

Effects of a 5-year exercise-centered health-promoting programme on mortality and ADL impairment in the elderly

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Abstract

Objective: the effects of regular exercise over 5 years on mortality and ADL impairment were evaluated in elderly people.
Design: intervention study.
Setting: Tsuru City, Yamanashi Prefecture, Japan.
Methods: the subjects of this study were 245 elderly people living at home. Of these individuals, 155 (56 males aged 76.5 ± 4.2 years at the baseline level; 99 females aged 76.2 ± 4.8 years) who voluntarily participated in our original health-promoting programme were regarded as an intervention group. The remaining 90 (29 males aged 77.6 ± 5.2 years at the baseline level; 61 females aged 77.3 ± 5.1 years) were regarded as a control group. The programme was a 5-year intervention consisting of collective sessions given six times a year every 2 months. The intervention was a combination of an exercise programme based on theories of exercise physiology and a support programme based on health education theories. The relative risks of death and ADL impairment adjusted for age, presence or absence of cardiovascular or musculo-skeletal disorders, and functional fitness level at the baseline were calculated using logistic regression analysis.
Results: the rates of participant compliance per year were 67.7% in the first year of the intervention period and gradually decreased thereafter to 43.9% in the last year. Amongst female subjects the percentage of those who exercised habitually at the end of the study period was the same as that in the baseline in the intervention group but was signifi cantly lower at the end of the study in the control group ($\chi^2 = 10.576$, $P < 0.01$). The relative risk of death in the intervention group was 1.0 (95% CI 0.22–4.51) amongst the males and 0.16 (95% CI 0.03–0.81) amongst the females. Relative risk of ADL impairment was 0.22 (95% CI 0.03–1.42) amongst the males and 0.36 (95% CI 0.13–1.02) amongst the females.
Conclusion: These findings suggest that the improved mortality and state of independence in the female portion of the intervention group occurred as a result of increased physical exercise levels in daily life. However, validation of our results must await research that employs a randomized control trial to avoid various biases and confounding factors between the intervention and the control groups.

Keywords: *elderly, exercise, intervention study, mortality, ADL impairment*

Introduction

In Japan the population is rapidly ageing. This phenomenon is expected to result in an increase in the number of individuals affected by conditions such as dementia and being bed-ridden, in addition to lifestyle-related disorders such as cancers, cardiovascular disorders, and diabetes mellitus [1]. Impairment of abilities needed for independent living is a cause of reduction or exacerbation of (i) medical conditions or physical functions, (ii) mental functions such as emotions and self-recognition, (iii) roles in the family or the society and functions of daily living including recreational activities, (iv) relations with family and friends, and (v) housing environment and the comfort of living in the local community.

Furthermore, problems related to old age such as increases in medical and welfare expenditure associated

with an increase in individuals who need support and a decrease in the working population due to a falling birth rate are serious social problems that Japan must urgently solve. Under these circumstances, prolongation of active life expectancy [2] (i.e. maintenance of the health of older people as long as possible so that they can live independently over a long period) is considered to be a goal in devising future health-protecting measures for the elderly, along with treating diseases and restoring impaired functions.

In many previous studies [3–7], exercise or physical activities have been suggested to have preventative effects on death, ADL impairment, and the occurrence of diseases. However, these results were obtained from cohort studies and they did not necessarily indicate their cause–effect relationship. Interventional studies are indispensable in ascertaining the preventative effects of exercise or physical activities against these age-related health impairments. Most of the interventional studies using exercise reported to date, however, encompassed a study period of only few months to about 1 year. Only a few previous studies considering the effect of an exercise intervention have been conducted over a period of several years [8, 9].

In this study, health-promoting programmes consisting mainly of exercise were conducted in physically independent elderly subjects for a period of over 5 years, and the effects of regular exercise over this period on mortality and ADL impairment were evaluated.

Methods

Subjects

In the present study the following inclusion criteria for the subjects in an intervention group were used at the baseline: (i) age of the subject was 70 years or older; (ii) the subject was maintaining independent living in daily life and free from serious medical problems; (iii) the subject was able to (or wished to) attend 'Health Class' regularly for 5 years. Based on these criteria, 155 elderly people (56 males aged 76.5 ± 4.2 years at the baseline level; 99 females aged 76.2 ± 4.8 years) living at home in a local community voluntarily participated as the subjects in the intervention group.

