# Muscular resistance training using applied pressure and its effects on the promotion of growth hormone secretion

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## Abstract

***Objective:*** We compared the effects of resistance training with and without pressure applied to the muscles on the secretion of growth hormone, insulin-like growth factor - I (IGF - I), and serum levels of lactic acid and free fatty acids.
***Methods:*** Ten volunteers were divided into 2 groups who underwent 15 - minute resistance exercise: the AP group used a device to apply pressure to the proximal part of both upper arms and the proximal part of both thighs (AP group) and the control group exercised without the device. The subjects' background factors and physical and mental status were determined by questionnaire, and laboratory blood tests were conducted 15 minutes before exercise, immediately after exercise (0 minutes), then at 15 minutes, 60 minutes, and 120 minutes.
***Results:*** The AP group had significantly greater secretion of growth hormone at 15 minutes after exercise compared to the control group, which actually had a decrease in growth hormone secretion. The serum lactic acid level was significantly higher in the AP group 15 minutes after exercise compared to values in the control group. The AP group had a significant rise in serum free fatty acid levels at 60 and 120 minutes after exercise, while no significant change was observed in the control group. No significant differences in mental symptoms were seen between the 2 groups; the control group reported more dyspnea.
***Conclusions:*** Resistance training using applied pressure induces the production of lactic acid and the secretion of growth hormones, and causes serum free fatty acid levels to rise.

**Key words:** anti-aging medicine, exercise therapy, lactic acid, free fatty acids

## Introduction

The purpose of anti-aging medicine is not simply to prolong life but to prevent the physical and mental deterioration caused by aging, and as a result to maintain a high quality of life (QOL).[1] From an anti-aging perspective, exercise is significant in that it maintains muscular volume, cardiopulmonary capability, and QOL through stress management. Another important result of exercise is the promotion of the secretion of growth hormones from the pituitary gland.[1] In the field of sports medicine, a variety of training methods are being developed with the aim of promoting the efficient secretion of growth hormones.

In this study, we focused on exercise therapy in healthy subjects using a training aid product that applies appropriate pressure to the muscles (KAATS,® manufacturer: Phoenix K.K. ,Tokyo,Japan),[2-4] and compared its effects on the secretion of insulin-like growth factor - I (IGF - I), lactic

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acid, and free fatty acids with those of conventional resistance training.

## Materials and Methods

The subjects in our study were healthy volunteers aged from 30 to 40 years old with no serious illnesses or subjective symptoms, who gave their consent to participate in this study. There were 20 subjects (10 men and 10 women). Their mean age was 38.4 ± 5.1 years, height was 165.6 ± 9.2 cm, weight was 63.0 ± 16.0 kg, and body fat percentage was 25.0% ± 4.1%.

Ten subjects each (5 men and 5 women) were divided into 2 groups: those who used the applied pressure device (AP group) and the control group. The AP group underwent a 15-minute resistance exercise by wearing the device and having a set pressure applied, via a rubber belt, to the proximal part of both upper arms and the proximal part of both thighs. The pressure was applied to both arms and legs simultaneously. The pressure was adjusted to 80mmHg in arms and 100 mmHg in legs. A sports trainer provided instructions on the use of the applied pressure device to the AP group. The control group underwent similar resistance exercises for 15 minutes without having pressure applied to their muscles. The exercises were performed in a group as indicated in written instructions under the supervision of the trainer (time keeper). These tests were conducted on February 11, 2004. The study design is shown in Figure 1.

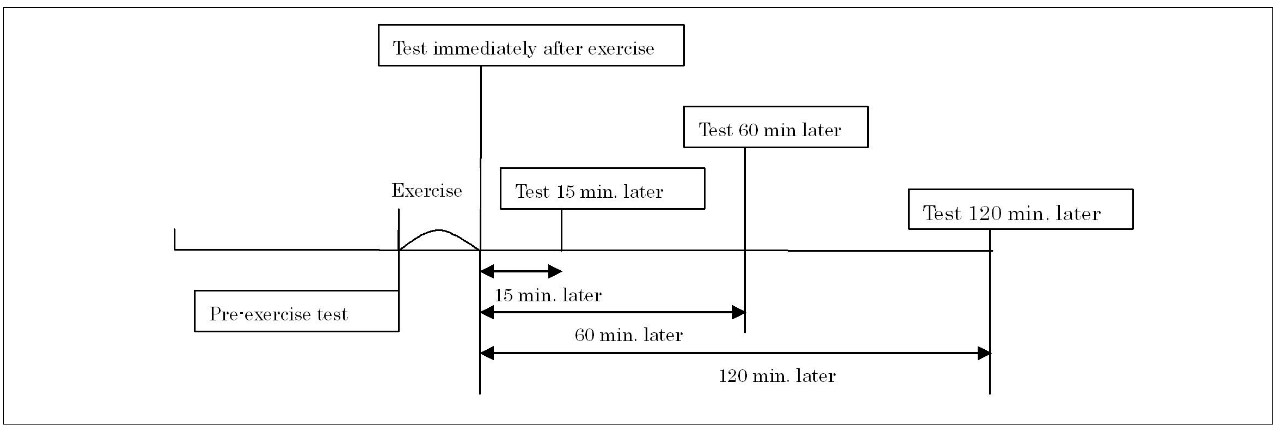


**Figure 1.** Study design.

Before the exercise, The subjects' background factors, such as sex, age, height, weight, occupation, and presence of past illness or complications were entered in the Anti-Aging QOL Common Questionnaire: (AAQol),[5-7] from which their condition was evaluated (Tables 1 through 3). The subject's physical and mental status was evaluated based on a symptom score derived from the AAQoL. This questionnaire uses an ordinal scale with the following values: 1 = none at all; 2 = almost none; 3 = slightly; 4 = moderately; 5 = severely.

Blood tests were performed 5 times: 15 minutes before exercise, immediately after exercise (0 minutes), then 15 minutes, 60 minutes, and 120 minutes. The setting of these time periods was based on the fact that, in preliminary experiments, the levels of growth hormones, lactic acid, and free fatty acids after exercise peaked at 15 minutes, 0 minutes (immediately after exercise), and 120 minutes after exercise, respectively. Pre-exercise examination items included peripheral blood tests, glutamic-oxaloacetic transaminase; glutamic-pyruvic transaminase; gamma-glutamyltranspeptidase alkaline phosphatase, blood urea nitrogen, creatinine, uric acid, total cholesterol, triglycerides, electrolytes (sodium [Na+], potassium [K+], and chlorine [Cl-]), blood glucose, lactic acid, free fatty acids, glycosylated hemoglobin, insulin-like growth factor-I (IGF-I); somatomedin C, dehydroepiandrosterone sulfate (DHEA-s), and thyroid hormones (TSH, free T3, and free T4) cortisol values. Some of these items were measured over time. None of the subjects withdrew from the study.

The t-test, rank sum test, one way analysis of variances (ANOVA), or Kruskal-Wallis ANOVA was used to statistically analyze the findings from the survey and laboratory testing. The standard correlation analysis was also performed. The results were shown in terms of mean ± standard deviation, and a probability value of less than .05 was considered to be significant.

**Table 1.** Physical symptom questionnaire.

Please tell us what your symptoms are.

