

# EFFECT OF ENDURANCE EXERCISE ON RESTING TESTOSTERONE LEVELS IN SEDENTARY SUBJECTS

Ashira Hiruntrakul<sup>1</sup>, Ratanavadee Nanagara<sup>2</sup>, Alongkot Emasithi<sup>1</sup>, Katarina T. Borer<sup>3</sup>

<sup>1</sup>Department of Physiotherapy, Faculty of Associated Medical Science, Khon Kaen University, Thailand

<sup>2</sup>Department of Medicine, Faculty of Medicine, Khon Kaen University, Thailand

<sup>3</sup>Division of Kinesiology, Department of Movement Science, University of Michigan, Ann Arbor, USA

## SUMMARY

**Objective:** To investigate the effects of moderate-intensity and low frequency exercise on resting serum testosterone and cortisol levels, resting heart rate, and isokinetic strength among healthy sedentary young men.

**Design:** A randomized controlled study. Forty sedentary young men aged 18 to 25 years old, pedaled 50 minutes on a bicycle ergometry at 60% of maximal effort once a week for 12 weeks in an exercise group.

**Outcome measures:** Resting total and free serum testosterone, serum cortisol, anthropometric data, resting heart rate, and isokinetic strength during shoulder and knee extensions.

**Results:** Resting serum total and free testosterone, as well as cortisol did not differ significantly between groups. Neither group showed any significant changes in anthropometric data and isokinetic strength at the end of study. However, the resting heart rate of the exercise group reduced significantly after the training ( $p < 0.05$ ). Also, the isokinetic strength of shoulder and knee significantly increased ( $p < 0.05$ ).

**Conclusions:** Twelve weeks of moderate-intensity and low frequency training had no effect on resting serum testosterone, but were sufficient to increase aerobic fitness among sedentary young men. The type of exercise training may encourage sedentary individuals to participate regularly in the program on physical activity.

**Key words:** testosterone, endurance exercise, strength, frequency

**Address for correspondence:** A. Hiruntrakul, Department of Physiotherapy, Faculty of Associated Medical Science, Khon Kaen University, Thailand. E-mail: hashir@kku.ac.th

## INTRODUCTION

Physical activity increases strength (1, 2) as well as aerobic fitness (3), alters hormonal level (4–10), and decreases risks of cardiovascular morbidity and mortality (11–13). The influence of long-term physical training on hormonal response has been well established in athletes, but not yet among healthy sedentary men. Long-term physical training at moderate intensity 3 times a week, however, may possibly discourage the sedentary individuals to comply with the program. The drop-out rate is about 50% during the first 6 to 12 months (15). The current recommendation for all healthy adults aged 18 to 65 years old is to engage in moderate-intensity aerobic physical activity for a minimum of 30 minutes 5 days each week, or vigorous-intensity aerobic physical activity for a minimum of 20 minutes 3 days each week (14). Undoubtedly, the effects of exercise also vary a great deal upon age and baseline fitness of the individuals. Generally, the benefits are more evident among the younger and unfitted individuals. As the prevalence of physically inactive adults is now increasing (16) rapidly, establishing a suitable exercise program to improve their hormonal level and fitness is quite crucial. They usually have low compliance and adherence to the generally recommended training programs. Therefore, the exercise program with low frequency perhaps fits better in their lifestyle and is easier to accomplish it for them. Based on

the results of our pilot study (unpublished data), a moderate-intensity exercise at frequency of once a week was enough to observe some changes in testosterone level after 12 weeks. The purpose of this study then was to investigate the effects of moderate-intensity and low frequency exercise training (1 hour, once a week) on serum testosterone, cortisol and lipid profiles, anthropometric data, and isokinetic strength in sedentary young men after 12 weeks.

## MATERIALS AND METHODS

### Subjects

Forty healthy sedentary men (mean age  $20.8 \pm 1.85$  yr) without cardiopulmonary, orthopedic, neurological or metabolic diseases were recruited. A sedentary status was defined as an individual who participated in any exercises less than 1 hour per week for at least 12 months prior to the beginning of this study. All subjects were informed verbally and in writing about the aim, protocol and demands of the study, and gave their written informed consents if they decided to participate. The study protocol was approved by the Khon Kaen University Ethics Committee for Human Research. Subjects were randomly assigned by simple drawing to either the exercise ( $n=20$ ) or the control group ( $n=20$ ).

