Program of Exercise Training as Total Health Promotion Plan and its Evaluation

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Abstract: Program of Exercise Training as Total Health Promotion Plan and its Evaluation: Masaru Fukahori, et al. Department of Public Health and Hygiene, Oita Medical University—As part of a Total Health Promotion Plan (THP) at the workplace, quantitative exercise on the basis of the maximum heart rate (HRmax) on a treadmill was continued for six months and the possible relationship with lipid metabolism was evaluated. Subjects were 108 male workers selected from among 1,300 employees of a petroleum complex, having two or more risk factors for circulatory disorders including hypertension, hyperlipidemia, obesity and hyperglycemia confirmed by annual health checkups at the workplace in 1996 and being able to take exercise. They were randomly assigned to one exercise group (54 men) and one control group (54 men). The exercise group was instructed to take 20 minutes' walking exercise on a treadmill, three times a week for six months. The speed of the treadmill was set so that the heart rate while walking would be maintained within the range 70–75% of the HRmax. After six months' exercise, decreases in the waist-hip ratio (WHR) and significant increases in HDL- and HDL2 cholesterol (HDL2C) were seen in the exercise group. The HDL2C/HDL3 cholesterol ratio increased in the exercise group, and decreased in the control group, but no effect in improving total cholesterol was observed. Furthermore, in the exercise group an increase was noted in the adaptive walking speed at which the walking in the 70–75% HRmax range could be continued. In the present study a 6-month exercise program with the heart rate as an index was proposed as a part of THP. As a result, the exercise group were found to have increases in HDL-C and HDL2C, which are known to have an anti-arteriosclerotic action. In addition to these effects on serum lipids, the exercise program proved to be effective in increasing adaptive walking speed and in lowering WHR.

J Occup Health 1999; 41: 76–82

Key words: Program of exercise training, Health promotion, Physical fitness, Work environment

The main objective of traditional industrial hygiene has been to prevent disorders in workers or to discover them in their early stage, but with the aim of maintaining and promoting workers' health more actively, the Ministry of Labor of Japan started to implement a Silver Health Plan (SHP) in 1979, covering workers in the middle and old age range, to promote their health. Ten years later, in 1988, a Total Health Promotion Plan (THP) was provided in the Occupational Safety and Health Act in Japan as a comprehensive set of health measures by extending the coverage to workers of all ages and by incorporating not only exercise training but also health and nutrition guidance and mental health care. Work management has also become involved the safety and health problems of older workers. In order to evaluate changes in the various functional capacities of workers as they become older, the concept of promoting physical activity was introduced in the area of work management in our enterprise. Evaluation is by physical exercise and physiological tests. This THP has been introduced in different enterprises in order to suppress the incidence of diseases related to lifestyle, such as cerebrovascular diseases and ischemic heart diseases, and to preserve/promote workers' health. Such integrated work management and health care activities were found to be effective in preventing occupational injuries including low back pain.

Beneficial effects of exercise have been recognized: the HDL cholesterol levels are higher in those who are in the habit of taking exercise than in those who are not; and the metabolism of lipids, glucose tolerance and blood pressure values can be improved by forming the habit of taking exercise. In other words, since exercise is effective in lowering the risk of cardiovascular diseases, exercise training for the high risk group would be beneficial from the standpoint of prevention. The actual rate of implementation has, however, been reported to be low, irrespective of the size of the enterprises. One of
the reasons for this is that there have been almost no proposals of practical training programs in accordance with THP, and the evaluation of their efficacy.

In the present study we instructed subjects requiring exercise training for health control to take quantitative exercise based on the maximum heart rate on a treadmill and evaluated its effects by examining the changes in serum lipid levels and adaptive walking speed as indicators. In addition, we discussed alternative schemes for popular use of the program used in this study.

Subjects and Methods

Subjects
The subjects were 108 men who were selected from about 1,300 employees, and were aged 19 to 61 years, the average being 43 years. They worked in the petroleum complex. They consisted of clerks who worked in offices and had not done even light exercise, and workers actively engaged in heavy work requiring exertion, and who had two or more risk factors relating to the circulatory organs including hyperlipidemia, hypertension, obesity and hyperglycemia found in annual health checkups conducted at the workplace in 1996. They were also judged to be able to follow the exercise program prescribed by an industrial physician. Diagnostic criteria were as follows: hyperlipidemia; workers with total serum cholesterol of 220 mg/dl or more or HDL cholesterol of 40 mg/dl or less; hypertension was those who had systolic blood pressure of 140 mmHg or higher or diastolic blood pressure of 90 mmHg or higher and who were judged to be not requiring chemotherapy; obesity was those with BMI of 24.0 kg/m² or higher; and hyperglycemia was those with fasting blood sugar of 110 mg/dl or higher.