**( 1 None at all 2 Almost none 3 Slightly 4 Moderately 5 severely )**

| **Physical symptoms** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Tired eyes | □ | □ | □ | □ | □ |
| Blurry eyes | □ | □ | □ | □ | □ |
| Eye pain | □ | □ | □ | □ | □ |
| Stiff shoulders | □ | □ | □ | □ | □ |
| Muscular pain / stiffness | □ | □ | □ | □ | □ |
| Palpitations | □ | □ | □ | □ | □ |
| Dyspnea | □ | □ | □ | □ | □ |
| Tendency to gain weight | □ | □ | □ | □ | □ |
| Weight loss; thin | □ | □ | □ | □ | □ |
| Lethargy | □ | □ | □ | □ | □ |
| No feeling of good health | □ | □ | □ | □ | □ |
| Thirst | □ | □ | □ | □ | □ |
| Skin problems | □ | □ | □ | □ | □ |
| Anorexia | □ | □ | □ | □ | □ |
| Early satiety | □ | □ | □ | □ | □ |
| Epigastralgia | □ | □ | □ | □ | □ |
| Liable to catch colds | □ | □ | □ | □ | □ |
| Coughing and sputum | □ | □ | □ | □ | □ |
| Diarrhea | □ | □ | □ | □ | □ |
| Constipation | □ | □ | □ | □ | □ |
| Headache | □ | □ | □ | □ | □ |
| Dizziness | □ | □ | □ | □ | □ |
| Tinnitus | □ | □ | □ | □ | □ |
| Lumbago | □ | □ | □ | □ | □ |
| Arthralgia | □ | □ | □ | □ | □ |
| Edematous | □ | □ | □ | □ | □ |
| Easily breaking into a sweat | □ | □ | □ | □ | □ |
| Frequent urination | □ | □ | □ | □ | □ |
| Hot flash | □ | □ | □ | □ | □ |
| Excessive sensitivity to cold | □ | □ | □ | □ | □ |
| Others ( ) | □ | □ | □ | □ | □ |

**Table 2.** Mental symptom questionnaire.

**( 1 None at all 2 Almost none 3 Slightly 4 Moderately 5 severely )**

| **Physical symptoms** | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Irritability | □ | □ | □ | □ | □ |
| Easily angered / short-tempered | □ | □ | □ | □ | □ |
| Loss of motivation | □ | □ | □ | □ | □ |
| No feeling of happiness | □ | □ | □ | □ | □ |
| Nothing to look forward in life | □ | □ | □ | □ | □ |
| Daily life is not enjoyable | □ | □ | □ | □ | □ |
| Loss of confidence | □ | □ | □ | □ | □ |

| | | | | | |
|---|---|---|---|---|---|
| Reluctance to talk with others | □ | □ | □ | □ | □ |
| Depressed | □ | □ | □ | □ | □ |
| A feeling of uselessness | □ | □ | □ | □ | □ |
| Shallow sleep | □ | □ | □ | □ | □ |
| Difficulty falling asleep | □ | □ | □ | □ | □ |
| Pessimism | □ | □ | □ | □ | □ |
| Lapse of memory | □ | □ | □ | □ | □ |
| Inability to concentrate | □ | □ | □ | □ | □ |
| Inability to solve problems | □ | □ | □ | □ | □ |
| Inability to make judgments readily | □ | □ | □ | □ | □ |
| Inability to sleep because of worries | □ | □ | □ | □ | □ |
| A sense of tension | □ | □ | □ | □ | □ |
| Feeling of anxiety for no special reason | □ | □ | □ | □ | □ |
| Vague feeling of fear | □ | □ | □ | □ | □ |
| Others (                    ) | | | | | |

## Results

### Background factors

Table 3 shows the background factors as well as the pre-exercise data of the subjects in the AP group and the control group. Concerning lifestyle habits such as smoking, drinking alcohol, and exercise, the number of cigarettes smoked was significantly higher in the control group (AP group: 3.0 ± 6.7 cigarettes/day versus control group: 11.5 ± 10.0 cigarettes / day). No significant differences were seen between the 2 groups in other items. Tables 4 and 5 show the results of the investigation into physical and mental symptoms, based on the Anti-Aging QOL Common Questionnaire. Of the physical symptoms, only dyspnea occurred slightly more often in the control group than in the AP group ($P$ = .0344). No significant differences were seen between the 2 groups in terms of their mental symptoms.

**Table 3.** Analysis of background factors in study participants.

| Variable | Unit | AP | Control | $P$ value |
|---|---|---|---|---|
| Smoking | Cig./day | 3.0 ± 6.7 | 11.5 ± 10.0 | 0.0390[†] |
| Drinking<br>(in terms of sake) | Go/day x<br>day/week | 1.8 ± 2.5 | 3.2 ± 4.7 | 0.0810 |
| Exercise | Times/week | 2.1 ± 2.6 | 0.5 ± 0.7 | 0.0810 |
| Height | Cm | 165.6 ± 10.5 | 165.7 ± 8.3 | 0.9739 |
| Weight | kg | 64.1 ± 16.6 | 62.0 ± 16.2 | 0.7808 |
| BMI | | 23.0 ± 3.1 | 22.3 ± 4.0 | 0.6598 |
| Body fat % | % | 25.9 ± 3.1 | 24.1 ± 4.8 | 0.3440 |
| Systolic BP | mmHg | 134.5 ± 22.7 | 132.2 ± 16.2 | 0.7973 |
| Diastolic BP | mmHg | 86.3 ± 12.1 | 80.2 ± 11.6 | 0.2650 |
| Fasting blood sugar | mg/dl | 95.9 ± 3.3 | 93.0 ± 15.2 | 0.5619 |
| Lactic acid | mg/dl | 1.06 ± 0.36 | 1.13 ± 0.31 | 0.6463 |
| Free fatty acids | mEq/L | 0.56 ± 0.20 | 0.55 ± 0.23 | 0.9099 |
| HbA1c | mg/dl | 4.89 ± 0.26 | 4.79 ± 0.44 | 0.5444 |
| Growth hormone | ng/ml | 4.28 ± 6.99 | 6.44 ± 7.44 | 0.5119 |
| IGF-1 | ng/ml | 193.9 ± 42.1 | 188.6 ± 67.2 | 0.8374 |
| Cortisol | μgdl | 18.0 ± 5.6 | 17.5 ± 5.8 | 0.8504 |

| | | | | |
|---|---|---|---|---|
| DHEA-s | ng/ml | 1801.7 ± 505.9 | 2426.5 ± 1572.1 | 0.2471 |
| TSH | μgIU/ml | 1.79 ± 1.13 | 1.59 ± 0.83 | 0.6574 |
| free T4 | ng/dl | 0.88 ± 0.13 | 0.99 ± 0.16 | 0.1102 |
| free T3 | pg/ml | 1.38 ± 0.23 | 1.28 ± 0.26 | 0.4726 |

BMI, body mass index; BP, blood pressure; IGF-I, insulin-like growth factor-I; HbA1c, glycosylated hemoglobin; TSH, thyroid stimulating hormone; T3, T4, thyroid hormones; DHEA-s, dehydroepiandrosterone sulfate. "One Go" means 180 ml of Sake.

n = 10, mean ± SD, *t*-test.

**Effects of muscle resistance training**

Subjects in the AP group had a rise in serum growth hormone levels from 4.28 ± 6.99 ng/ml before exercise to 8.82 ± 5.94 ng/ml 15 minutes after finishing resistance training (Table 6). In contrast, subjects in the control group had a decrease in serum growth hormone levels from 6.44 ± 7.44 ng/ml before training to 4.50 ± 8.04 ng/ml 15 minutes after finishing resistance exercises. We examined the rate vis- à -vis the pre-exercise values, and found that the AP group showed significantly greater reactive secretion of growth hormones than the control group ($P = 0.0449$).

