# The Effectiveness of an Aerobic Exercise Intervention on Worksite Health-Related Physical Fitness - A Case in a High-Tech Company

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**Background:** The major objective of this prospective study was to evaluate the effects of aerobic exercise intervention with goals of improving health-related physical fitness in one high-tech company in Taiwan.

**Methods:** This study was conducted as a quasi-experimental design. Among the 54 subjects enrolled in the study, 26 subjects of the volunteers agreed to participate in an aerobic exercise program. The control group was comprised of a similar sample of 28 subjects working at the same company. Subjects in the exercise group participated in a 12-week aerobic exercise program, while subjects in the control group did not participate.

**Results:** The results of analysis of variance with repeated measures of health-related physical fitness showed that the subjects in the exercise group had significantly more improvements in abdominal muscle strength and endurance than the subjects in the control group.

**Conclusions:** This study indicated that one 12-week aerobic exercise program was effective in improving the abdominal muscle strength and endurance of employees of a high-tech company.

*(Chang Gung Med J 2006;29:100-6)*

**Key words: aerobic exercise, physical fitness, cardiorespiratory endurance, abdominal muscle strength and endurance, flexibility of the lower back, body-mass-index.**

Evidence from previous studies has shown that physical inactivity has positive association with clinical risk indicators such as abnormal blood pressure and fasting plasma glucose.[1,2] Furthermore, the decline in average daily energy expenditure is a likely underlying cause of the obesity.[3] Indisputable evidence links both obesity and inactivity to risks of cardiovascular disease and type 2 diabetes.[4] Results of previous studies have shown that the impact of participation in aerobic physical activity not only increased energy expenditure but also improved health-related physical fitness.[5]

Health-related physical fitness was initially defined to include cardiovascular endurance, abdominal muscle strength and endurance, lower back flexibility, and body mass composition.[6] Both increased energy expenditure and improved cardiovascular fitness have been associated with lower incidence of obesity and lower risk for cardiovascular diseases and type 2 diabetes.[7] The results of a majority of studies have shown that regular physical activity has the benefit of maintaining a healthy weight. For those who need to lose weight, physical activity is a critical component of weight management.[8]

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Received: Sep. 16, 2005; Accepted: Dec. 13, 2005
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Therefore, the promotion of physical activity should be an important part of public health policy. What remains to be determined is how to effectively promote physical activity in a practical way and at an affordable price.[9]

Previously, researchers have demonstrated that work sites are opportune settings for delivering health promoting exercise programs.[10,11] Health promotion resources available at work include various means for educating employees and support of changes through health-related policies at the organizational level. Attractive features of these programs include convenient access to populations in need, and the potential for cost recovery through reduced absenteeism and health care expenditures.[12] Despite these apparent strengths, empirical data on the effectiveness of work-site physical activity programs in Taiwan are relatively sparse.

In this pilot study, we conducted as prospective quasi-experimental design to evaluate the effects of aerobic exercise programs with the goals of improving health-related physical fitness in a high-tech company.

## METHODS

### Participants

This study was conducted at the Nanya Technology Corporation in Northern Taiwan. The company conducts research and development, design, manufacture, and sales of DRAM products, with worldwide sales offices in USA, Europe, Japan and China. Subjects for the study were self-selected from the employees to participate in this program. Study inclusion criteria consisted of absence of physical illness and disabilities that would limit daily physical activities. All participants received written and oral instructions for the study and each gave their written informed consent prior to participation. Among the 54 subjects enrolled in the study, 26 subjects of the volunteers agreed to participate in the aerobic exercise program. The control group comprised a similar sample of 28 subjects working at the same company and recruited in the same manner. None of the subjects history of cardiovascular, pulmonary or musculoskeletal diseases. The subjects had not previously participated in aerobic exercise programs and all were relatively sedentary in that they had not participated in other forms of sports or exercise for health.

