowelin, Landin, Lager, & Bengtsson, 1995; Rowe & Kahn, 1985; Yuen & Dunger, 2007). GH deficiency and metabolic syndrome in adults share many features, with the central ones being abdominal obesity and insulin resistance (Johansson et al.). These similarities, along with the association of central adiposity with reduced GH secretion, have prompted several investigators to examine the potential of GH treatment in participants with metabolic syndrome (Yuen & Dunger).

Metabolic syndrome is a cluster of metabolic risk factors that comprises hyperglycemia, dyslipidemia, abdominal obesity, and hypertension (Grundy, 2004). The National Cholesterol Education Program’s Adult Treatment Panel III report defined metabolic syndrome as an aggregation of cardiovascular risk factors including low high-density-lipoprotein (HDL) cholesterol and high fasting glucose, triglycerides, waist circumference, and blood pressure (Ford, Giles, & Dietz, 2002; Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004). Metabolic syndrome is a strong risk factor for cardiovascular disease and Type 2 diabetes. Recent data from older American and Italian cohorts suggest that metabolic syndrome’s prevalence is higher in women than men (Maggi et al., 2006; Scuteri, Najjar, Morrell, & Lakatta, 2005). Women experience distinct changes in hormone levels with aging, particularly after menopause. A significant decline in muscle force has also been reported to occur after menopause, and there is evidence that this may be precipitated by hormonal factors (Phillips, Rook, Siddle, Bruce, & Woledge, 1993). In postmenopausal women, increased abdominal visceral fat is directly associated with higher fasting levels of glucose, cholesterol, and triglycerides and inversely related to HDL cholesterol levels. Moreover, abdominal fat is strongly related to insulin sensitivity and mean arterial blood pressure in older women. Previous studies have suggested that decreased insulin sensitivity is associated with increased features of metabolic syndrome in obese postmenopausal women and that visceral fat and fasting triglyceride accumulation might be potential mediators of this relationship (Karelis, Henry, St-Pierre, Prud’Homme, & Rabasa-Lhoret, 2006; Karelis et al., 2007). Recently, postmenopausal status was
reported to be associated with an increased risk of metabolic syndrome independent of normal aging in Korean women (Kim, Park, Ryu, & Kim, 2007).

The effects of GH therapy have been reported as improvements in body composition, bone density, cardiovascular risk factors, quality of life, and so forth (Kim, Chung, Lee, & Kim, 2006). Although series of reports on the increasing GH resulting from exercise are being published (Kanaley et al., 1997; Wideman, Weltman, Hartman, Veldhuis, & Weltman, 2002), evidence verifying the effects of increases in GH on metabolic-syndrome factors is lacking. In particular, no research has been published on whether combined-exercise training (aerobic and resistance exercise) is more effective than aerobic exercise in improving the metabolic-syndrome factors, as well as increasing levels of GH. As such, we thought it would be useful to conduct a study on the optimal exercise program for postmenopausal middle-aged women exposed to metabolic-syndrome factors. Therefore, the purpose of this research was to examine the effects of combined-exercise training on GH, IGF-1, and metabolic-syndrome factors for middle-aged women and to determine whether the changes in GH or IGF-1 induced by exercising correlate with metabolic-syndrome factors.

**Methods**

**Participants**

Untrained postmenopausal women (50–65 years of age) volunteered to participate in this study. Informed and written consent was obtained from all participants before the start of the study, and the institutional review board of the Institute of Sports Science of Seoul National University approved the study. The criteria for being healthy, in addition to subjective well-being, were a history of no diabetes or hypertension and no medical treatment for any disease during the past 2 years. Participants were defined as postmenopausal by the absence of menses for at least the last 2 years. All participants were nonsmokers, and none used hormone therapy. All participants were instructed to maintain their typical diet and activity pattern throughout the study, and compliance with this instruction was assessed via food-frequency and physical activity questionnaires administered at the beginning and end of the study. Anthropometric and blood parameters were assessed at the beginning and end of the study, as was body composition (via bioelectrical-impedance analysis in the fasted state).