The serum lactic acid level before and after exercise changed in the AP group from 1.06 ± 0.36 mg/dl before exercise to 2.91 ± 1.55 mg/dl immediately after exercise and 2.14 ± 0.87 mg/dl 15 minutes after exercise, while that of the control group changed from 1.13 ± 0.31 mg/dl before exercise to 2.78 ± 0.99 mg/dl immediately after exercise and 1.58 ± 0.68 mg/dl 15 minutes after exercise (Table 6). Although the level 15 minutes after exercise had risen significantly over the pre-exercise level in the AP group, no significant differences were seen in the control group. We examined the rate vis- à -vis the pre-exercise value and found that the AP group had a significantly higher value of lactic acid 15 minutes after completion of exercise than the control group ($P = 0.0259$).

The serum free fatty acid levels before and after exercise changed in the AP group from 0.56 ± 0.20 mEq/L before exercise to 0.62 ± 0.26 mEq/L 60 minutes after exercise and 0.78 ± 0.30 mEq/L 120 minutes after exercise (Table 6). The levels of the AP group 60 and 120 minutes after exercise were both significantly higher than the pre-exercise levels ($P < 0.01$). The level changed in the control group, from 0.55 ± 0.23 mEq/L before exercise to 0.58 ± 0.23 mEq/L 60 minutes after exercise and 0.67 ± 0.22 mEq/L 120 minutes after exercise. No significant rise in free fatty acid levels was seen in the control group. Similarly, a comparison between the AP group and the control group showed no significant differences in free fatty acid levels ($P = 0.3750$).

The serum IGF-I level before and after exercise changed in the AP group from 193.9 ± 42.1 ng/ml before exercise to 195.1 ± 58.9 ng/ml 60 minutes after exercise and 189.2 ± 43.4 ng/ml 120 minutes after exercise (Table 6). The level changed in the control group, from 188.6 ± 67.2 ng/ml before exercise to 185.6 ± 76.4 ng/ml 60 minutes after exercise and 181.7 ± 60.9 ng/ml 120 minutes after exercise. No significant changes in IGF-I were seen in either the AP group or the control group.

Figure 2 shows levels of growth hormone, lactic acid, and free fatty acids before and after muscle stress training. No adverse reactions or events were seen in either the AP group or the control group throughout the course of stress training.

**Table 4.** Scores from the physical symptom questionnaire

| Symptoms | AP | Control | *P* value |
|---|---|---|---|
| Tired eyes | 2.4 ± 0.7 | 2.9 ± 0.9 | 0.1753 |
| Blurry eyes | 2.0 ± 0.8 | 2.2 ± 0.9 | 0.6132 |
| Eye pain | 1.5 ± 0.5 | 1.7 ± 0.5 | 0.3880 |
| Stiff shoulders | 3.1 ± 1.3 | 2.4 ± 1.2 | 0.2199 |
| Muscular pain/stiffness | 2.4 ± 0.7 | 2.2 ± 1.0 | 0.6182 |
| Palpitations | 1.5 ± 0.5 | 1.9 ± 0.7 | 0.1800 |

| | | | |
|---|---|---|---|
| Dyspnea | 1.3 ± 0.5 | 2.1 ± 1.0 | 0.0344[†] |
| Tendency to gain weight | 2.7 ± 0.9 | 2.5 ± 1.1 | 0.6652 |
| Weight loss; thin | 1.4 ± 0.7 | 2.1 ± 1.1 | 0.1068 |
| Lethargy | 2.0 ± 0.5 | 2.3 ± 0.8 | 0.3306 |
| No feeling of good health | 1.9 ± 0.3 | 2.1 ± 1.0 | 0.5520 |
| Thirst | 2.0 ± 0.7 | 2.1 ± 1.0 | 0.7947 |
| Skin problems | 2.2 ± 1.2 | 2.4 ± 1.2 | 0.6410 |
| Anorexia | 1.7 ± 0.5 | 1.3 ± 0.5 | 0.0806 |
| Early satiety | 1.6 ± 0.8 | 2.0 ± 0.8 | 0.2546 |
| Epigastralgia | 1.8 ± 0.7 | 1.6 ± 0.7 | 0.5560 |
| Liable to catch colds | 1.9 ± 0.6 | 2.2 ± 0.6 | 0.2790 |
| Coughing and sputum | 2.1 ± 0.8 | 2.2 ± 0.8 | 0.7730 |
| Diarrhea | 1.7 ± 0.7 | 2.2 ± 0.8 | 0.1451 |
| Constipation | 1.9 ± 0.9 | 1.9 ± 1.3 | 0.9999 |
| Headache | 1.9 ± 0.9 | 1.8 ± 0.6 | 0.7730 |
| Dizziness | 1.3 ± 0.5 | 1.6 ± 0.7 | 0.2790 |
| Tinnitus | 1.4 ± 0.5 | 1.6 ± 0.5 | 0.3979 |
| Lumbago | 2.4 ± 1.0 | 2.1 ± 0.7 | 0.4453 |
| Arthralgia | 1.7 ± 0.8 | 1.7 ± 0.7 | 0.9999 |
| Edematous | 1.5 ± 0.7 | 1.8 ± 0.8 | 0.3823 |
| Easily breaking into a sweat | 2.0 ± 1.3 | 2.3 ± 1.3 | 0.6215 |
| Polakisuria | 1.9 ± 0.7 | 1.7 ± 0.7 | 0.5350 |
| Hot flash | 1.5 ± 0.7 | 1.8 ± 0.9 | 0.4240 |
| Excessive sensitivity to cold | 2.0 ± 0.9 | 2.1 ± 1.1 | 0.8297 |

This questionnaire uses an ordinal scale with the following values: 1 = none at all; 2 = almost none; 3 = slightly; 4 = moderately; 5 = severely.

n = 10, mean ± SD, *t*-test

**Table 5.** Scores from the mental symptom questionnaire.

| Symptom | AP | Control | *P* value |
|---|---|---|---|
| Irritability | 2.7 ± 0.8 | 2.5 ± 1.1 | 0.6470 |
| Easily angered | 2.9 ± 0.7 | 2.3 ± 0.8 | 0.1033 |
| Loss of motivation | 1.9 ± 0.6 | 2.1 ± 0.9 | 0.5520 |
| No feeling of happiness | 1.8 ± 0.6 | 1.5 ± 0.5 | 0.2643 |
| Nothing to look forward in life | 1.7 ± 0.7 | 1.4 ± 0.5 | 0.2790 |
| Daily life is not enjoyable | 2.0 ± 0.8 | 1.7 ± 0.5 | 0.3306 |
| Loss of confidence | 1.9 ± 0.6 | 1.8 ± 0.4 | 0.6601 |
| Reluctance to talk with others | 1.5 ± 0.7 | 2.1 ± 1.2 | 0.1892 |
| Depressed | 1.6 ± 0.7 | 1.5 ± 0.5 | 0.7222 |
| A sense of uselessness | 1.7 ± 0.7 | 1.9 ± 0.6 | 0.4825 |
| Shallow sleep | 1.3 ± 0.7 | 2.2 ± 1.2 | 0.0575 |
| Difficulty falling asleep | 1.3 ± 0.7 | 2.1 ± 1.2 | 0.0822 |
| Pessimism | 2.0 ± 0.7 | 2.1 ± 1.2 | 0.8201 |
| Lapse of memory | 2.6 ± 0.7 | 2.8 ± 1.0 | 0.6182 |
| Inability to concentrate | 2.1 ± 0.6 | 2.2 ± 0.6 | 0.7142 |
| Inability to solve problems | 2.1 ± 0.6 | 2.1 ± 0.7 | 0.9999 |
| Inability to make judgments readily | 2.0 ± 0.7 | 2.3 ± 0.8 | 0.3823 |
| Inability to sleep because of worries | 1.6 ± 0.7 | 1.8 ± 0.6 | 0.5109 |