### Procedure

The prospective quasi-experimental study design involved pre- and post-measurement tests relating to the 12-week period of the aerobic exercise program. The dependent variables, health-related fitness as Chester step test (cardiorespiratory endurance), timed sit-ups (abdominal strength and endurance), sit-and-reach (lower back flexibility), and body-mass-index (BMI, for body composition) were measured in all subjects. Subjects in the exercise group participated in 12 weeks of aerobic exercise classes held 2 days per week. Each exercise session lasted 60 min and was led by a certified instructor. It included 20 min of warm up exercises (including stretching and balancing exercises), 30 min of aerobic exercise, and was followed by 10 min of cool down exercises (similar to the warm up exercises). During the same 12-week period, the subjects in the control group were instructed to continue with their current level of activity, with no control for social interaction.

### Health-related physical fitness assessment

All measurements were taken at the company, 1 week before the exercise program began and again 12 weeks after the start of the program. All measurements were completed on the same specified day. Health-related physical fitness was categorized in four components. First, for cardiorespiratory endurance we used the Chester step test. The aims of the Chester step test was to predict $VO_2$ max as a means of grading a person's aerobic power, where this score can also act as a baseline against which improvement can be measured. In relation to this study, where a 0.35 m step was used, heart rate was monitored via a wireless radiotelemetry chest strap and wristwatch system (Polar Electro, Kempele, Finland) and rating of perceived exertion using Borg's 6-20 scale were record during the last 15 seconds of each testing stage. It was previously reported that the Chester step test was a reliable tool for the assessment of cardiorespiratory fitness and the prediction of aerobic capacity.[13] Second, abdominal muscle strength and endurance was measured using sit-up. The sit-up test was scored as the number of sit-ups performed within a 1-minute period. The subjects laid down on a mat with knees bent at right

angles and hands behind their heads. The ankles were firmly held by their partners for support. The subject's elbows alternately touched the opposite knee during the execution of the test. Third, we measured the flexibility of the lower back using the sit-and-reach technique. The sit-and-reach test was scored as the most distant point (in cm) reached on the ruler with their fingertips. We used a specially constructed box with a measuring scale where 23 cm is at the level of the feet. Each subject was given three trials and the best result was chosen. The subject removed his/her shoes before sitting at the test apparatus with the knees fully extended. Finally, we tested the Body-Mass-Index. The heights and weights of all subjects were measured to estimate BMI. Weight was measured with the subject wearing light shorts, a shirt and socks. Height was measured with the subject standing with heels together and gently stretched upward.

**Data analysis and statistics**

Wilcoxon Rank Sum test and Fisher's Exact test were used to analyze the statistical differences in baseline characteristics between study participants in the exercise group and control group. Analysis of variance with repeated measures was used to detect any differences in physical fitness between the exercise group and the control group during the study period. All data were analyzed using SPSS statistical software, version 12.0 (SPSS, Chicago, Ill., USA). All reported p values less than 0.05 were considered statistically significant.

## RESULTS

Of the 54 participants recruited, 16 subjects from the exercise group failed to complete the program and all subjects from the control group returned for the follow-up evaluations. The compliance rate was 38.5% (10/26) in the exercise group and 100% (28/28) in the control group.

Table 1 shows the initial physical characteristics of the two groups. The subjects in the control group were younger and had a smaller mean value of BMI than those subjects in the exercise group. Except for abdominal muscle strength and endurance, there were no significant differences in any of the other basic characteristics between the two groups. The abdominal muscle strength and endurance of the control group in the pre-test was significantly higher than that of the exercise group ($p = 0.04$).

**Table 1.** Initial Physical Characteristics of the Exercise and Control Groups

| Item | Exercise group (n = 10) | Control group (n = 28) | *p*-value* |
|---|---|---|---|
| Gender [n (%)] | | | |
| Male | 4 (40) | 14 (50) | 0.72 |
| Female | 6 (60) | 14 (50) | |
| Age (years) | 29.25 ± 2.99 | 27.75 ± 4.05 | 0.31 |
| BMI | 23.73 ± 5.07 | 22.47 ± 2.73 | 0.57 |
| Cardiorespiratory endurance (Chester step test) | 59.68 ± 8.56 | 56.24 ± 10.49 | 0.22 |
| Abdominal muscle strength and endurance (Time sit-ups, n/1 min) | 19.70 ± 6.55 | 26.96 ± 8.83 | 0.04 |
| Flexibility of the lower back (Sit and reach, cm) | 29.93 ± 10.59 | 29.64 ± 5.39 | 0.38 |