**Table 1.** Comparison parameters between the groups and time

Parameters	Exercise (N=19)		Control (N=18)	
	Before	After	Before	After
Age (yrs)	21.00 ± 2.00	21.00 ± 2.00	20.00 ± 1.00	20.00 ± 1.00
Weight (kg)	61.73 ± 10.94	62.2 ± 10.94	65.72 ± 11.16	66.08 ± 11.69
Height (cm)	1.71 ± 0.05	1.71 ± 0.05	1.71 ± 0.04	1.71 ± 0.04
BMI (kg/m <sup>2</sup> )	20.99 ± 3.35	21.20 ± 2.90	22.35 ± 3.44	22.47 ± 3.58
Percent fat	6.52 ± 4.34	6.57 ± 3.57	7.89 ± 4.76	8.78 ± 6.08
FFM	57.33 ± 7.56	57.97 ± 7.20	60.11 ± 7.34	59.67 ± 6.56
WHR	0.80 ± 0.05	0.78 ± 0.05	0.81 ± 0.07	0.82 ± 0.08
Resting Heart rate (bpm)	88 ± 3.76	78 ± 2.09*	90 ± 3.65	93 ± 4.78†
Total testosterone (ng/cm <sup>3</sup> )	5.32 ± 1.62	5.55 ± 1.01	5.44 ± 1.24	5.91 ± 1.32
Free testosterone (pg/cm <sup>3</sup> )	20.76 ± 6.25	19.18 ± 4.56	18.93 ± 4.39	20.36 ± 4.22
Cortisol (µg/cm <sup>3</sup> )	28.16 ± 7.72	27.14 ± 7.96	28.07 ± 5.67	28.35 ± 8.77
Shoulder flexion (watts)	35.63 ± 10.74	44.74 ± 11.33*	49.61 ± 12.33	52.00 ± 11.11
Shoulder extension (watts)	53.42 ± 17.86	68.84 ± 17.72*	66.61 ± 14.20	67.61 ± 15.04
Knee flexion (watts)	66.63 ± 17.39	88.89 ± 20.37*	80.50 ± 27.09	87.72 ± 20.57
Knee extension (watts)	113.37 ± 27.04	137.05 ± 29.13*	133.83 ± 38.90	132.67 ± 39.26

\* Difference from before training,  $p < 0.05$ ; † Difference from exercise group,  $p < 0.05$

## Study Protocol

Before starting the exercise program, the anthropometric data, blood samples, and isokinetic strength of left knee and shoulder were obtained from all subjects. For the exercise group, subjects were scheduled to visit the exercise laboratory regularly once a week for 14 weeks. The first 2 visits were for familiarization with the exercise protocol, and the other 12 visits were training sessions. The training program consisted of a 5-minute warm up, a 50-minute pedaling on a bicycle ergometer at 60%  $\dot{V}O_{2max}$ , and a 5-minute cool down. For the control group, subjects were allowed to continue their regular life-style. Both groups were instructed not to change their dietary patterns and keep their diaries concerning their activities, stressful events, and food consumption during the whole training period and submitted it to researcher at the end. The anthropometric data, blood samples, and isokinetic strength were re-assessed at 14 weeks.

## Outcome Measures

### Primary outcome variables

**Testosterone, cortisol, and lipid profiles.** All subjects were asked to have overnight fast, refrain from alcohol, strenuous activity, and sexual activity 24 hours prior to the blood collection day. After 30-minute rest, a 15 cm<sup>3</sup> of venous blood was drawn from the antecubital vein. The blood was allowed to clot at room temperature before being centrifuged. The serum was then kept frozen at -85 °C for analyses. Total as well as free testosterone and cortisol were determined by the radioimmunoassay (RIA) at Medical Nuclear Unit, Department of Radiology, Faculty of Medicine, Khon Kaen University. Total testosterone was measured using the commercially available RIA kit (TESTO-CT2, CIS Bio International, France) with a lower limit of detection, inter- and intra-assay CVs of 0.1 ng/cm<sup>3</sup>, 7%, and 7.5%, respectively. Free testosterone was analyzed by the RIA kit (DSL-4900, DSL Inc,

USA) with a lower limit of detection, inter- and intra-assay CVs of 0.18 pg/cm<sup>3</sup>, 7.3%, and 5.2%, respectively. Cortisol was measured using the commercially available RIA kit (MP Biomedical, USA) with a lower limit of detection, inter- and intra-assay CVs of 0.17 µg/cm<sup>3</sup>, 7.6%, and 6.1%, respectively.

### Secondary outcome variables

**Anthropometric data.** Skinfold thickness was measured by Lange calipers (Beta Technology, USA) at 7 standard sites to determine body fat. Percent body fat (%BF), fat weight (kg), and fat free mass (kg) were calculated from body density (Db), based on Jackson and Pollock (17) and Brozek's equations (18).

**Muscle strength.** Cybex 6000 dynamometer (Lumax Inc, NY, USA) was used to measure isokinetic strength of left knee and shoulder at the velocities of 90, 120 and 180 °/sec. Three trials for each velocity with 20 seconds of rest in between. Peak torque as well as average power was recorded.