| | | | |
|---|---|---|---|
| A sense of tension | 2.2 ± 0.8 | 2.2 ± 0.9 | 0.9999 |
| Feeling of anxiety for no special reason | 1.6 ± 0.4 | 1.8 ± 0.4 | 0.3553 |
| A vague feeling of fear | 1.4 ± 0.5 | 1.5 ± 0.5 | 0.6733 |

This questionnaire uses an ordinal scale with the following values: 1 = none at all; 2 = almost none; 3 = slightly; 4 = moderately; 5 = severely.

n = 10, mean ± SD, *t*-test.

**Table 6.** Changes in measured variables over time.

| Variable | Unit | AP | Control | *P* value |
|---|---|---|---|---|
| **Growth hormones** | | | | |
| Pre-exercise value | ng/ml | 4.28 ± 6.99 | 6.44 ± 7.44 | |
| 15 min. after exercise | ng/ml | 8.82 ± 5.94 | 4.50 ± 8.04 | 0.0449 |
| **Lactic acid** | | | | |
| Pre-exercise value | mg/dl | 1.06 ± 0.36 | 1.13 ± 0.31 | |
| Right after exercise | mg/dl | 2.91 ± 1.55‡ | 2.78 ± 0.99‡ | 0.8254 |
| 15 min. after exercise | mg/dl | 2.14 ± 0.87‡ | 1.58 ± 0.68 | 0.0259 |
| **IGF-I** | | | | |
| Pre-exercise value | ng/ml | 193.9 ± 42.1 | 188.6 ± 67.2 | |
| 60 min. after exercise | ng/ml | 195.1 ± 58.9 | 185.6 ± 76.4 | 0.7586 |
| 120 min. after exercise | ng/ml | 189.2 ± 43.4 | 181.7 ± 60.9 | 0.7548 |
| **Free fatty acid** | | | | |
| Pre-exercise value | mEq/L | 0.56 ± 0.20 | 0.55 ± 0.23 | |
| 60 min. after exercise | mEq/L | 0.62 ± 0.26‡ | 0.58 ± 0.23 | 0.7334 |
| 120 min. after exercise | mEq/L | 0.78 ± 0.30‡ | 0.67 ± 0.22 | 0.3750 |

n = 10, mean ± SD

‡$P < 0.01$, paired *t*-test (vis- à -vis pre-exercise values).

*P* value: Examination of the difference with pre-exercise values or of rates; AP group vs. control group

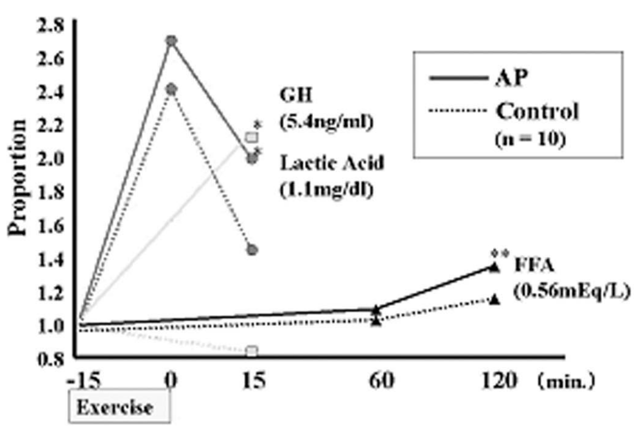


**Figure 2.** Changes over time of the levels of growth hormone, lactic acid, and free fatty acids before and after muscle stress training. The pre-exercise value for each item was set as 1, and the subsequent changes are represented as a proportion of their pre-exercise values. Parentheses show the mean pre-exercise values. GH, growth hormone; FFA, free fatty acid; AP, applied pressure group. †$P < 0.05$, t-test, AP group vs. control group. ‡$P < 0.01$, paired *t*-test, vis- à -vis pre-exercise values.

**Analysis by sex**

Tables 7 and 8 show the results of a sex-specific study of exercise-induced reactive secretion of growth hormones. Among male subjects, growth hormone levels rose significantly in the AP group, from 0.56 ± 0.50 ng/ml before exercise to 12.54 ± 3.92 ng/ml 15 minutes after exercise ($P$= 0.0027), but the levels in the control group changed from 1.04 ± 1.51 ng/ml to 7.48 ± 11.01 ng/ml, also a significant change (Figure 3). Meanwhile, female subjects showed patterns of change different from those of the male subjects. First, concentrations of the growth hormone before exercise were 0.80 ± 1.09 ng/ml in men and 9.90 ± 7.71 ng /ml in women, showing that women had a significantly higher value than men (P < 0.05). Moreover, with female subjects, while the AP group saw no significant changes between the pre-exercise growth hormone level of 8.00 ± 8.66 ng/ml and 5.10 ± 5.43 ng/ml 15 minutes after exercise, the control group saw the levels drop significantly, from 11.84 ± 7.03 ng/ml to 1.52 ± 1.35 ng/ml ($P$ = 0.0163). We examined the rate vis- à - vis the pre-exercise value and found that the control group secreted significantly fewer growth hormones than the AP group ($P$ = 0.0256).

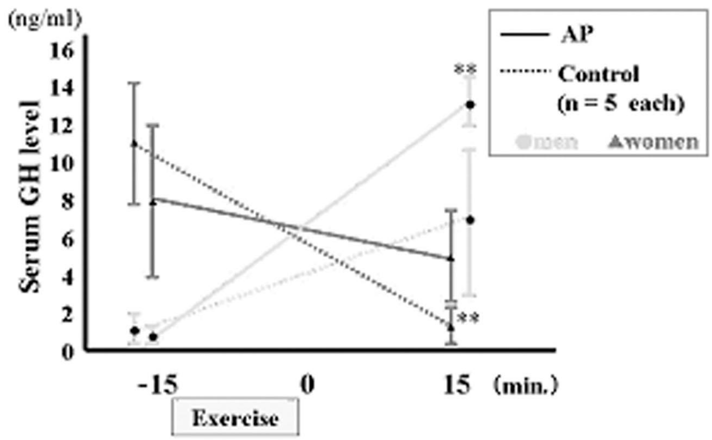


**Figure 3.** Growth hormone levels before and after exercise according to sex of subject.
GH, growth hormone. ‡$P$ < 0.01, paired t-test, vis- à -vis pre-exercise values

In male subjects, the serum lactic acid level changed before and after exercise in the AP group, from 1.24 ± 0.43 mg/dl before exercise, to 3.70 ± 1.77 mg/dl immediately after exercise and 2.48 ± 1.9 mg/dl 15 minutes after exercise (Table 7). In the AP group, the values immediately after exercise and 15 minutes after exercise both rose significantly over the pre-exercise values ($P$ = 0.0087 and $P$ = 0.0079, respectively). No significant differences were seen in the changes in lactic acid values between the AP group and the control group.