**Abbreviations:** BMI: body mass index.
Data are means ± SD unless noted otherwise.
*Baseline comparison of two groups

In Table 2 we listed the results of the analysis of variance with repeated measures of physical fitness. Because the interaction of the groups during the testing periods was not significant in any of these variables, the *p*-value for testing the significance of the group factor is showed in Table 2. Except for abdominal muscle strength and endurance, there were no significant differences between the two groups or the two testing periods. After completing the 12-week exercise program, the subjects in the exercise group had significantly greater improvements of abdominal muscle strength and endurance than the subjects in the control group ($p = 0.03$).

## DISCUSSION

The result of our current study provided data to indicate improvement in the abdominal muscle strength and endurance of employees from a high-tech company following a 12-week aerobic exercise program. However, the results should be interpreted with a few limitations. The major limitation of this study was that it was conducted as non-randomized, self-selective experimental design which may have led to the self-selection bias. That may have resulted in a biased estimate of the effects of aerobic exercise

**Table 2.** Results of Analysis of Variance with Repeated Measures of Health-Related Physical Fitness between the Exercise Group (n = 10) and the Control Group (n = 28)

| Item | Group | Pre-test | Post-test | F-value | *p*-value* |
|---|---|---|---|---|---|
| BMI | Exercise group | 23.73 ± 5.07 | 23.50 ± 4.54 | 0.87 | 0.36 |
| | Control group | 22.47 ± 2.73 | 22.46 ± 2.70 | | |
| Cardiorespiratory endurance | Exercise group | 59.68 ± 8.56 | 56.74 ± 6.75 | 2.41 | 0.13 |
| (Chester step test) | Control group | 56.24 ± 10.49 | 52.72 ± 6.46 | | |
| Abdominal muscle strength and | Exercise group | 19.70 ± 6.55 | 23.60 ± 5.56 | 5.30 | 0.03 |
| endurance (Time sit-ups, n/1 min) | Control group | 26.96 ± 8.83 | 27.96 ± 6.97 | | |
| Flexibility of the lower back | Exercise group | 29.93 ± 10.59 | 32.25 ± 6.94 | 0.01 | 0.95 |
| (Sit and reach, cm) | Control group | 29.64 ± 5.39 | 28.07 ± 9.32 | | |

**Abbreviations:** BMI: body mass index.
Data are means ± SD unless noted otherwise.
* Testing the significance of the group factor

on physical fitness. As shown in the present study, except for the mean value of abdominal muscle strength and endurance in the exercise group, the mean values of the pre-test for health-related physical fitness were, in general, within an acceptable range from a public health point of view. These results would bias the study towards a particularly healthy study population with a better physical fitness. These observations may explain our findings that only abdominal muscle strength and endurance showed improvement in the exercise group after 12 weeks of aerobic exercise.

In the present study, the results of analysis of variance with repeated measures showed significantly more improvement in muscle strength and endurance for the subjects in the exercise group than in the control group. This result is similar to the results of studies that have used concurrent aerobic and resistance exercise,[14] as well as most other previous studies.[15,16] It is difficult to compare results directly because strength testing protocols in the studies were different.

In our present study, the improvement in flexibility of the lower back (sit and reach test) was not as great as that in abdominal muscle strength and endurance (sit-up test) in the exercise group. This finding is similar with the findings of studies that used concurrent aerobic and resistance exercise.[14] Although the participants performed stretching exercises prior to and following each training session, the differential effects observed in flexibility and abdominal muscle strength and endurance may be attributed to our aerobic exercise training program that might not stress flexibility as much as the abdominal muscle strength and endurance. Therefore, fewer effects were observed in the flexibility than the abdominal muscle strength and endurance.