**Experimental Protocol**

Participants were randomly assigned to one of three groups: an aerobic-exercise (walking + aerobics) training group (AEG; \( n = 7 \)), a combined-exercise (walking + resistance training) training group (CEG; \( n = 8 \)), and a control group (CG; \( n = 7 \)). CG was given a placebo program of flexibility exercise to be performed three times a week with supervision. All the groups completed pre- and posttraining assessments of all variables.

**Blood Glucose, HDL, and Triglycerides**

Blood samples were obtained in the morning after a 12-hr fast and collected into Vacutainer tubes EDTA. Plasma samples from the participants were packed in ice and sent to the NEODIN Medical Institute in Seoul. Serum triglyceride concentrations were determined by enzymatic methods using a Technicon RA-500 analyzer (Bayer, Tarrytown, NY, USA), and HDL cholesterol levels were assessed after precipitation of low-density-lipoprotein cholesterol in the infranatant by the heparin-manganese chloride method (Burstein & Sammaille, 1960). Plasma glucose was measured using an enzymatic technique (Richterich & Dauwalder, 1971).

**GH and IGF-1**

Serum GH concentrations were assessed by an immunometric assay (Immulite Analyzer, Diagnostic Products Corp., Los Angeles, CA, USA). The sensitivity of this method was 0.01 ng/ml, with intra- and interassay coefficients of variation (CV) being 5.2% and 5.9%, respectively (National Committee for Clinical Laboratory Standards, 1991). Serum IGF-1 level was determined by a commercial enzyme-linked immunosorbent assay (ELISA, Diagnostic Systems Laboratories, Texas, USA). The method had a sensitivity of 0.01 ng/ml and intra- and interassay CVs of 4.9% and 7.7%, respectively (Daughaday & Rotwein, 1989).

**Training Program**

The training groups consisted of the AEG and the CEG. AEG walked and did aerobic exercise (aerobics) 3 days/week for 12 weeks. The exercise intensity was 60–80% of heart-rate reserve. CEG walked and did resistance exercise in 30- to 40-min sessions consisting of three sets of eight exercises (seated chest press, lat pull-down, seated leg extension, leg curl, biceps curl, seated triceps extension, shoulder press, and sit-up) at 50–70% of one-repetition maximum. Each training session, including walking and resistance exercise, lasted an hour. Stretching was recommended before and after the exercise sessions for all participants. Heart-rate monitors (Polar Edge, Polar Electro, Kempele, Finland) and exercise diaries were used. All exercise sessions and exercise prescriptions were supervised by an exercise specialist and were conducted according to the guidelines of the American College of Sports Medicine (2005). All the participants were asked about their previous diet and daily exercise habits. This was checked with a questionnaire followed by an interview at the beginning and end of the intervention.
Statistical Analysis

Descriptive data are presented as means and standard deviations. One-way ANOVA was used to examine differences in participant characteristics between groups at baseline. The effects of the interventions on GH, IGF-1, and metabolic-syndrome factors were analyzed by means of repeated-measures ANOVA. Tukey's post hoc tests were used to identify significantly different means among treatments. Pearson's product–moment correlation was used to compare the correlation between the changes in growth hormones induced by exercising and the risk factors of metabolic syndrome. Statistical significance was set at $p < .05$, and all analyses were performed using SPSS version 12.0 software (SPSS, Inc., Chicago, IL, USA).

Results

The differences between groups were not statistically significant at baseline (Table 1). The groups were similar in age, height, body weight, and percentage body fat.