The subjects in a control group were based on the same inclusion criteria as the intervention group, excluding the third criterion. The control group consisted of 90 elderly people (29 males aged 77.6 ± 5.2 years at the baseline level; 61 females aged 77.3 ± 5.1 years) living at home in the same local community as the subjects in the intervention group. They voluntarily participated in the 'Elderly Health Survey' conducted by the authors in collaboration with the local government in 1993. The distribution of the subjects in each age and sex group in the intervention and the control groups are shown in Table 1.

Table 1. Number of subjects in each category in control and intervention group

	Intervention group		Control group	
Age (years)	Male	Female	Male	Female
70–74	20	44	8	18
75–79	21	28	12	20
80–84	13	22	6	18
85+	2	5	3	5
Total	56	99	29	61

The objectives and contents of this study and the handling of the results of measurements were explained to the subjects at their participation in the measurement survey, and informed consent was obtained from each of them. Human rights, including the privacy of individuals, were carefully respected in the analysis of the results. This study was carried out as a joint project with the health-promotion section in the local community.

Health-promoting programme

This programme is a 5-year intervention consisting of collective sessions (each lasting 120 minutes) given 6 times a year at 2-month intervals. The intervention was a combination of an exercise programme based on theories of exercise physiology and a support programme based on health education theories (Fig. 1).

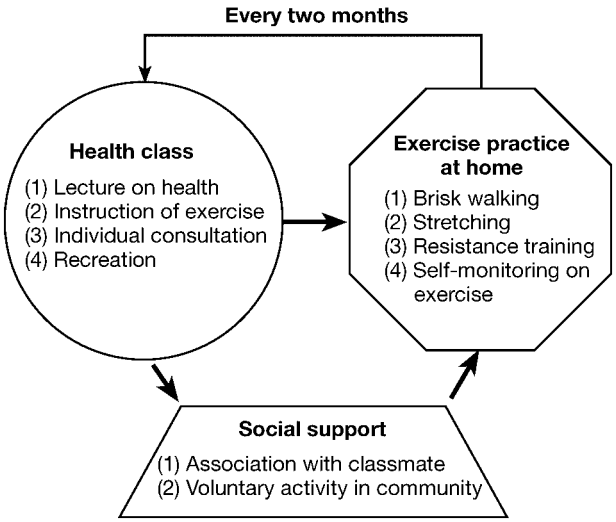

Figure 1. Flow chart of the health-promoting programme. This programme constituted the group-based, home-based, and community-based programme. Health class was given 6 times a year every 2 months. A session which takes 120 minutes concluded the lecture on health, instruction of exercise, health consultation, and recreation. Exercises which were walking, stretching, and resistance training performed at home. Voluntary activities associated with classmates were organised and managed in the community.

Exercise programme

The exercise programme was a home-based type and composed mainly of gymnastics and walking not requiring special equipment or a wide field so that it could be performed readily at or near the participants' home. The gymnastics consisted of five stretch exercises: (i) relaxing of the whole body, (ii) stretching of the shoulders, (iii) stretching of the dorsal part of the thigh, (iv) stretching of the hips, (v) stretching of the waist. It also consisted of two leg muscle development exercises using rubber tubes: (i) knee extension in the seated position, and (ii) hip flexion in the seated position. The subjects were instructed to walk with strides longer than usual. We instructed them to perform these exercises as often as possible in their daily routine.

Support programme

The support programme was organised as follows to facilitate the establishment and continuation of an exercise habit.

(i) Self-monitoring: to objectively evaluate the exercise level, the subjects were required to record in a diary the details of the exercises they performed (type, frequency, and duration of exercise) and the total number of steps of walking daily using a pedometer. This exercise diary was collected at the health class and used for individual counselling.

(ii) Counselling: to eliminate negative factors associated with exercising and to promote changes towards an active lifestyle, the study staff gave individual consultations at each class for linking and systematizing the subjects' motives. Goals of exercise were set individually depending on changes in physical condition, fitness level, and self-efficacy.