Methods
One hundred eight subjects selected as described above were assigned at random to one exercise and one control groups each consisting of 54 persons (Fig. 1). As for the subjects of the exercise group, confirmation was made in advance that the exercise for this study would not cause any problem by examining their respective stress electrocardiograms for the presence/absence of arrhythmia, ST-change and increase in blood pressure. The following was conducted on all the subjects of the exercise and control groups: physical examinations, life style questionnaire, food frequency questionnaire aiming to estimate dietary cholesterol intake and fasting blood sampling for measurements of TCH, HDLc, triglyceride (TG) and HDL₃⁻ cholesterol (HDL₃C, HDL₄C) before the start of the study and 3 and 6 months after.

Physical examinations included the measurement of height, body weight and the waist-hip ratio (WHR). The degree of obesity was calculated from the Body Mass Index (BMI). For waist and hip size, the girth at the navel and also at the synchondrosis pubis level was measured. Life style data including cigarette smoking, alcohol drinking, regular exercise and intensity of physical activity were obtained by means of a questionnaire. For smoking and drinking, “yes” means that the subjects were in the habit regardless of the quantity; for regular exercise, “yes” means that the subjects were taking more than 30 minutes’ exercise at least 3 times a week; physical activity was graded as “light”, “moderate” and “heavy” according to the number

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**Fig. 1.** Flowchart for the evaluation of the physical fitness and health promotion.

*Subjects were selected among men with two or more risk factors for hypertension, hyperlipidemia, obesity and hyperglycemia among annual health checkups in 1996.*
of hours standing and walking each day and following the criteria of the National Nutrition Survey. Blood samples were all taken in the morning before breakfast. Particularly in December when people drank more, the subjects were asked to refrain from drinking as much as possible the day before blood sampling. The blood samples were collected in vacuum tubes. The tubes of serum for examination were, after being allowed to stand and to coagulate, centrifuged to separate the serum. The serum samples were sent to SRS, Inc., a clinical laboratory center, in the morning of the sampling day. Hematological examinations were all entrusted to SRS, Inc., with precision being assured by its internal and external quality control units. It was confirmed that there was no problem with regard to the precision of measurements during the period of this study.

Statistical analyses of data were done with SAS Statistics software, Release 6.11. An appropriate t-test was applied to the changes from the baseline to 3- and 6-month data to detect any significant differences.

Five persons dropped out of the exercise group, and two out of the control group due to transfer or leg injury, so that the final numbers of subjects 6 months later were 49 and 52, respectively.

**Training**

Aeromill STM-1420 (NIHON Koden CORPORATION) treadmill were used for exercise training. By using an interval training protocol set up on this treadmill (Fig. 2), the intensity of walking exercise was adjusted to 70–75% of the maximum heart rate (HR$_{max}$=220 minus the subject's age). This treadmill model displays actual measurements transmitted from a sensor attached to the chest of the walker and their percentages of the HR$_{max}$ every 5% from 50%. That is, the subjects could monitor their own heart rate while taking exercise and confirm the intensity of exercise at any time. In the present study the subjects were trained to take this 20-min exercise 3 times a week for 6 months. During this period, each subject had his own notebook, with the date of the exercise, set point of walking speed, subjective symptoms and the day's maximum heart rate recorded. By using two treadmills, a schedule was set so that all the subjects in the exercise group could do the specified exercise within their working hours.

Since the walking speed differs from person to person according to their physical fitness, a preliminary test was carried out to determine the adaptive walking speed for each subject. In this test, set up on the treadmill model used, the speed was gradually accelerated at 1, 4 and 7 minutes during 10 minutes' walking exercise; based on the heart rate recorded at the end of each stage and the walking speed, the speed at which heart rates of 60, 65 and 70% HR$_{max}$ would be attained was estimated by the least squares method. Taking into consideration the speed estimate producing 70% HR$_{max}$ thus obtained, subjective symptoms and increases in heart rate during exercise, the speed producing a heart rate of 70–75% HR$_{max}$ was determined. Such a walking test was conducted once a month on all the subjects in the exercise group in order to evaluate their physical fitness and, based on its changes, the speed was appropriately corrected, so that the intensity of exercise could be maintained at 70–75% HR$_{max}$.

**Results**

Table 1 compares the baseline lifestyle data of the exercise and control groups; there are no difference between the two groups. Table 2 shows the changes in WHR, BMI and daily dietary cholesterol intake from the baseline to 3 and 6 months after. In WHR of the exercise group, significant decreases were noted both at 3 and 6 months after. BMI values showed a decreasing tendency in the exercise group.