### Statistical Analysis

All data were presented as mean ± SD. A 2x2 (group x time) ANOVA was used to examine the effects of exercise on all dependent variables between 2 groups (exercise vs control) and times (before vs after). The statistics were analyzed using program SPSS, version 10 (SPSS Inc., Illinois, USA). The level of significance was set at  $p < 0.05$ .

## RESULTS

### Baseline Characteristics

At baseline, subjects had comparable body weights, body mass indexes, waist-to-hip ratios, and blood plasma parameters (Table 1).

The isokinetic strength of the control group was greater than the exercise group. (Table 1,  $p < 0.05$ ). During the experimental period, 3 patients were unable to complete the training program: 1 (exercise group) and 2 (control group) withdrew for personal reasons.

**After 12-week training.** The level of resting serum total and free testosterone, as well as cortisol did not differ significantly between groups. Neither group showed any significant changes in body mass index, fat free mass, body fat, and waist/hip ratio. However, the resting heart rate of the exercise group reduced significantly after the training ( $p < 0.05$ ). Also, the isokinetic strength of shoulder and knee significantly increased ( $p < 0.05$ ). Isokinetic strength of shoulder flexion/extension and knee flexion/extension did not significantly differ between groups at the end of study.

## DISCUSSION

This was a randomized controlled study examining the effects of moderate-intensity and low-frequency exercise on the testosterone level and general health status in sedentary young men. The results showed that both resting total and free testosterone levels did not statistically change despite a significant increase in arm and leg strength after the 12-week training program. The level of free testosterone, however, had tendency to decline. The similar findings have been reported in previous studies based on different population and training method (19–23). Up to date, the effects of exercise on the testosterone level remain controversial. Some studies reported a tremendous increase in the testosterone level after the moderate-intensity exercise lasting 45 to 90 minutes (1, 27, 28), while others reported unchanged or slightly decreased testosterone concentration after exercise at the similar level and duration (19–23, 25, 26, 29). A decline in testosterone levels were also noted after moderate- to high-intensity exercise (31, 32). The duration and intensity of the program thus appear to play an important role. The possible explanations can be as follows. After initiating the submaximal exercise, the level of serum total testosterone is elevated by the hemoconcentration. Continuing the exercise causes more blood flow to the exercised muscles and less flow to the testicles. The hormonal secretion then starts to decline. In addition, the hepatic blood flow probably decreases as well followed by declining of the hepatic clearance. Therefore, the testosterone level may elevate once again. After a prolonged period of the exercise, the skeletal muscles are able to uptake a greater amount of hormone. Consequently, the testosterone level is gradually lessened. Several studies denoted that suppression of reproductive hormones in endurance-trained males may exist due to overtraining. A low level of resting testosterone in men after endurance training has some adverse affects on physiological processes related to androgenic-anabolic actions of testosterone such as decreased protein synthesis and muscle mass and favorable affects, the physiologic adaptations such as cardiovascular protective effects (33).

The exercise group also experienced an increase in muscle power of both upper and lower extremities after the training program (power = 86.71,  $\alpha = 0.05$ ). It is possible that this group had poorer strength than the control group at the beginning of the program; therefore, the changes became more apparent. This was similar to previous reports (2, 38, 39). Strength improvement after 12-week exercise, despite an unchanged testosterone level, may be

due to changes in muscle fiber profile, metabolic adaptation, and neural recruitment in skeletal muscles (40–42). Unfortunately, we did not evaluate these parameters because they were not variables of interest in this study. Our results also indicated that the exercise group had minor increase in fat free mass (FFM), suggesting that training may alter hormonal environment (testosterone, growth hormone, catecholamine, etc) or hormone receptor density (e.g. androgen receptors) that possibly contribute to an increase in muscle strength (43, 44).

There was no significant improvement of BMI of the exercise group after training as all subjects were allowed to continue their dietary patterns. However, some positive effect on waist-hip ratio was observed even without statistical significance. This could be the result of an increase in fat free mass or a decrease in abdominal fat. Longer duration of the exercise program is most likely to bring more positive results.

The limitations of our study were the individual characteristics of subjects and duration of exercise. Our subjects were sedentary volunteers who prefer not to exercise even only once a week. However, this was a longitudinal controlled study in sedentary young men investigating the effects of exercise on serum testosterone level that could enroll more sample size compared to previous studies.

## CONCLUSION

In summary, low-frequency (once a week) and moderate-intensity exercise program did not affect the level of resting serum testosterone in sedentary young men after 12-week training. There were also some positive effects of this protocol on muscle strength and cardiovascular fitness. For that reason, the low-frequency and moderate-intensity exercise program is probably still beneficial for health promotion campaign in sedentary individuals who have poor compliance and adherence to the general exercise programs. Further study should examine if these beneficial effects were still present if more feasible exercise program is designed.

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