(iii) Social support: to enhance the voluntary nature of exercising, the subjects were supported in organizing and managing voluntary exercise groups and events (walking groups, hiking, recreational events, etc.). To inform the participants' families and regular absentees about the state of the classes, a newsletter called Fitness Bulletin was published, and brief reports on the classes and contributions from the participants, such as poems and illustrations, were included. Public health nurses provided home-visit guidance, and the attendants made friendly visits to those who missed classes.

Investigation items

Initial survey

The initial survey was carried out in April 1995 for the intervention group and in October 1993 for the control group. The following investigation items were measured on both groups.

(i) *Functional fitness*. In this study, functional fitness has been operationally defined as an individual's ability to pursue daily life activities, and an objective test for assessing functional fitness has been developed [10, 11]. The test is based closely on the assessment of daily life physical activities. However, unlike conventional ADL scales, this instrument is primarily designed for assessing functional status in independently living older people.

The functional fitness test is designed to assess the major physical movements performed during daily activities which are classified into four groups: standing and sitting movements (getting up from the lying position, standing up, sitting, and lying down); locomotive movements (walking, running, walking up and down the stairs); housework movements (cooking, sewing, cleaning); and self-care movements (changing clothes, taking a bath, grooming). The ability to perform these movements in the test is evaluated by measuring the time taken to perform a given movement, which is related to the movement in each group of movements in daily life.

Functional fitness is assessed by scoring the measurement in each test-item using the formula below separately for males and females, with the sum of the scores for the 4 items being calculated as the total score of functional fitness. The total score of functional fitness is considered to be better as this value is higher. Score for each item = (50 + (mean – measured value)/standard deviation of samples × 10) ÷ 10.

(ii) *History or current status of cardiovascular and musculo-skeletal disorders*. The history or current status of cardiovascular and musculo-skeletal disorders in each subject that were identified as the confounding factor of the functional fitness in our previous studies, were examined through interviews by physicians or public health nurses.

(iii) *Exercise habit and social activities*. A questionnaire that had been used in previous studies [12] for exercise habits and social activities was used here to obtain this information from the subjects. Exercise habit was looked at in terms of the subject's frequency of walking and doing gymnastics. Social activities were investigated in terms of the frequency of doing a hobby, associating with others, participating in a senior club activity, and volunteering. Their answers were recorded as 'often', 'sometimes', or 'seldom'.

Follow-up survey after 5 years

Following follow-up surveys were carried out in April 2000 for the intervention group and in October 1998 for the control group.

(i) *Mortality and state of independence*. Every subject in each group who attended the initial survey was followed-up after 5 years with regard to mortality and independence in daily living. The follow-up survey was conducted by public health nurses in the community. Deaths of subjects during the study period was confirmed using death certificates.

The state of living in daily life of those who survived after 5 years was assessed using the standardized sheet for the assessment of independence published by the Ministry of Health and Welfare [1]. Subjects were classified under

Table 2. Characteristics of the subjects in age, history of disease, and functional fitness score in control and intervention group at baseline. History of disease was indicated as the percentage of subjects with a history of cardiovascular and/or musculo-skeletal disorders

	Male			Female		
	Intervention group	Control group	Significance	Intervention group	Control group	Significance
Average age (years)	76.5 ± 4.2	77.6 ± 5.2	ns	76.2 ± 4.8	77.3 ± 5.1	ns
History of disease (%)	66	65	ns	85	69	$P < 0.05$
Functional fitness score	20.6 ± 3.2	18.9 ± 3.2	$P < 0.05$	20.6 ± 3.3	19.0 ± 3.1	$P < 0.01$

the categories: Independent, Mobility Impairment, and ADL Impairment. Those who were classified under Mobility Impairment were almost independent but had difficulty in walking outdoors without help. Those in the ADL Impairment category needed help with eating, dressing, using the toilet, and other domestic activities.

The procedure of the survey was as follows: first, a notification of the follow-up survey was mailed to the subjects inviting them to participate in the collective examination. The participants in the collective examination were interviewed and all were confirmed to be independent. Those who did not participate in the collective examination were contacted by telephone or home visit. In this study, the subjects ranked as no impairment were considered to be independent, and those ranked as mobility and/or ADL impairment were considered to be disabled, and the cumulative incidence rate of disability during the 5 years was calculated.

(ii) *Exercise habit*. The habits of exercise were investigated similarly to the initial survey.