Figure 3 shows the changes in serum lipid (TCH, HDLC and TG) levels in 6 months in the exercise and control groups. TCH levels showed an increasing tendency with time in both the groups, with significant increases noted at 6 months after in the control group. For HDLC levels, an increasing tendency was noted in the exercise group both at 3 and 6 months after; significant increases were detected also in the control group at 6 months after. TG levels showed a decreasing tendency but no significant difference was noted. Fig. 4 shows the changes in HDL$_2$C and HDL$_3$C, subfractions of HDLC. For HDL$_2$C, although significant increases were seen in the exercise group at 6 month after, there was no change in the control group at any time. HDL$_2$C levels significantly decreased in the exercise group, but significantly increased in the control group. From these results, the increases observed in HDLC levels were considered to be attributable to those of HDL$_2$C and HDL$_3$C in the exercise and control group, respectively. In addition, the ratio of HDL$_2$C to HDL$_3$C (HDL$_2$C/ HDL$_3$C) was increased in the exercise group, but significantly decreased in the control group (Fig. 4).
There was no difference between both groups ages.

When the changes in adaptive walking speed permitting continuous walking at the intensity of 70–75% HRmax were analyzed (Fig. 5), significant increases were seen between the baseline and 3-month average values and between 3- and 6-month average values in most of the exercise group. Most of the exercise group maintained their spontaneous physical training-20-min exercise more 3 times a week to identify areas of collaboration to promote physical activity for health. Participants agreed to establish a consultative group on promoting worker’s health at workplaces.

**Discussion**

In the present study exercise training was done as a part of health-building in accordance with THP at an enterprise with about 1,300 employees. The outline of THP in Japan is as follows: based on the results of medical examination conducted by industrial physicians, a health control chart is prepared for each worker describing the actual conditions, exercise training corresponding to his/her exercise function, mental health care, nutrition and hygiene guidance needed; professional staff assume their respective roles in accordance with this chart. Its implementation rate is by no means high, however. According to Yanagida’s report, the system for health-building is far from established particularly in minor enterprises, with the rate of implementation of exercise training in particular being only 15% even among major enterprises. Although the main reason for this was the absence of an appropriate trainer or place, it seemed important to propose any practical training program and its efficacy in order to increase the rate of implementation exercise training in THP.

The exercise training in this study was characteristic, that is, the intensity of exercise was kept to 70–75% HRmax by monitoring heart rate during walking on a
treadmill and comparisons were made between two groups randomly assigned with regard to the serum lipid levels which would reflect the effects of exercise. In addition, subjects in the exercise group were, after learning to walk at 70-75% HRmax on the treadmill, expected to become capable of taking approximately the same exercise in daily activities without using the treadmill.

Of 54 initially assigned to the exercise group, 3 subjects dropped out during the first month due to the pressure of
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Of 54 initially assigned to the exercise group, 3 subjects dropped out during the first month due to the pressure of
the work and 2 due to leg injury unrelated to the exercise on the treadmill. Ten subjects, out of the final 49, exercised 3 times per week on average and the others independently initiated additional exercise twice or more per week, demonstrating that the exercise habit was acquired. Accordingly, the effect of acquired exercise habit was evaluated by comparing the results with those of the control groups.

There have been a number of studies dealing with the association between exercise and serum lipids, with increases in HDLc, particularly the HDL2C subfraction, reported12, 13. The mechanism of the increase was attributed to an increase in LCAT (lectin cholesterol acyltransferase) activity and a decrease in hepatic triglyceride lipase (converting HDL2C to HDL3C) activity after exercise13, 14. Concerning TCH, on the other hand, some authors reported a decrease and others reported no change15.

In our study, although no effects were seen for TCH, it can be said that the exercise was effective at least in preventing its increase when the significant increases in TCH in the control group are taken into consideration. For HDLC, serum levels showed significant increases at 3 and 6 months after from the baseline, whereas almost no change was detected during the period from 3 to 6 months; in addition, significant increases were also seen in the control group. In the exercise group, however, the subfraction HDL2C increased at 6 months after and, in contrast to this, HDL3C decreased. In the control group, on the other hand, HDL2C showed a significant increase at 6 months after. The HDL2C/HDL3C ratio increased significantly in the exercise group and decreased significantly in the control group. These results mean that the increase in HDLC in the exercise and control groups was attributable to increased HDL2C, with possible anti-arteriosclerotic action, and to increased HDL3C, respectively. The fact that HDL2C significantly increased after 6 months suggests that exercise 3 times or more a week should be continued for 6 months or so in order to augment the HDL2C level. Although a tendency to a decrease in TG was seen in the exercise group, there was no significant difference between the exercise and control groups.