The absence of significant improvements in cardiorespiratory endurance (Chester step test) in this study was surprising given that the results of most previous studies suggested that cardiorespiratory endurance improved after aerobic exercise.[17] This discrepancy may be due to the small number of subjects in the present study and which may have led to greater variations among participants. Consequently, there were no significant differences between either the two groups or two testing periods.

In the exercise group, BMI improved but did not reach a statistically significant level in the current study. This result is possible because the body composition is affected not only by exercise, but also by other factors including food intake. Although participants were instructed not to change their dietary habits, no measure of nutritional intake was performed. Further research is needed to determine how nutrition and aerobic exercise training may interact to affect the body composition.

Subject's compliance has been reported to be an important factor in the exercise training aimed at improving physical fitness.[15] In order to ensure compliance of the subjects to the exercise training program, in the present study, subjects were asked to choose groups based on their anticipated compliance. Most subjects wanted to choose the control group because they were unable to attend the exercise training 2 times a week for 3 months. The compliance in our study was only 70.4% (38/54), whereas other studies reported a 70-85% of compliance.[15,16,18,19] The

main reason for the noncompliance was the absence from aerobic exercise sessions. The major reasons for the absence from aerobic exercise sessions were sickness, busy at work, and traveling for business. These reasons were similar to those reported in most previous studies of exercise programs.[15,16,18]

The result of previous studies on exercise programs for health-related physical fitness were conflicting since the exercise programs employed in these studies varied in mode, duration, intensity, and frequency. The most commonly used duration and frequency in the reported studies were 30 to 60 minutes per session, two to three times a week.[15-17,20] The length of the exercise programs varied from 3 to 48 months. The exercise sessions used in the present study were 60 minutes long, two times per week, which are popular and feasible for the general population. However, the most recent guidelines for healthy aerobic activity from American College of Sports Medicine were 40 to 65 minutes per session, three to five times a week.[21] The frequency of the exercise sessions may need be to increased to three to five times a week before the training effects on cardiorespiratory endurance, flexibility and body composition of the exercise group in this study are demonstrated.

This was a pilot study that was conducted in a workplace for health promotion. Because the aerobic exercise training program was held at the company, it was convenient and safe for the study subjects to participate. We also observed additional benefits of aerobic exercise training for the exercise group. To participate in the exercise training as a group may have provided additional psychological and social benefits such as enjoyment and new friendships that contributed to a willingness to continue participation in the program. The subjects in the exercise group appeared to enjoy the training as evidenced by the high attendance rate during the program. Furthermore, the enthusiasm demonstrated by the participants during the exercise sessions suggested that they enjoyed the program. Because our exercise program was conducted in a group setting, it provided an opportunity for the participants to interact socially with their peers.

In summary, our findings suggest that abdominal muscle strength and endurance improved after 12 weeks of aerobic exercise. Note, however, that this study was non-randomized. Nonetheless, our study results suggested that the workplace is an appropriate setting for increasing physical activity.

**Acknowledgement**

This study was supported by grants from the National Science Council of the Republic of China, Taiwan (Contract No. NSC91-2416-H-182-004).

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# 職場有氧運動對健康體適能成效評估：以某高科技公司爲例

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**背 景：** 本研究爲前瞻性研究，研究目標對象爲北部某高科技公司之員工，主要研究目的爲評估以增進健康體適能爲主要目標之 3 個月有氧運動介入。

**方 法：** 本研究採類實驗設計 (quasi-experimental design)，依研究對象意願分爲介入組 26 名與對照組各 28 名。介入組進行 12 週的有氧運動，每週 2 次，每次 60 分鐘；對照組不做介入運動。

**結 果：** 應用重覆測量變異數分析，結果顯示有氧運動介入後，介入組相較於對照組，在肌耐力方面有統計上之顯著進步；而在心肺耐力、柔軟性、及身體質量指數方面，並無統計上之顯著進步。

**結 論：** 研究結果顯示 3 個月有氧運動介入能有效提昇研究對象之肌耐力。
(長庚醫誌 2006;29:100-6)

**關鍵詞：** 有氧運動，體適能，心肺耐力，肌耐力，柔軟性，身體質量指數。

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