Statistical analysis

Student's *t*-test for un-paired data was used to test the differences in ages and total score of functional fitness between the two groups. The χ^2-test was used to evaluate differences in the changes in exercise habit and social activities during the study period between the intervention and the control groups. In order to adjust for the differences in physical characteristics at baseline between the two groups logistic regression analysis was carried out using mortality and degree of independence as dependent variables, and the presence or absence of intervention (present = 1, absent = 0) as independent variables. The subjects were categorized into 'survivors' (0) and 'deceased' (1) with regard to mortality, and into 'completely independent subjects' (0) and 'others' (excluding those who died) (1) with regard to degree of independence. Age, history, or current status of musculo-skeletal and/or cardiovascular disorders (present = 1, absent = 0), and total score of functional fitness at baseline were included in the model as adjustment variables. The relative risks, adjusted for these confounding factors, for death and disability and the 95% confidence intervals (95% CI) associated with the intervention group were calculated against the control group as a reference value. All these analyses were performed using the SPSS statistical package for Windows at a 5% level of significance.

Results

Characteristics of subjects

Comparisons were made between the intervention group and control group with regard to the age, state of contraction of cardiovascular or musculo-skeletal disorders, and level of functional fitness at the initial survey (Table 2). As a result, no difference was observed in age between the two groups in either males or females. The percentage of subjects who previously or currently suffered from cardiovascular or musculo-skeletal disorders was not different between the two groups in males but was significantly higher in the intervention group than in the control group in females. The total score of functional fitness was significantly higher in the intervention group than in the control group in both males and females ($P < 0.05$ for males, $P < 0.01$ for females).

Compliance of the programme

Participation in the health class

Attendances at the health class in this programme more than three times during a year were regarded as a complied participation. The rates of the complied participants per year were 67.7% in the first year of the intervention period and 43.9% in the last year. After exclusion of those who could not participate in this programme due to death or disability, the actual rate of the subjects who remained active in the programme until the last year of the intervention period was 57.6%.

Change in the exercise habit and social activities between pre and post intervention

Table 3 shows the difference of the changes in exercise habits and social activities during the study period in this study. In the females, only exercise habit showed a significant difference ($\chi^2 = 10.576$, $P < 0.01$) of the change

Table 3. Change in exercise habits and social activities during the study period

	Group (*n*)	Baseline % (*n*)	After 5 years % (*n*)	Significance
Gymnastics or walking				
Male	Control (20)	65.0 (13)	70.0 (14)	
	Intervention (44)	77.3 (34)	86.4 (38)	ns
Female	Control (34)	85.3 (29)	61.8 (21)	
	Intervention (82)	70.7 (58)	80.5 (66)	$P < 0.01$
Hobby				
Male	Control (20)	60.0 (12)	65.0 (13)	
	Intervention (43)	76.7 (33)	83.7 (36)	ns
Female	Control (34)	58.8 (20)	52.9 (18)	
	Intervention (82)	76.8 (63)	63.4 (52)	ns
Association with others				
Male	Control (19)	89.5 (17)	84.2 (16)	
	Intervention (44)	97.7 (43)	94.1 (38)	ns
Female	Control (34)	97.1 (33)	94.1 (32)	
	Intervention (83)	98.8 (82)	97.6 (81)	ns
Participation in senior club activities				
Male	Control (20)	85.0 (17)	60.0 (12)	
	Intervention (44)	97.7 (43)	84.1 (37)	ns
Female	Control (34)	88.2 (30)	73.5 (25)	
	Intervention (83)	96.4 (80)	80.7 (67)	ns
Volunteer activity				
Male	Control (20)	45.0 (9)	55.0 (11)	
	Intervention (44)	61.4 (27)	59.1 (26)	ns
Female	Control (34)	29.4 (10)	29.4 (10)	
	Intervention (83)	48.2 (40)	38.6 (32)	ns

during the study period between the intervention and the control groups. None of the social activities showed a significant difference of the change between the two groups.

Mortality and ADL impairment

At the follow-up survey after 5 years, all the subjects, except for one female in the control group, had their present health status identified. The summary of the effects of the intervention on the mortality and ADL impairment in each sex is shown in Table 4.