In female subjects, the serum lactic acid levels changed before and after exercise in the AP group, from 0.88 ± 0.13 mg/dl prior to exercise, to 2.12 ± 0.84 mg/dl immediately after exercise and 1.80 ± 0.46mg/dl 15 minutes after exercise, while in the control group, the levels changed from 1.06 ± 0.41 mg/dl prior to exercise to 2.56 ± 0.65 mg/dl immediately after exercise and 1.38 ± 0.37 mg/dl 15 minutes after exercise (Table 8). In the AP group, the values immediately after exercise and 15 minutes after exercise both rose significantly over the pre-exercise values ($P$ = 0.0150 and $P$ = 0.0084, respectively). No significant differences were seen in the changes in lactic acid values between the AP group and the control group.

In male subjects, the serum free fatty acid levels changed before and after exercise in the AP group, from 0.61 ± 0.15 mEq/L before exercise, to 0.63 ± 0.32 mEq/L 60 minutes after exercise and 0.83 ± 0.35 mEq/L 120 minutes after exercise (Table 7). The AP group saw no significant changes between the pre-exercise values and the values 60 minutes after exercise and 120 minutes after exercise. In the control group, the levels changed from 0.58 ± 0.22 mEq/L prior to exercise, to 0.57 ± 0.28 mEq/L 60 minutes after exercise and 0.65 ± 0.26 mEq/L 120 minutes after exercise. No significant rises in free fatty acid values were seen in the control group. No significant differences were seen in the changes in free fatty acid values between the AP group and the control group.

In female subjects, the serum free fatty acid levels changed before and after exercise in the AP group from 0.51 ± 0.24 mEq/L prior to exercise to 0.61 ± 0.21 mEq/L 60 minutes after exercise and 0.73 ± 0.28 mEq/L 120 minutes after exercise (Table 8). In the AP group, the values 60 minutes and 120 minutes after exercise had risen significantly over pre-exercise values (both $P = 0.0009$). In the control group, the levels changed from 0.53 ± 0.26 mEq/L before exercise to 0.59 ± 0.21 mEq/L 60 minutes after exercise and 0.69 ± 0.20 mEq/L 120 minutes after exercise. The value of the control group 120 minutes after exercise rose significantly over the pre-exercise level ($P = 0.0224$). No significant differences were seen in the changes in free fatty acid values between the AP group and the control group.

**Table 7.** Changes over time in male subjects

| Variable | Unit | AP | Control | *P* value |
|---|---|---|---|---|
| **Growth hormones** | | | | |
| Pre-exercise value | ng/ml | 0.56 ± 0.50 | 1.04 ± 1.51 | |
| 15 min. after exercise | ng/ml | 12.54 ± 3.92$^{‡}$ | 7.48 ± 11.01 | 0.0654 |
| **Lactic acid** | | | | |
| Pre-exercise value | mg/dl | 1.24 ± 0.43 | 1.20 ± 0.20 | |
| Right after exercise | mg/dl | 3.70 ± 1.77$^{‡}$ | 3.00 ± 1.28$^{†}$ | 0.2310 |
| 15 min. after exercise | mg/dl | 2.48 ± 1.09$^{‡}$ | 1.78 ± 0.89 | 0.1210 |
| **IGF-I** | | | | |
| Pre-exercise value | ng/ml | 203.3 ± 60.8 | 201.1 ± 86.7 | |
| 60 min. after exercise | ng/ml | 221.8 ± 77.4 | 211.5 ± 101.5 | 0.3016 |
| 120 min. after exercise | ng/ml | 197.6 ± 61.5 | 194.3 ± 85.1 | 0.4434 |
| **Free fatty acid** | | | | |
| Pre-exercise value | mEq/L | 0.61 ± 0.15 | 0.58 ± 0.22 | |
| 60 min. after exercise | mEq/L | 0.63 ± 0.32 | 0.57 ± 0.28 | 0.2461 |
| 120 min. after exercise | mEq/L | 0.83 ± 0.35 | 0.65 ± 0.26 | 0.2461 |

n = 5, mean ± SD. $^{†}P < 0.05$, $^{‡}P < 0.01$, paired *t*-test vis- à -vis pre-exercise values. P value: Examination of the difference with pre-exercise values or of rates; AP group vs. control group

**Table 8.** Changes over time in female subjects.

| Variable | Unit | AP | Control | *P* value |
|---|---|---|---|---|
| **Growth hormones** | | | | |
| Pre-exercise value | ng/ml | 8.00 ± 8.66 | 11.84 ± 7.03 | |
| 15 min. after exercise | ng/ml | 5.10 ± 5.43 | 1.52 ± 1.35$^{†}$ | 0.0256 |
| **Lactic acid** | | | | |
| Pre-exercise value | mg/dl | 0.88 ± 0.13 | 1.06 ± 0.41 | |
| Right after exercise | mg/dl | 2.12 ± 0.84$^{†}$ | 2.56 ± 0.65$^{‡}$ | 0.3067 |
| 15 min. after exercise | mg/dl | 1.80 ± 0.46$^{‡}$ | 1.38 ± 0.37 | 0.0593 |
| **IGF-I** | | | | |
| Pre-exercise value | ng/ml | 184.4 ± 8.0 | 176.2 ± 47.5 | |
| 60 min. after exercise | ng/ml | 168.4 ± 5.3 | 159.6 ± 34.0 | 0.4722 |
| 120 min. after exercise | ng/ml | 180.8 ± 16.6 | 169.1 ± 26.8 | 0.3958 |
| **Free fatty acid** | | | | |
| Pre-exercise value | mEq/L | 0.51 ± 0.24 | 0.53 ± 0.26 | |

| | | | | |
|---|---|---|---|---|
| 60 min. after exercise | mEq/L | 0.61 ± 0.21‡ | 0.59 ± 0.21 | 0.2044 |
| 120 min. after exercise | mEq/L | 0.73 ± 0.28‡ | 0.69 ± 0.20† | 0.2044 |

n = 5, mean ± SD. †$P$ < 0.05, ‡$P$ < 0.01, paired *t*-test vis- à -vis pre-exercise values); $P$ value: Examination of the difference with pre-exercise values or of rates; AP group vs. control group

**Study of sex differences**

Because sex differences were seen in exercise-induced reactive secretion of growth hormones, we investigated sex differences in terms of background factors, mental symptoms, and pre-exercise examination results (Table 9). The results revealed the following lifestyle habits and background factors to be subject to sex differences: frequency of exercise (men: 2.1 ± 2.62 times/week; women: 0.5 ± 0.7 times/week, $P$ = 0.0250), height (men: 173.4 ± 5.0 cm, women: 157.9 ± 4.2 cm, $P$ = 0.0000), weight (men: 74.8 ± 14.6 kg, women: 51.2 ± 4.2 kg, $P$ = 0.0001), systolic pressure (men: 144.4 ± 17.6 mmHg, women: 122.3 ± 14.2 mmHg, ($P$ = 0.0062), and diastolic pressure (men: 90.5 ± 12.2 mmHg, women: 76.0 ± 6.0 mmHg, $P$ = 0.0034). Blood examination items that showed sex differences were growth hormone (men: 0.80 ± 1.09 ng/ml, women: 9.92 ± 7.71 ng/ml, $P$ = 0.0016), DHEA-s (men: 2955.7 ± 1082.7 ng/ml, women: 1272.5 ± 445.2 ng/ml, $P$ = 0.0002), and thyroid hormone T3 (men: 1.52 ± 0.26 pg/ml, women: 1.33 ± 0.18 pg/ml, $P$ = 0.0335).

