Influences of a Lack of Chronic Exercise on the Condition of Peripheral Blood Circulation in Women

Influences of a Lack of Chronic Exercise on the Condition of Peripheral Blood Circulation in Women

Toshimitsu Ebisu, Ph.D., Ed.D.
Lab. of Human and Health Sciences, Department of Lifelong Learning, Faculty of Education and Regional Studies, University of Fukui

Kaori Yoshikawa
Fukui School for Physically and Mentally Retarded Children

Tomohisa Yokoya
Health Section, Kaga City Hall

Yoshimi Sasaki
Graduate School of Education, University of Fukui

Yuji Yanagimoto, Ph.D.
Faculty of Health Science, Hyogo University

Abstract

The purpose of this study is to clarify the changes in the condition in peripheral blood circulation due to a lack of exercise. Twenty-three healthy and untrained female college students volunteered to be subjects in this study. Two groups, one of 15 and one of 8 subjects, were randomly assigned to the experiment and the control groups, respectively. Since the ideal energy consumption for women per day is suggested to be 2, 200 kcal/day, the experiment group was asked to maintain an energy consumption of less than 2, 200 kcal/day during the period of 12 weeks and the control group was asked to maintain the energy consumption more than 2, 200 kcal/day during the same period. An energy consumption level of less than 2, 200 kcal/day was considered to be the lack of exercise in this study. The acceleration plethysmograph (APG) was applied in this study to determine the condition of the peripheral blood circulation

In the results of this study, it was found that a daily lifestyle that featured the consumption of less than 2, 200 kcal/day adversely affects the condition of the peripheral blood circulation, whereas a lifestyle featuring the consumption of 2, 200 kcal/day or more brings about a good influence upon the condition of the peripheral blood circulation. It, therefore, seems that a lack of exercise decreases the peripheral blood circulation.

Introduction

The death rate due to chronic disease recently is on the rise. The causes are attributed to such risk factors as drinking, smoking, mental stress, lack of exercise, excessive intake of saturated fatty acids, insufficient intake in dietary fiber, obesity and aging[1]. Among these the harmful influence of lack of exercise in daily life looms large since our present society and its activities are highly mechanized and removed from physical labour.

Research studies on the influences of a lack of exercise have been conducted focusing on experiments involving bed rest and space flight. Studies on bone density have been frequently conducted in weightlessness during space flight[1]. The physical responses to a lack of exercise can also be clarified in a study on detraining. The physical response due to detraining is considered to be the response to a lack of exercise in comparison with the response to retraining[1]. A training effect is reported nearly to disappear due to two-week of detraining[2]. The effects of detraining include decreases in maximum oxygen consumption[3),4),5)], increase in percent body fat (%Fat), and a decrease in lean body mass (LBM)[6].

Ebisu, et al.[6] reported decreases in blood aldolase, LBM and trunk flexion in standing position along with increases in serum phospholipid, %Fat and the total amount of body fat (Fat) due to one and a half months detraining. On the other hand, after one and a half months of retraining following detraining, they reported increases in blood aldolase, LBM and trunk flexion in standing position along with decreases in serum phospholipid, %Fat and Fat. Both sets of results were based on the analysis of 26 blood substances, six pulmonary functions, four body composition variables, and seven fitness tests during the periods of detraining and retraining.

Due to the lack of exercise, the peripheral blood circulation is also considered to decrease. The human body consists of 60 trillion cells[7]. Gas exchanges between oxygen and carbon dioxide in these cells and exchanges of nutriment are fundamentally done in the capillaries[7]. A guideline to show the condition of blood circulation basically depends upon whether or not blood pumped out from the heart flows from an artery to a vein through a capillary[7].

In the case that the peripheral blood circulation proving insufficient, sufficient oxygen and nutriment cannot be supplied to tissue and cells. If the situation lasts for a long period of time, it seems that organized changes will appear[8),9)]. Hence, the condition of the peripheral blood circulation can be an important factor in health[8),

10),11).

Although the decrease in the efficiency of blood flow due to a lack of exercise has been pointed out[12], research studies to clarify the response of the condition of the peripheral blood circulation have been little reported. The purpose of this study is, therefore, to clarify the changes in the condition of the peripheral blood circulation due to a lack of exercise.