In the intervention group, 11 (8 males and 3 females) died and 11 (3 males and 8 females) became disabled. In the control group, 13 (5 males and 8 females) died, and 18 (4 males and 14 females) became disabled. Therefore, the crude cumulative mortality rate during the 5 years was 14.3%, and the crude cumulative incidence rate of ADL impairment was 5.4% in the males of the intervention group and 17.2% and 13.8%, respectively, in the males of the control group. In the females, the crude cumulative mortality rate during the 5 years was 3.0%, and the crude cumulative incidence rate of ADL impairment was 8.1% in the intervention group and 13.3% and 23.3%, respectively, in the control group. Logistic regression analysis using the baseline age, percentage of subjects with musculo-skeletal or cardiovascular disorders, and total score of functional fitness as adjustment variables showed a significant main effect of the intervention only in the females. The adjusted relative risk of death was 1.0 (95% CI 0.22–4.51) in the

Table 4. Relative risks of death and ADL impairment in intervention group

	Male				Female			
	Subjects	Events	CR (%)[a]	RR[b] (95 % CI)[c]	Subjects	Events	CR (%)[a]	RR[b] (95 % CI)[c]
Death								
Control	29	5	17.2	1.00 (referent)	60	8	13.3	1.00 (referent)
Intervention	56	8	14.3	1.00 (0.22–4.51)	99	3	3.0	0.16 (0.03–0.81)
ADL impairment								
Control	29	4	13.8	1.00 (referent)	60	14	23.3	1.00 (referent)
Intervention	56	3	5.4	0.22 (0.03–1.42)	99	8	8.1	0.36 (0.13–1.02)

[a]CR: crude cumulative rate of death and ADL impairment.
[b]RR: relative risk adjusted for age, history of disease, and functional fitness level in baseline.
[c]95%CI: 95% in confidence interval.

males and 0.16 (95% CI 0.03–0.81) in the females. That of ADL impairment was 0.22 (95% CI 0.03–1.42) in the males and 0.36 (95% CI 0.13–1.02) in the females.

Discussion

The subjects of this study were voluntary respondents to our recruitment, and the functional fitness level of both groups of subjects was slightly better than the national average. The 5-year cumulative mortality rate (14.4%) of the control group including both genders in this study was slightly lower than that in the previous study based on whole aged population in a community [13] but within the range of results in previous studies [14] in Japan. There is no reference data concerning the incidence of ADL impairment obtained by the same evaluation criteria as those used in this study.

Since the subjects in this study were not allocated at random to the intervention and the control groups, various biases could exist between the two groups. Studies to date have demonstrated that mortality and ADL impairment are related to gender, age, presence or absence of cardiovascular or musculo-skeletal disorders, and functional fitness level [15]. In this study, therefore, the effects of intervention were evaluated after adjustment for these confounding factors of death and ADL impairment by statistical analysis. As a result, the intervention group in the females showed the lower adjusted relative risks of 0.16 (95% CI 0.03–0.81) for death and 0.36 (95% CI 0.13–1.02) for ADL impairment. These results indicated that the programme used in this study was clearly effective for preventing the occurrence of death and almost effective for preventing the occurrence of ADL impairment in the elderly females and supported the results of the previous cohort studies [3–7] that evaluated the relationship between physical activity level and prognosis in the elderly. The results for the female portion of the intervention group seemed to be caused by increased or continued performance of physical exercise, including the intervention exercise programme throughout the study period, as compared with the control group. This is shown as the difference in change of exercise habits during the study period (Table 3).

Analysis of the levels of exercise amongst the women showed that the percentage of those who acquired or retained the habit of exercising at the end of the study period was the same as that in the baseline in the intervention group, but was significantly lower at the end of the study in the control group. These changes in the female groups resulted in a significant difference in the percentage of those who exercised regularly at the end of the study. These results suggested that the female subjects in the intervention group have maintained a high compliance to exercising during the study period against a general decrease in physical activity level with the advance of age in late life as observed in the control subjects. This finding might be associated with a keener awareness of their health problems (i.e. that women are more liable to become bed-ridden and to be bed-ridden for a longer period in old age in the current tendency to longevity).