Table 2 shows the changes in body weight, body-mass index, and percentage body fat after the 12-week intervention. A main effect on time was found on body weight ($p < .05$), body-mass index, and percentage body fat ($p < .05$). An interaction effect between time and group on body weight, body-mass index, and percentage body fat was observed ($p < .05$). The changes in GH and IGF-1 levels after the intervention are demonstrated in Table 3. A main effect on time and group was observed on GH ($p < .05$). An interaction effect between time and group on GH was observed ($p < .05$). There were no main or interaction effects on IGF-1. In addition, Table 4 shows the changes in metabolic-syndrome factors after the 12-week intervention. A main effect of time was observed in waist circumference ($p < .05$) and HDL cholesterol ($p < .05$). An interaction effect between time and group on glucose was observed ($p < .05$). However, there were no main or interaction effects on systolic or diastolic blood pressure or triglycerides. Finally, the correlation of changes in GH, IGF-1, and metabolic-syndrome factors is shown in Table 5. After the exercise intervention, no significant correlations were found between changes in GH, IGF-1, and metabolic-syndrome factors.

Discussion

Our study focused on how 12 weeks of combined-exercise training influence changes in GH, IGF-1 secretion, and metabolic-syndrome factors in women 50–65 years of age. The release of GH is regulated by multiple factors including age, sex, nutritional status, sleep, and body composition and physiological factors such as insulin and IGF-1 (Hartman, 2000). However, the precise mechanism through which these factors influence GH secretion is difficult to evaluate because of their interactions.

### Table 1  Physical Characteristics for All Groups, $M \pm SD$

<table>
<thead>
<tr>
<th></th>
<th>AEG ($n = 7$)</th>
<th>CEG ($n = 8$)</th>
<th>CG ($n = 7$)</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>55 ± 4.8</td>
<td>54 ± 3.6</td>
<td>58 ± 4.2</td>
<td>NS (.273)</td>
</tr>
<tr>
<td>Height, cm</td>
<td>157.4 ± 5.9</td>
<td>157.5 ± 5.7</td>
<td>155.7 ± 6.8</td>
<td>NS (.823)</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>68.3 ± 12.9</td>
<td>59.8 ± 7.7</td>
<td>58.2 ± 7.1</td>
<td>NS (.128)</td>
</tr>
<tr>
<td>Fat, %</td>
<td>33.6 ± 3.8</td>
<td>31.7 ± 3.0</td>
<td>31.0 ± 3.1</td>
<td>NS (.315)</td>
</tr>
</tbody>
</table>

*Note. AEG = aerobic-exercise group; CEG = combined-exercise group; CG = control group; NS = not significant.*

### Table 2  Changes in Body Weight, Body-Mass Index, and Body Fat After a 12-Week Exercise Intervention, $M \pm SD$

<table>
<thead>
<tr>
<th></th>
<th>Aerobic Exercise Pre</th>
<th>Post</th>
<th>Combined Exercise Pre</th>
<th>Post</th>
<th>Control Group Pre</th>
<th>Post</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight, kg</td>
<td>68.3 ± 12.9</td>
<td>66.9 ± 12.8</td>
<td>59.8 ± 7.7</td>
<td>59.2 ± 7.1</td>
<td>58.2 ± 7.1</td>
<td>58.6 ± 7.3</td>
<td>a*, c*</td>
</tr>
<tr>
<td>Body-mass index, kg/m²</td>
<td>27.4 ± 3.4</td>
<td>26.8 ± 3.3</td>
<td>24.0 ± 1.9</td>
<td>23.8 ± 1.7</td>
<td>24.0 ± 2.6</td>
<td>24.2 ± 2.7</td>
<td>a*, c*</td>
</tr>
<tr>
<td>Body fat, %</td>
<td>33.6 ± 3.8</td>
<td>32.8 ± 3.5</td>
<td>31.7 ± 3.0</td>
<td>30.4 ± 3.1</td>
<td>31.0 ± 3.1</td>
<td>31.6 ± 2.8</td>
<td>a*, c*</td>
</tr>
</tbody>
</table>

*Note. a = time; b = group; c = Time × Group.  
*a* $p < .05$. 

