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Original Article

Effects of promoting daily physical activity on physical and mental health in older individuals

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Abstract. [Purpose] A trial was conducted to examine the effects of promoting daily physical activity, tailored to specific living situations, on physical and mental health indicators in older adults. [Participants and Methods] Participants in the 'Intervention' group (N=21) wore accelerometers during the 12-week trial period, and for one week during preliminary and follow-up surveys. Based on their physical activity levels as measured by accelerometers, participants were given instructions to increase their daily physical activity. Participants in the 'Control' group (N=18) wore the accelerometer only during the preliminary and follow-up survey. [Results] Number of steps increased significantly in the intervention group and a significant decrease in light physical activity time was observed in the control group. No such decrease was observed in the intervention group. With regard to health-related quality of life, significant interactions were observed between groups based on the 36-Item Short-Form Health Survey Mental Component Summary score, and some sub-items. A combined analysis of both groups found a significant positive correlation between the change in light physical activity time and the Mental Component Summary score. [Conclusion] An increase in daily physical activity was considered to have a sustained bolstering effect on mental health.
Key words: Accelerometer, Daily physical activity, Health-related quality of life

INTRODUCTION

Numerous longitudinal and cohort studies have reported that high daily physical activity are associated with decreased risk of mortality, and contribute to the maintenance and promotion of health for older individuals similar to the effects of exercise or sports[1–6]. Recent studies using accelerometers have reported that not only moderate-vigorous physical activity but also light physical activity might contribute to health maintenance and promotion[7]. Daily physical activity is mainly composed of light physical activity[8], which is considered to be particularly important for older adults. This is because that they spend a greater proportion of their day performing at this physical activity level than at any other age, and often find it difficult to initiate or maintain a moderate-vigorous physical activity level.

The effects of interventions intended to increase the amount of ordinary daily physical activity have however not yet been fully examined. Ordinary daily physical activity is influenced by culture and lifestyle, which vary by nationality, region, gender, and age[3], when considering the effects of an intervention on daily physical activity. Thus, it may be important to consider the specific living situations of individuals prior to implementing interventions.

Among older individuals, physical activity is known to have a positive influence on not only physical functioning but also

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quality of life (QoL). Previous studies have reported that a high degree of physical fitness helps maintain good QoL[9, 10], and exercise and training improve health-related QoL (HRQoL)[11, 12]. However, the relationship between HRQoL and the amount of daily physical activity has not been adequately investigated by intervention trials.

This study sought to examine the impact of a daily physical activity intervention on physical fitness indicators and HRQoL. Therefore, we conducted a non-randomized controlled trial with older participants in the form of an ordinary daily physical activity intervention trial, tailored to specific living situations ascertained through individual interviews.

PARTICIPANTS AND METHODS

Participants were older adults living in two municipal communities in the Ishinomaki area of Miyagi Prefecture, and they were recruited through advertisements in local newspapers and by invitation from district public health nurses. After holding a briefing session about trial implementation, we recruited 58 participants. Participants were provided a written and verbal explanation of the purpose of the trial, the methods, and the advantages or disadvantages for the participant as a result of the trial. The study was performed in accordance with the Declaration of Helsinki. All the participants provided written informed consent before participating. The data generated were analyzed retrospectively after the study was approved by the Ethical Review Committee for Trials Involving Human Subjects at Ishinomaki Senshu University (approval number: 2014-001).

The inclusion criteria were as follows: 1) those who were older adults aged ≥60 years; 2) those who were aware of performing insufficient exercise and considered their average daily steps to be less than 10,000; 3) those who were able to walk independently and participate in the program on designated days; and 4) those who were able to attach an accelerometer to their waist without any problem. The exclusion criteria were as follows: 1) those considered to be inappropriate for participation by their primary doctors; 2) those in whom unfavorable symptoms, such as chest pain, shortness of breath, or arthralgia, may develop even with low- or moderate-intensity exercise, such as walking; and 3) those who were unable to participate in the program on designated days.

The trial included a preliminary survey, a 12-week intervention period, and a follow-up survey. After a preliminary survey, participants were assigned to either an Intervention group (26 individuals) or a Control group (26 individuals), taking into account whether they were taking part with a spouse, any friendships with other participants, such that the trial was conducted in a non-randomized controlled manner. In the Intervention group, the average age ± SD was 64.8 ± 3.0 years, the average height 156.6 ± 10.1 cm, the average weight 59.1 ± 9.0 kg, and the average BMI 24.0 ± 2.2 kg/m². In the Control group, the average age ± SD was 65.0 ± 2.7 years, the average height 155.5 ± 7.9 cm, the average weight 58.4 ± 12.1 kg, and the average BMI 24.0 ± 3.4 kg/m². No statistically significant differences were found between the Intervention and Control groups in terms of age, weight, height, BMI, or gender ratio.

Participants in the Intervention group wore accelerometers (Actimarker, Panasonic, Osaka, Japan)[13] except when sleeping or bathing to assess the amount of physical activity for one week before the beginning of the 12-week intervention trial. The Actimarker is a small (60.0 × 13.0 × 35.0 mm) and lightweight (24.0 g) accelerometer. This device collects tri-axial acceleration data at 20 Hz, and the standard deviation of the data for 1 min periods is defined as the mean value of acceleration. The metabolic equivalents (METs) value is calculated based on the relationship between the average value of acceleration and the MET value, measured using a respiratory gas metabolic system[13].