Glass *et al.* [16] reported that social activities (church activities, going to see movies, dining, watching sports, short trips, and involvement in social organization) and productive activities (gardening, cooking, shopping, local volunteer activities, and paid jobs) were associated with the reduced relative risk of death similarly to physical exercises in aged people. Also, ADL has been shown to decrease more markedly in individuals who have no association with other people, work, or hobby [14, 17, 18]. In the present study, however, there were no significant differences between the female portion of the intervention and the control groups with regard to the changes in the percentage of those who were associated with the various social activities.

In the male subjects, the effects of the intervention were not significant, unlike in the female subjects. The reasons for these results could be: first, the small number of male samples as compared with the female samples may have affected the results in this study. Such a small number of subjects as we had in the male control group (n = 29) diminishes the power of the analytical test for significance of difference and also makes the result(s) unstable. Re-evaluation of this point with a greater number of samples is needed in the future. Secondly, a potential for bias which has attenuated the effect of intervention might have arisen from the male subjects. There was no difference in the change in exercise habits during the study period between the intervention and the control groups. The percentages of those who acquired or retained the habit of exercising at the end of the study were the same as the baseline values in both groups. These results suggest that the male subjects in both the intervention group and in the control group maintained their exercise habits during intervention period, unlike the female control subjects. This may be the cause of the absence of lower relative risks in the male intervention group.

A previous study [19] has reported that physical activity level generally declines with the advance of age in late life, so we might conclude that there was a bias present – such as that most of the subjects in the male control group were highly motivated and active. Such a bias might have been derived from the sampling method and/or contamination of the information for the health promoting exercise between the intervention and the control groups because the subjects in both groups lived in the same area of the community. However, this might not explain the results in the males because the same bias could have arisen in the females.

Since one of the goals of health care of the elderly is prolongation of active life expectancy, it is important to maintain a high physical activity level over a long period, and the development of programmes that help them stay active is urgently anticipated. From a public health perspective, it is also important that a large part of the population of aged people can be involved in health promoting measures and can continue to be involved over a long period. In our study, after exclusion of those

who could not participate in this programme due to death or ADL impairment, the actual percentage of subjects who remained active in the programme through to the last year was 57.6%. Although this value was lower than that in our 5-month intervention study (84.8%) [20] which used the same programme as this study, the fact that nearly 60% of the subjects continued to participate in this programme for 5 years is considered to be satisfactory with regard to the adherence to the programme. Previous studies [21, 22] indicated that an enhancement of motivation and a reduction in the burden of the subjects are important for improving the compliance to an exercise programme. To this end, our programme incorporated a support programme for promotion of exercise behaviour. The activities of voluntary groups in particular are intended to enhance the motivation to live physically and socially active lives for a longer period through improving fitness and associating with friends. These sub-programmes might be helpful for maintaining the high adherence that was observed in this study.

In an aged society like Japan, individuals requiring support are more often female, as women have a longer mean life span and are a predominant majority of those in late old age. Therefore, health-protecting measures for elderly females are matters of extreme importance. The present study of a 5-year intervention using (i) a health-promoting program, (ii) calculation of relative risks for death and ADL impairment by intention to treat analysis, and (iii) control for the potential influences of the non-randomized design by adjusting for confounding factors, provides significant evidence of health-protecting measures for elderly females. The fact that the reduced adjusted relative risks of death and ADL impairment were observed in the female intervention group indicates that the age-related risks of those in elderly women can be reduced by maintaining performance of low-intensity physical exercises such as muscle stretching, muscle strength training, and walking during late old age. However, validation of our results must await research that employs a randomized control trial to avoid various biases and confounding factors except for those adjusted in this study. It also remains to be determined whether the age-related risks of death and ADL impairment in elderly men can be reduced by maintaining physical exercises during late old age or not. Similarly, it is unknown whether individuals who are frail or younger aged persons under the age of 70 years will respond in a similar manner as observed among the female subjects in our study. Finally, it is uncertain which exercise prescription (i.e. frequency, and/or duration of exercise) is the best for health outcomes observed in this study. Further research is needed to clarify these issues.

Key points

- Following a 5-year health promoting programme of physical exercises, lower relative risks of death and ADL impairment were obtained in the females but not in the males.
- The improved mortality and state of independence in the female's intervention group occurred as a result of increased physical exercise levels in daily life. Effects of a 5-year exercise-centred health-promoting programme on mortality and ADL impairment in the elderly.

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