**Table 9.** Sex differences seen in background factors

| Variable | Unit | Men | Women | $P$ value |
|---|---|---|---|---|
| Smoking | Cig./day | 3.0 ± 6.7 | 11.5 ± 10.0 | 0.0726 |
| Drinking (in terms of sake) | Go/day x day/week | 1.8 ± 2.5 | 3.2 ± 4.7 | 0.0706 |
| Exercises | Times/week | 2.1 ± 2.6 | 0.5 ± 0.7 | 0.0250† |
| Age | years | 38.6 ± 5.1 | 38.2 ± 5.3 | 0.8653 |
| Height | cm | 173.4 ± 5.0 | 157.9 ± 4.2 | 0.0000‡ |
| Weight | kg | 74.8 ± 14.6 | 51.2 ± 4.2 | 0.0001‡ |
| BMI | | 24.7 ± 3.8 | 20.6 ± 1.4 | 0.0040‡ |
| Body fat % | % | 23.7 ± 4.8 | 26.3 ± 2.8 | 0.1463 |
| Systolic BP | mmHg | 144.4 ± 17.6 | 122.3 ± 14.2 | 0.0062‡ |
| Diastolic BP | mmHg | 90.5 ± 12.2 | 76.0 ± 6.0 | 0.0034‡ |
| Fasting blood sugar | mg/dl | 95.7 ± 15.0 | 93.2 ± 4.0 | 0.6175 |
| Lactic acid | mg/dl | 1.22 ± 0.32 | 0.97 ± 0.30 | 0.0887 |
| Free fatty acid | mEq/L | 0.60 ± 0.18 | 0.52 ± 0.24 | 0.4241 |
| HbA1c | mg/dl | 4.88 ± 0.44 | 4.80 ± 0.26 | 0.6284 |
| Growth hormone | ng/ml | 0.80 ± 1.09 | 9.92 ± 7.71 | 0.0016‡ |
| IGF-I | ng/ml | 202.2 ± 70.6 | 180.3 ± 32.4 | 0.3848 |
| Cortisol | μg/dl | 18.1 ± 6.0 | 17.4 ± 5.5 | 0.8024 |
| DHEA-s | ng/ml | 2955.7 ± 1082.7 | 1272.5 ± 445.2 | 0.0002‡ |
| TSH | ngIU/ml | 1.57 ± 0.96 | 1.81 ± 1.01 | 0.5941 |
| free T4 | ng/dl | 0.93 ± 0.178 | 0.94 ± 0.13 | 0.9091 |
| free T3 | pg/ml | 1.52 ± 0.26 | 1.33 ± 0.18 | 0.0335† |

BMI, body mass index; BP, blood pressure; IGF-I, insulin-like growth factor-I; HbA1c, glycosylated hemoglobin; TSH, thyroid stimulating hormone; T3, T4, thyroid hormones; DHEA-s, dehydroepiandrosterone sulfate.

n = 10, mean ± SD, *t*-test.

"One GO" means 180 ml of Sake.

Table 10 and 11 show the results of the survey on mental symptoms using the Anti-Aging QOL Common Questionnaire. Regarding physical symptoms, men had higher scores than women for "diarrhea" ($P < 0.01$) and "easily breaking into a sweat" ($P < 0.01$), while women had slightly higher scores than men for "constipation" ($P < 0.05$) and "headache" ($P < 0.05$). No sex differences were seen in mental symptoms.

**Table 10.** Sex differences seen in physical symptoms.

| Symptoms | Men | Women | $P$ value |
|---|---|---|---|
| Tired eyes | 2.8 ± 0.6 | 2.5 ± 1.0 | 0.4240 |
| Blurry eyes | 2.2 ± 0.8 | 2.0 ± 0.9 | 0.6132 |
| Eye pain | 1.6 ± 0.5 | 1.6 ± 0.5 | 0.9999 |
| Stiff shoulders | 2.6 ± 1.4 | 2.9 ± 1.2 | 0.6055 |
| Muscular pain/stiffness | 2.4 ± 0.8 | 2.2 ± 0.9 | 0.6182 |
| Palpitations | 1.6 ± 0.5 | 1.8 ± 0.8 | 0.5109 |
| Dyspnea | 1.6 ± 1.0 | 1.8 ± 0.8 | 0.6182 |
| Tendency to gain weight | 2.6 ± 1.2 | 2.6 ± 0.8 | 0.9999 |
| Weight loss; thin | 2.0 ± 0.9 | 1.5 ± 1.0 | 0.2581 |
| Lethargy | 2.4 ± 0.7 | 1.9 ± 0.6 | 0.0962 |
| No feeling of good health | 2.1 ± 0.88 | 1.9 ± 0.6 | 0.5520 |
| Thirst | 2.4 ± 0.8 | 1.7 ± 0.7 | 0.0553 |
| Skin problems | 2.4 ± 1.2 | 2.2 ± 0.6 | 0.6410 |
| Anorexia | 1.6 ± 0.5 | 1.4 ± 0.5 | 0.3979 |
| Early satiety | 1.9 ± 0.7 | 1.7 ± 0.8 | 0.5743 |
| Epigastralgia | 1.8 ± 0.8 | 1.6 ± 0.7 | 0.5560 |
| Liable to catch colds | 2.0 ± 0.7 | 2.1 ± 0.6 | 0.7222 |
| Coughing and sputum | 2.3 ± 0.7 | 2.0 ± 0.8 | 0.3823 |
| Diarrhea | 2.4 ± 0.7 | 1.5 ± 0.5 | 0.0044‡ |
| Constipation | 1.4 ± 0.7 | 2.4 ± 1.2 | 0.0327† |
| Headache | 1.5 ± 0.5 | 2.2 ± 0.8 | 0.0314† |
| Dizziness | 1.5 ± 0.7 | 1.4 ± 0.5 | 0.7222 |
| Tinnitus | 1.5 ± 0.5 | 1.5 ± 0.5 | 0.9999 |
| Lumbago | 2.2 ± 0.9 | 2.3 ± 0.8 | 0.8006 |
| Arthralgia | 1.9 ± 0.9 | 1.5 ± 0.5 | 0.2317 |
| Edematous | 1.9 ± 0.7 | 1.4 ± 0.7 | 0.1373 |
| Easily breaking into a sweat | 2.9 ± 1.4 | 1.4 ± 0.7 | 0.0064‡ |
| Polakisuria | 1.9 ± 0.7 | 1.7 ± 0.7 | 0.5350 |
| Hot flash | 1.9 ± 1.0 | 1.4 ± 0.5 | 0.1753 |
| Excessive sensitivity to cold | 1.4 ± 0.5 | 2.7 ± 1.0 | 0.0013‡ |

This questionnaire uses an ordinal scale with the following values: 1 = none at all; 2 = almost none; 3 = slightly; 4 = moderately; 5 = severely.

n = 10, mean ± SD, *t*-test.