Materials and Methods

Twenty-three healthy and untrained female college students volunteered to be subjects in this study. Groups of fifteen and eight subjects were randomly assigned to the experiment and the control groups, respectively. Since the waveform of the APG shows a strong correlation to age[13], the same age group of the subjects was used in this study. By applying the suggestion[14] that the ideal energy consumption a day is 2, 200 kcal/day for women, the experiment group was asked to maintain the energy consumption of less than 2, 200 kcal/day during a period of 12 weeks and the control group was asked to maintain the energy consumption of more than 2, 200 kcal/day during the same period. Energy consumption of less than 2, 200 kcal/day was considered to be the lack of exercise in this study.

Informed consent was obtained from all of the subjects by explaining the purpose and the methods of this study. The energy consumption per day was determined by using a measuring instrument of calory consumption called the Calory Counter Alpha (made by Suzuken Inc.). The measuring instrument was worn on a subject's belt. The data indicated for 24 hours a day were obtained every day during the 12 weeks after inputting the subject's values of age, height and body weight. The measuring instrument was taken off from the belt and placed on a desk while the subject was sleeping and taking a bath.

The APG was applied in this study to determine the condition of the peripheral blood circulation, since the APG has been reported to show a high reproduction and a little fluctuation of the base line and one of the non-invasive measurements[10]. The APG (Precaregraph APG-200, Misawa Home, Inc.) was used in this study. The APG was determined by a forefinger of a subject's dominant hand inserted to the inside of the APG sensor in sitting position, as described in Maeda's study[11]. The APG was measured at rest prior to the experiment, six weeks after starting the experiment, and at the end of the experiment, which was 12 weeks after starting the experiment.

Results and Discussion

The mean and the standard deviation of their energy consumption values a day prior to and at the end of the experiments are illustrated in Table 1. The testing results of significance between the two experiments are also indicated in the table. As shown in Table 1, subjects' energy consumption values after the 12 weeks in the experiment group were significantly less than that in the control group, although there was no significant difference between the two groups prior to the experiment.

As previously stated, the experiment group was asked to maintain the energy consumption of less than 2,200 kcal/day and the control group was asked to maintain the energy consumption of more than 2,200 kcal/day during the experiment period. As the result during the 12-week experiment period, it was found that the mean value of the energy consumption in the experiment group was less than 2,200 kcal/day and the mean value of the control group was more than 2,200 kcal/day (see in Table 1 below).

Table 1. Difference in energy consumption per day in the experiment and the control groups prior to and after 12-week experiment.

Group	prior to the experiment	after the experiment
Experiment G. (n=15)	1805.5±86.8	1847.5±40.7
	N.S.	***
Control G. (n=8)	1752.9±95.8	2216.0±10.0

(kcal, Mean ± S.D.) (N.S. : No significant difference, *** $p<0.001$)

The mean and the standard deviation values of APG scores in both the experiment and the control groups prior to, after six weeks (at the half way point of the experiment period), and after 12 weeks are indicated in Table 2. The results of significance between the two experiments are also shown in the table. The experiment group indicated significantly less value than the control group after 12 weeks, although no significant difference was found between the two groups prior to and after six weeks of the experiment.

A lack of exercise during 12 weeks seems to adversely affect the condition of the peripheral blood circulation, since the higher the APG score, the better the condition of the peripheral blood circulation[11]. Among the seven kinds (A through G) of the waveforms, the percentage of A and B types is relatively high for someone in their twenties[8]. Since all of the subjects in this study showed either the A or the B type in both groups, a lack of exercise in daily life negatively influences the

condition of the peripheral blood circulation even in subjects who show the range of the normal scores. Habitual, regular exercise is functionally an improvement factor on the condition of the peripheral blood circulation[8]. It is understandable that the experiment group showed less APG scores in this study. In other words, the daily life consuming less than 2, 200 kcal/day on average brings about the difference of the condition of the peripheral blood circulation.

Table 2. Difference of the APG scores between the two groups.

Group	prior	after 6 weeks	after 12 weeks
Experiment G. (n=15)	49. 40±10. 62	43. 67±16. 24	28. 93±16. 50
	N.S.	N.S.	**
Control G. (n=8)	39. 63±13. 96	48. 75±11. 36	52. 62±11. 08

(Mean ± S.D.) (N.S. : No significant difference, ** $p<0.01$)

The results of the test of the significance of the APG scores in the experiment group prior to, after six weeks, and after 12 weeks of the experiment are illustrated in Table 3. The APG scores prior to and after six weeks significantly decreased compared with the scores after 12 weeks, although there was no significant difference between the scores prior to and after six weeks of the experiment.