Researches aiming to develop training programs have generally been animated by findings showing that the more one takes exercise, the more physical fitness improves. They have also played an important role in establishing methods for popular use to improve maximum oxygen intake and to strengthen muscles. There has been a delay, however, in developing exercise programs aimed at reducing risk factors of any particular disease, for example cardiovascular disease. According to recent reports, it requires much less exercise to reduce pathogenic factors than that required to increase physical fitness and maintain it at a higher level15, 16. Although it is advisable for almost all people to take exercise of the former quantity, there are few adults who do so. For those who have little occasion to practice a sport, moderate exercise and appropriate physical activities in daily life will be very beneficial for health.

Normal function of muscles and bones depends on a sufficient range of mobility being maintained for all joints. Since the loss of flexibility in the hip-posterior femoral region, in particular, is liable to develop into chronic low back pain, it is important to keep this region flexible. In this respect, suitable motion and movement should be included in exercise and rehabilitation programs in preventive medicine. Since persons of middle or old age in particular tend to be defective in this flexibility and to suffer from its symptoms in daily activities, appropriate stretching movements of the upper/lower parts of the body, neck and rump should be emphasized in the exercise program. Stretching exercise is more effective when taken at least three times a week and at the time of warming up or cooling down before and after aerobic training. To give employees appropriate jobs from the viewpoint from their health, conventional exercises should be performed to warm up the muscles before starting work. They are effective for softening muscles that are used repeatedly during work.

The strength and endurance of the muscle does not show any linear correlation with the strength of the respiratory/circulatory organs and motor capacity [physical ability]. In leisure activities and labor, however, physiological stress induced by movements of arms such as lifting up, carrying and holding a heavy object is directly proportional to the maximum muscular strength. It follows that if the strength and endurance of muscles are maintained or enhanced, physiological stress due to daily activities and works can be reduced. The maintenance of appropriate muscular strength is more important for aged persons, because the net weight of muscles declines with age.

With the interval of training on a treadmill conducted in this study, the subjects could reach their own walking speed producing 70–75% RH-max and we could recommend to persons of middle and advanced age with different age and working conditions an exercise program applicable to their daily life: the amount of walking necessary for the maintenance and promotion of health. The results, if generally applied, can lead to working out a method for devising such a program by using other readily available devices such as an ergometer or pedometer. Furthermore, rating of perceived exertion (RPE) which does not need any equipment would be useful if introduced into such a program11, 17, 18. RPE is closely related to a number of variables relating to exercise, such as % maximum exercise peak oxygen intake, % heart rate reserve, minute ventilation and lactic acid level in blood. It has also been demonstrated that
RPE is highly reproducible as a method of measuring exercise irrespective of age and sex: almost all people feel exercise a little hard or hard (RPE 13–16) at the ventilation threshold (60–75% of oxygen intake at peak) and reach a limit of fatigue at RPE 18–19 (very hard). RPE, linearly increasing as the intensity of exercise increases, is reflected in the closest correlation the physiological reactions such as heart rate, minute ventilation and oxygen consumption which linearly increases with exercise intensity. In the early stage of the program, users are instructed to take exercise at a specified heart rate and to control RPE at that intensity. After the user learns from experience the relation between heart rate and RPE, it is no longer necessary to frequently monitor the heart rate, and RPE becomes the only measure to control the intensity of exercise. This is because the changes in RPE can be used as a guideline to modify the prescribed exercise.

We consider it quite possible that adaptive physical activity could be devised for workers in order to promote a THP program. It is a well-known fact that physical training is accompanied by a reduction in plasma lipids and improvement in physical fitness, but the advocacy of physical activity for health includes supporting activities in medium and large-sized enterprise, thereby promoting the creation of comfortable workplaces. The scope of activities was later increased and now covers a wide range. Industrial health staff other than industrial physicians-health nurses, nurses and health supervisors, etc., are striving to enhance the workers’ physical condition. More studies should be done to determine whether a high level of physical fitness plays a prominent role in the workplace.

Conclusion

In the present study, we proposed a program consisting of walking exercise which induced 70–75% of the maximum heart rate as part of exercise training in accordance with THP. As a result in the exercise group, increases were observed in HDL-C and HDL-C which have an anti-atherosclerotic action. Beneficial effects of exercise other than these were demonstrated, such as increased adaptive walking speed and decreased WHR.

References