**Table 11.** Sex differences seen in mental symptoms

| Symptoms | Men | Women | $P$ value |
|---|---|---|---|
| Irritability | 3.0 ± 0.9 | 2.2 ± 0.8 | 0.0544 |
| Easily angered | 2.9 ± 0.9 | 2.3 ± 0.7 | 0.1033 |
| Loss of motivation | 2.1 ± 0.9 | 1.9 ± 0.6 | 0.5520 |

| | | | |
|---|---|---|---|
| No feeling of happiness | 1.6 ± 0.7 | 1.7 ± 0.5 | 0.7142 |
| Nothing to look forward in life | 1.5 ± 0.5 | 1.6 ± 0.7 | 0.7222 |
| Daily life is not enjoyable | 1.7 ± 0.7 | 2.0 ± 0.7 | 0.3306 |
| Loss of confidence | 1.8 ± 0.6 | 1.9 ± 0.3 | 0.6601 |
| Reluctance to talk with others | 1.9 ± 1.3 | 1.7 ± 0.7 | 0.6685 |
| Depressed | 1.5 ± 0.7 | 1.6 ± 0.5 | 0.7222 |
| A sense of uselessness | 1.9 ± 0.7 | 1.7 ± 0.5 | 0.4825 |
| Shallow sleep | 1.8 ± 1.3 | 1.7 ± 0.8 | 0.8409 |
| Difficulty falling asleep | 1.7 ± 1.3 | 1.7 ± 0.6 | 0.9999 |
| Pessimism | 2.3 ± 1.2 | 1.8 ± 0.7 | 0.2468 |
| Lapse of memory | 2.9 ± 1.0 | 2.5 ± 0.7 | 0.3136 |
| Inability to concentrate | 2.3 ± 0.5 | 2.0 ± 0.7 | 0.2643 |
| Inability to solve problems | 2.2 ± 0.6 | 2.0 ± 0.7 | 0.5001 |
| Inability to make judgments readily | 2.1 ± 0.7 | 2.2 ± 0.8 | 0.7730 |
| Inability to sleep because of worries | 1.5 ± 0.5 | 1.9 ± 0.7 | 0.1800 |
| A sense of tension | 2.5 ± 0.9 | 1.9 ± 0.7 | 0.1091 |
| Feeling of anxiety for no special reason | 1.7 ± 0.5 | 1.7 ± 0.5 | 0.9999 |
| Vague feeling of fear | 1.3 ± 0.5 | 1.6 ± 0.5 | 0.1964 |

This questionnaire uses an ordinal scale with the following values: 1 = none at all; 2 = almost none; 3 = slightly; 4 = moderately; 5 = severely.

n = 10, mean ± SD, *t*-test

**Factors that influence reactive secretion of growth hormones**

The correlation between individual subjects' growth hormone secretion rates (value 15 minutes after exercise ÷ pre-exercise value) and each background factor was studied. By sex, men had significantly higher secretion rates than women ($r$ = 0.5362, $P$ < 0.05) which correlated significantly with height ($r$ = 0.5653, $P$ < 0.01), weight ($r$ = 0.5071, $P$ < 0.05), systolic pressure ($r$ = 0.4899, $P$ < 0.05), and diastolic pressure ($r$ = 0.5486, $P$ < 0.005). Analysis of the growth hormone secretion rate's common logarithm value showed that, by sex, men had a significantly higher secretion rate ($r$ = 0.7244, $P$ < 0.01), and that it correlated significantly with height ($r$ = 0.6950, $P$ < 0.01), weight ($r$ = 0.5157, $P$ < 0.05), systolic pressure ($r$ = 0.5434, $P$ < 0.005), serum DHEA-s level ($r$ = 0.5862, $P$ < 0.01), and pre-exercise growth hormone value ($r$ = -0.6902, $P$ < 0.01).

Next, we studied the correlation between reactive secretion of growth hormones and physical/mental symptoms as revealed by the Anti-Aging QOL Common Questionnaire. The only item that showed a significant correlation with a higher secretion rate of growth hormones was "irritability," a mental symptom ($r$ = 0.5121, $P$ < 0.05). Conversely, items associated with inhibition of growth hormone secretion were physical symptoms such as "headache" ($r$ = -0.4762, $P$ < 0.05) and "excessive sensitivity to cold" ($r$ = -0.4661, $P$ < 0.05) and the mental symptom of "no feeling of happiness" ($r$ = -0.4779, $P$ < 0.05). Analysis of the growth hormone secretion rate's common logarithmic value showed that none of these items promoted growth hormone secretion, while items such as "headache" ($r$ = -0.5315, $P$ < 0.05), "excessive sensitivity to cold" ($r$ = -0.6070, $P$ < 0.01), and "vague feeling of fear" ($r$ = -0.4792, $P$ < 0.05) tended to inhibit such secretion.

**Factors that influence free fatty acid production**

The correlation between individual subjects' free fatty acid production rates (value 120 minutes after exercise ÷ pre-exercise value) and each background factor was studied. The results showed free fatty acid production rates to be inversely correlated with T4 ($r$ = -0.6453, $P$ < 0.01) and T3 ($r$ = -0.6686, $P$ < 0.01). In other words, the lower the thyroid hormone value, the higher the post-exercise free fatty acid production rate tended to be. Moreover, pre-exercise free fatty acid values were inversely correlated with HbA1c ($r$ = -0.5032, $P$ < 0.05), so the higher the HbAlc level, the lower the free fatty acids value tended to be.

## Discussion

It is known that, because growth hormone metabolites measurable in the urine increase with resistance training, exercise induces the reactive secretion of growth hormones. This fact has been used by sports medicine as a benchmark for developing training programs and methods. However, there are as yet no reports on the kinetics of post-exercise secretion of growth hormones, lactic acid, and free fatty acids in the Japanese population.

The results of our test suggest that 15-minute resistance training induces the production of lactic acid and the secretion of growth hormones, activates fat metabolism that promotes fat decomposition, and brings about the tendency for serum free fatty acid levels to rise. We also found that, by improving this resistance training and conducting training by applying pressure to the muscles, we were able to significantly boost the reactive secretion of growth hormones. Because changes in free fatty acids also increase significantly, we believe that the metabolism of fat cells is activated.

**Sex differences**

We studied the sex differences between lifestyle habits and other background factors, mental symptoms and pre-exercise examination data, and found that a characteristic feature seen with our subjects was that the men exercised significantly more than did the women, and tended to smoke and drink less than their female counterparts, showing that they were more conscious of the need to take care of their health. Although male and female subjects were the same ages, the "age" of DHEA-s hormone was significantly younger for men than for women, and the age of IGF-I hormone tended to be younger in men than in women. These may reflect the differences in their lifestyle habits.

A difference was seen between men and women in the kinetics of secretion of growth hormones. First, women had significantly higher pre-exercise values than men, and while no significant differences were seen in the IGF-I value, which is an indicator of growth hormone secretion, women tended to have lower values than men. There are as yet no reports providing evidence that women have higher growth hormone levels than similarly aged men, and thus the problem is how to interpret our findings. Our clinical trial was conducted at an athletics field on the grounds of Heisei International University campus. There is a possibility that taking part in a study at a site so suggestive of exercise may already have stepped up the secretion of growth hormones in some female subjects. Because the secretion of growth hormones is temporary, by the time exercise training began, the subjects may already have entered a period of inactivity or insensitivity. Needless to say, reactivity may fundamentally differ between men and women. For example, in women, post-exercise growth hormone secretion may not peak 15 minutes after exercise: the peak may be postponed until even later. Regarding changes in free fatty acid levels, while men showed no significant differences, women saw their levels rise significantly. Therefore, because the effects of AP with respect to breaking down fatty acids were observed even in female subjects, women may find resistance training more useful in breaking down fat than will men.