The test of the condition of the peripheral blood circulation by the APG predicts diseases of the circulatory organs such as cerebral apoplexy, myocardial infarction and a kind of tumor, showing, as it does, a stage of functional change prior to the organizing and pathological changes[7]. According to the results of this study, it is predictable that a lack of exercise brings about a decrease in heart function, maximum oxygen uptake and blood flow efficiency along with increases in resting heart rate and systolic blood pressure[12].

Table 3. Changes in the APG scores of the experiment group prior to, after 6 weeks, and after 12 weeks of the experiment.

Period			t value
prior to	→	after 6 weeks of the experiment	1. 10
prior to	→	after 12 weeks of the experiment	4. 07**
after 6 weeks	→	after 12 weeks of the experiment	2. 40*

(* $p<0.05$, ** $p<0.01$)

The results of the test of the significance of the APG scores in the control group prior to, after six weeks, and after 12 weeks of the experiment are illustrated in

Table 4 below. There was no significant difference of the APG scores between any two periods. In other words, a daily life consuming less than 2, 200 kcal/day adversely affects the condition of the peripheral blood circulation, whereas the life consuming 2, 200 kcal/day or more brings about a good influence on the condition of the peripheral blood circulation. Although the average values of the APG scores showing less or more than 2, 200 kcal/day during the 12 weeks was investigated in this study, the next study should be conducted to investigate the influence of more or less than 2, 200 kcal/day every day.

Table 4. Changes in the APG scores of the control group prior to, after 6 weeks, and after 12 weeks of the experiment.

Period			t value
prior to	→	after 6 weeks of the experiment	1.37
prior to	→	after 12 weeks of the experiment	1.56
after 6 weeks	→	after 12 weeks of the experiment	0.60

(None of the t values is significant.)

It has been considered that the APG easily captures an image influenced by a resistance and the inside diameter of a peripheral blood vessel and provides effective information in order to judge the shape and the wall of a blood vessel in peripheral circulation[11]. Therefore, it seems that a lack of exercise decreases peripheral blood circulation.

References

1. Ebisu, T (2002) : *Physiology and Hygiene of Health*, The Fumaido Press. (in Japanese)
2. Lamb, D. R. (1978) : *Physiology of Exercise*. Macmillan Publishing Co. Inc.
3. Fournier, M. et al. (1982) : Skeletal muscle adaptation in adolescent boys: sprint and endurance training and detraining. *Medicine and Science in Sports and Exercise*, 14(6):453-456.
4. Klausen, K. et al. (1981) : Adaptive changes in work capacity, skeletal muscle capillarization and enzyme levels during training and detraining. *Acta. Physiol. Scand.*, 113:9-16.
5. Ready, A. E., Quinney, H. A. (1982) : Alterations in anaerobic threshold as the result of endurance training and detraining. *Medicine and Science in Sports and Exercise*, 14(4):292-296.
6. Ebisu, T., et al. (1987) : Influences of detraining upon blood substances,

pulmonary function, body composition and various physical fitness elements. *The Journal of Clinical Sports Medicine*, 4(12):1473-1478. (in Japanese)

7. Sano, Y. : Evaluation of peripheral circulation with accelerated plethysmography and its practical application. *J. Science of Labour*, 61(3):129-143, 1985. (in Japanese)

8. Sano, Y., et al. : Evaluation of peripheral circulation with accelerated plethysmography and its practical application (report 2) — quantification of inflection points of a waveform —. *Bulletin of the Physical Fitness Research Institute*, 68:17-25, 1988. (in Japanese)

9. Kagaya, J. (1995) : Exercise and muscle blood flow. *Health Care*, 37(6): 378-384. (in Japanese)

10. Honma, S., et al. : The relationship between accelerated plethysmogram, blood pressure and arteriolar elasticity. *Jpn. J. Phys. Fitness Sports Med.*, 41:98-107, 1992. (in Japanese)

11. Maeda, K. : Investigation of peripheral circulation with accelerated plethysmography in female students. *Jpn. J. School Health*, 39:177-180, 1997. (in Japanese)

12. Hatano, Y. et al. (2002) : *The Theory of Health Science*. Kadokawa Shoten, Inc. (in Japanese)

13. Takada, H. and Washino, K. : Acceleration plethysmograms and vascular age. *J. Educ. Health Sci.*, 43(4) : 353-359, 1998. (in Japanese)

14. Numajiri, K. (1987) : *The Energy Metabolism of Activities*. The Institute of Labor Science. (in Japanese)