Table 3  Changes in Growth Hormone and Insulin-like Growth Factor-1 After a 12-Week Exercise Intervention, $M \pm SD$

<table>
<thead>
<tr>
<th></th>
<th>Aerobic Exercise</th>
<th>Combined Exercise</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Post</td>
<td>Pre Post</td>
<td>Pre Post</td>
</tr>
<tr>
<td>Growth hormone, ng/ml</td>
<td>1.1 ± 0.4</td>
<td>1.6 ± 0.7</td>
<td>2.4 ± 1.5</td>
</tr>
<tr>
<td>Insulin-like growth factor-1, ng/ml</td>
<td>311.7 ± 97.7</td>
<td>350.4 ± 139.2</td>
<td>336.5 ± 79.8</td>
</tr>
</tbody>
</table>

Note. a = time; b = group; c = Time × Group; NS = not significant.
*p < .05. #Significant difference compared with CG with post hoc test.

Table 4 Changes in Metabolic-Syndrome Factors After a 12-Week Exercise Intervention, $M \pm SD$

<table>
<thead>
<tr>
<th></th>
<th>Aerobic Exercise</th>
<th>Combined Exercise</th>
<th>Control Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre Post</td>
<td>Pre Post</td>
<td>Pre Post</td>
</tr>
<tr>
<td>WC, cm</td>
<td>87.9 ± 8.6</td>
<td>84.7 ± 7.9</td>
<td>81.9 ± 4.7</td>
</tr>
<tr>
<td>SBP, mm Hg</td>
<td>136.4 ± 19.6</td>
<td>138.4 ± 12.9</td>
<td>126.5 ± 14.4</td>
</tr>
<tr>
<td>DBP, mm Hg</td>
<td>94.1 ± 17.8</td>
<td>94.7 ± 13.7</td>
<td>86.5 ± 11.7</td>
</tr>
<tr>
<td>TG, mg/dl</td>
<td>94.7 ± 48.0</td>
<td>92.8 ± 45.6</td>
<td>95.3 ± 21.8</td>
</tr>
<tr>
<td>HDL-C, mg/dl</td>
<td>60.6 ± 14.2</td>
<td>62.4 ± 14.5</td>
<td>57.6 ± 10.6</td>
</tr>
<tr>
<td>Glucose, mmol/L</td>
<td>4.9 ± 0.6</td>
<td>5.1 ± 0.7</td>
<td>5.0 ± 0.4</td>
</tr>
</tbody>
</table>

Note. WC = waist circumference; SBP = systolic blood pressure; DBP = diastolic blood pressure; TG = triglycerides; HDL-C = high-density-lipoprotein cholesterol; a = time; c = Time × Group; NS = not significant.

Table 5 Correlations of Changes in Growth Hormone (GH), Insulin-like Growth Factor-1 (IGF-1), and Metabolic-Syndrome Factors

<table>
<thead>
<tr>
<th>Variable</th>
<th>Δ GH</th>
<th>Δ FG</th>
<th>Δ SBP</th>
<th>Δ DBP</th>
<th>Δ HDL-C</th>
<th>Δ TG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Δ GH</td>
<td>.157</td>
<td>-.300</td>
<td>-.008</td>
<td>.078</td>
<td>-.351</td>
<td>-.040</td>
</tr>
<tr>
<td>Δ IGF-1</td>
<td>-.021</td>
<td>-.383</td>
<td>-.536</td>
<td>-.398</td>
<td>-.067</td>
<td>.155</td>
</tr>
</tbody>
</table>

Note. Δ = change; WC = waist circumference; FG = fasting glucose; SBP = systolic blood pressure; DBP = diastolic blood pressure; HDL-C = high-density-lipoprotein cholesterol; TG = triglycerides.

middle-aged people, there is a tendency of physiological decline in GH secretion, which leads to several clinical and laboratorial characteristics similar to those found in GH-deficient adults. Our results indicate that factors such as time and group were associated with GH secretion after 12 weeks of exercise training, and CEG showed increases in GH greater than those of AEG.