**Factors that influence reactive secretion of growth hormones**

To investigate the factors that influence the reactive secretion of growth hormones, we analyzed the correlation between various background factors and the secretion rate of growth hormones before and after exercise. An interesting finding was obtained. We found that male sex, height, weight, blood pressure, and serum DHEA-s value were factors that enhanced the reactive secretion of growth hormones. It goes without saying that height and weight were analyzed with a BMI within the range of 21 to 24. DHEA, a hormone whose level decreases with age, is drawing interest in the field of anti-aging medicine. Our results showed that this hormone steps up the reactive secretion of growth hormones, which was an extremely interesting finding.

Our analysis also showed that an individual's mental status affected the reactive secretion of growth hormones. That is to say, an individual in a negative mental state, such as having "no feeling of happiness" or "a vague feeling of fear" is liable to show lower levels of secretion of growth hormones even after going through the same round of exercises as the others. These symptoms may be related to excessive stress or depressive tendencies. Our results showed that the more intense the subjects' headache, the less likely it was that growth hormones would be secreted. However, because individuals participating in this study were healthy, the "headache" in this case was mostly muscle contraction-type headache, so tension and stress may also have been involved.

**Effects of exercise therapy**

There is evidence that exercise has numerous positive effects on a person's physical and mental status. It also makes the body lighter and alleviates stiff shoulders, and helps make a person more friendly and at ease with others.[1] In other words, it is useful, both physically and mentally, to help make a person more active and sociable. Besides these, exercise improves menopausal symptoms, stimulates the brain, reinvigorates mental activity, and enhances memory, thought, and concentration.

Thanks to mechanization and the development of transportation systems, modern life requires little physical effort. The proportion of physically inactive people is clearly on the rise. On average, from the age of 40 years, muscular atrophy is said to progress at a rate of 1% each year through daily living alone[8]. Once a person becomes bedridden, moreover, muscular atrophy accelerates rapidly to a rate of 1% once every 2 days. Because women have a smaller muscle volume than men to begin with, they should engage themselves more actively in muscular training. Ordinarily, people do not use all their articular range of motion in their daily activities. Not using the joints promotes articular contracture, as is evident in periarthritis scapulohumeralis, which is more commonly referred to as age-related frozen or stiff shoulder. This symptom can be prevented by stretching exercises. To prevent aging, today's people should incorporate, in their daily lifestyles, a well-balanced program of aerobic exercises, muscle training, and flexibility exercises.[9]

Some of the effects of exercise include the prevention of obesity, prevention of increased insulin resistance, burning of calories taken in, releasing stress, and enhancement of the quality of sleep. From the anti-aging medicine perspective, we wish to emphasize its effects on promoting the secretion of growth hormones and production of IGF-I. There are also reports that exercise is effective against arthralgia, lower back pain, and hypertension. Exercise is therefore expected to greatly contribute to enhancing a person's quality of life.

It has been shown that individuals aged 35 to 40 years can extend their healthy lifespan by 1 full year by incorporating moderate exercise into their daily lifestyle.[10] If people who had been outstanding athletes while in school give up sports after graduation, the benefits of physical exercise eventually wear off. It is important, therefore, that sports and exercise should be continued throughout life. It is also vital not to overdo or overexert oneself. Overly strenuous exercises that imitate those of professional athletes do more physical harm than good.

**Instructions/guidance on exercise**

Individuals older than 40 years who are new to exercise therapy should be instructed to start with mild exercise. They should be encouraged to walk (an aerobic exercise) for 30 minutes 4 times a week, undergo 20-minute muscle training twice a week, and 10-minute flexibility exercises (stretching) every day. The load of aerobic exercises may be increased if necessary, based on the individual's progress in the program. The maximum may be about 1 hour per day of jogging or swimming. Competitive marathons that last 2 hours or more apply too much stress. Every muscular training menu should include exercise of the quadriceps of the thigh because these are where age-related atrophy is the most conspicuous.[8] These muscles play an important role in the movement of raising the thighs when standing up and walking. Pressurized training using KAATS is regarded as a part of the muscle training program. Although this is an efficient training over short periods, its safety in the elderly has not yet been confirmed. Therefore, it is not suited to older people. The program is useful for people who are young, middle-aged, or in the prime of life and who wish to boost their health or to avoid becoming bedridden.

Factors that make an elderly person become bedridden are, first, reduction in bone density, and second, reduction in muscular strength. This is often triggered by compression fractures of the lumbar spine and the femoral neck due to falling and other accidents. To minimize the number of elderly people who require nursing care, exercise and training to prevent falls and to avoid injury even after a fall are likely to become increasingly important.[11]

**Conclusion**

Once people exceed the age of 30 years, if nothing is done, the volume of fat-free muscles normally decreases by 1% each year as a result of aging. Their fat tissues show a tendency to increase. In terms of anti-aging therapy, exercise therapy is extremely significant in that it promotes the secretion of growth hormones, fortifies the muscles, and consumes extra fat energy. If growth hormones can be stimulated to be secreted even more efficiently through pressurized training, this would constitute an even more effective anti-aging therapy.

## References


1. Yonei Y. The Mechanism of Aging and Lifespan. Tokyo: Nihon Jitsugyo Shuppan 2003 (In Chinese and Korean: in press).
2. Takarada Y, Takazawa H, Ishii N. Application of vascular occlusion diminishes disuse atrophy of knee extensor muscles. Med Sci Sports Exercise 2000; 20:2035-2039.
3. Takarada Y, Takazawa H, Sato Y, Takebayashi S, Tanaka Y, Ishii N. Effects of resistance exercise combined with moderate vascular occlusion on muscular function in humans. *J Appl Physiol* 2000; 88:2097-2106.
4. Takarada Y, Sato Y, Ishii N. Effects of resistance exercise combined with vascular occlusion on muscle function in athletes. *Eur J Appl Physiol* 2002;86:306-314.
5. Yonei Y, Mizuno Y, Hajime Orimo H, Mizushima Y. Effects of electro-potential therapy on symptoms associated with QOL and aging. Anti-Aging Med 2003;2:15-18.
6. Yonei Y, Mizuno Y. Effects of an isoflavone-containing cosmetic, eterrite,® on the mental and physical parameters associated with QOL and aging. Anti-Aging Med 2004;2:18-26.
7. Yonei Y, Date Y, Orimo H, Mizushima Y. Effects of low calorie diet therapy on obesity in male system engineers. Diagn Therapeut 2004;92: 7046-7049.
8. Fukunaga T, ed. Scientific Dictionary of Muscles. Tokyo: Asakura Shoten 2002.
9. National Health Institute, National Institute on Aging (USA) (authors), Takano T., (translator): Health Exercises from Age 50: Exercises, Sports, Safety and Nutrition. Tokyo: Iwanami Shoten 2001.
10. Paffenbarger RS, Hyde RT, Wing AL, Lee I.M., Jung D.L., Kampert J.B. The association of changes in physical-activity level and other lifestyle characteristics with mortality among men. *N Engl J Med* 1993;328: 574-576.
11. Muto Y, ed. Classes on Preventing Falls. Tokyo: Nihon Iji Shinposha 2002.