A number of previous studies have reported on the response of GH to resistance exercise. Craig, Brown, and Everhart (1989) reported that their older age group showed increased GH, although a greater increase in GH was found in their young age group. Hakkinen, Pakarinen, Kraemer, Newton, and Alen (2000) compared a group of middle-aged women with a group of older age women and found that the older women did not show increases in GH, whereas the middle-aged group did. Pyka, Wiswell, and Marcus (1992) reported a decrease in GH in an older age group that performed resistance exercise, whereas Hakkinen and Pakarinen (1995) reported that only their young age group showed elevations in GH compared with an older age group showing no significant elevation of GH after resistance exercise. With the previous studies and our current study, it appears that exercise during middle age (just before reaching old age) can positively increase the secretion of GH. It is likely that combined exercise including aerobic exercise and resistance exercise is the ideal method of exercise for this purpose.

Both AEG and CEG showed small effects such as increases in IGF-1, but these changes were not statistically significant. This result is in agreement with a review article by Copeland, Consitt, and Tremblay (2002), who found no changes in serum IGF-1 in women after resistance exercise. It is contrary to the study conducted by Kraemer, Gordon, and Fleck (1991), who reported...
that females showed increases in IGF-1 after resistance exercise. It has been reported that increases in IGF-1 are induced by increases in GH receptors (Adams, 1998). Regeneration and hypertrophy of muscle fibers also play major roles in increasing IGF-1 levels after exercise. Because the mechanism in which IGF-1 functions autocrine and paracrine in muscle supports the notion that anabolic activity enhancement would happen regardless of changes in serum IGF-1, the current results suggest that combined exercise including resistance exercise can affect changes in GH and the anabolic mechanism in muscle layers among middle-aged women, even if increases in IGF-1 are not statistically significant.

In this study, we found that body weight declined significantly over time, mostly in AEG. In addition, there was a tendency for percentage body fat to decrease after exercise training in both AEG and CEG. It is certain that resistance exercise and aerobic exercise have positive effects on changes in body composition in middle-aged women, which is supported by our results. Especially in CEG, it is likely that fat metabolism could be increased and density of muscle possibly induced by protein-synthesis facilitation (Sartorio et al., 2004), in spite of lesser decreases of body weight than those seen in AEG. With the recent rise in studies of risk factors for metabolic disease and exercising training, variant findings related to forms, intensity (strength), period, frequency of exercise, age, and sex of participants have been reported (Johnson, Slentz, & Houmard, 2007). Green, Stanforth, and Rankinen (2004) reported that 30 min of daily aerobic-exercise training at 55% of maximum oxygen consumption, conducted three times a week for 20 weeks, did not improve metabolic-syndrome risk factors in middle-aged menopausal women. Our data demonstrate that there was no correlated effect on waist circumference, blood pressure, triglycerides, or HDL cholesterol and only showed an effect on fasting glucose according to time and group. In particular, fasting glucose levels noticeably decreased in a time-dependent manner. These findings were in agreement with some previous reports that resistance exercise played a role in elevating insulin sensitivity and glucose regulation (Castaneda, Layne, & Munoz-Orians, 2002; Dunstan, Daly, & Owen, 2002; Ishii, Yamakita, Sato, Tanaka, & Fuji, 1998). Fasting glucose, a metabolic-syndrome factor, has a close relationship with insulin resistance. Namely, elevated insulin resistance lowers glucose utilization (McLaughlin et al., 2003), and high levels of glucose then result in increased morbidity in the form of insulin-independent (Type 2) diabetes mellitus and cardiovascular disease (Cefalu, Werbel, & Bell-Farrow, 1998). Accordingly, although not all metabolic-syndrome factors were successfully controlled in this study, it appears that combined exercise including resistance exercise can help decrease fasting glucose in middle-aged women; this partly supports the effectiveness of exercise in preventing metabolic disease.

Our results showed that increases in GH and IGF-1 immediately after exercise were not significantly correlated. In addition, there were no significant correlations between changes in GH, IGF-1, and metabolic-syndrome factors after the exercise intervention. Taken together, these data suggest that combined-exercise training enhanced GH, body composition, and metabolic-syndrome factors more than aerobic-exercise training did, even in middle-aged menopausal woman.

Acknowledgments

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References