After the trial started, participants were given counselling sessions for approximately 10 minutes with public health nurses based on the amount of physical activity assessed in the second, fourth, and eighth week of the trial period. During the first counselling session with the public health nurse, participants were asked about their walking habits and daily life patterns before being given appropriate advice about daily life behaviors that could increase their daily steps by referring to Table 1 according to their respective living situation. The target number of steps was decided by the participants with the advice of a public health nurse according to the results of their average daily accelerometer-measured steps. The standard advice is shown in Table 2. Participants in the Control group were asked to wear accelerometers for one week before the beginning and for one week before the end of the intervention trial.

Participants in both groups were provided with a health-related informational seminar. The seminar comprised a 60-minute lecture and was held over three sessions: during the first, fourth, and eighth week after the trial started. The first seminar offered insights about food and health with a lecture on how to take advantage of nutritious and special health foods. The second provided information about the importance of dietary habits to prevent lifestyle diseases caused by carbohydrate and lipid metabolism. The third was a lecture on the psychological aspects of a mindset geared towards maintaining healthy behavior.

The amount of physical activity was assessed by the accelerometer. With regard to intensity classification, physical activities were defined as inactivity time (IT) for sedentary behaviors measuring between 1.1 and 1.6 METs, light physical activity time (LPAT) between 1.6 and 3.0 METs, moderate physical activity time (MPAT) between 3.0 and 6.0 METs, and vigorous physical activity time (VPAT) for behaviors 6.0 METs or above[14].

Following the criteria for wearing time observed in a previous study using Actimarker devices[15], for this trial, the days selected for analysis were those on which at least 360 recorded minutes of data measuring at least 1.1 METS were recorded; participants with fewer than six eligible days of data were excluded from the analysis (one from the Control group and one from the Intervention group). No significant differences were observed in terms of average time the accelerometers were

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worn either between groups or before and after the intervention.

We selected three items for the Physical Fitness Test: grip strength as a muscular strength component; functional reach[16] as a balance function component; and a 10-meter gait speed measured as a component of activities of daily living (ADL) for older adults[17], with the participant being required to walk at a comfortable, self-determined speed.

As a QoL scale for comprehensively determining participants' physical and mental health condition, we used the Medical Outcomes Study 36-item Short-Form Health Survey (SF-36), version 2[18]. The sub-items are defined by two factors—physical and mental aspects—and the scale comprises eight subscales: Physical Functioning, Role Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role Emotional, and Mental Health. It is also possible to conduct evaluations using the Physical Component Summary (PCS), Mental Component Summary (MCS), or Role/Social Component Summary (R/SCS) scores based on these subscales.

In the preliminary survey 11 participants were found to have an average daily step count of at least 10,000 steps. Because many previous studies have suggested a daily 10,000 step goal for maintaining a level of physical activity for health[19], these participants were deemed unsuitable for further promotion of physical activities and were therefore excluded from the analysis. In the final analysis, there were 21 participants in the Intervention group (8 males and 13 females) and 18 in the Control group (6 males and 12 females).

To compare preliminary measurements between the Intervention and Control groups, we used an unpaired t-test for continuous variables with chi-squared tests for the gender ratio. For intra-group comparisons of preliminary and follow-up results, we used a paired t-test. For the intervention effect, after checking that there were no significant differences between groups in the preliminary measurement, we examined interactions using a mixed Analysis of Variance with a within participants factor of time (preliminary vs. follow-up survey) and a between participants factor of group (Intervention vs. Control group). Furthermore, relationships between change in demographics, amount of physical activities, and SF-36 summary scores were examined by calculating Pearson's correlation coefficients (r). For statistical analysis, we used SPSS ver. 21, with significance level set at $p<0.05$ for all tests.

Table 1. Specific advice for daily physical activities based on living situations

a) Participants with or hoping to develop the habit of taking walks
- Walk their dog themselves
- Highlight the paths they walk on a neighborhood map and try to color them all
- Visit shrines, temples, historical sites, restaurants, and cafes in their neighborhoods
- Enjoy conversing with their spouses or friends as they walk together
- Engage in artistic activities like taking photographs, sketching, or composing haiku while taking a stroll

b) Participants who have opportunities to get out of the house, such as commuting or shopping
- Walk to and from train stations and bus stops
- Do their shopping at stores that are slightly farther away
- Take a circuitous route to get to their destination
- Avoid using escalators or elevators by using the stairs in train stations or office buildings
- Walk all the way to the end of the platform when boarding a train and sit at the back of the bus when riding the bus
- When parking at a suburban large-scale shopping center, park at a location far from the entrance

c) Participants who lack the opportunity or desire to walk or leave the house
- Avoid using the remote to adjust their televisions or air conditioners
- Clear away the dishes and carry them to the sink or dishwasher after eating
- Walk to the door to check that it is locked before going to bed
- Go to get the morning paper for themselves
- Open and close windows and curtains for themselves

Table 2. Target values of steps based on walking situations

a) Participants with daily average steps of <5,000 steps

They were advised to increase their daily average by 500 steps over the first 4 weeks, then again by 500 steps over the next 4 weeks, and by a further 1,000 steps over the final 4 weeks of the trial, aiming for a total increase of 2,000 steps over the 12-week period.

b) Participants with daily average steps of >5,000 steps and <7,500 steps

They were advised to increase their daily average by 500 steps over the first 4 weeks, then by 1,000 steps over the next 4 weeks, and by a further 1,000 steps over the final 4 weeks of the trial, aiming for a total increase of 2,500 steps over the 12-week period.

c) Participants with daily average steps of >7,500 steps and <10,000 steps

They were advised to increase their daily average by 500 steps over the first 4 weeks and by 1,000 steps over the next 4 weeks and to be able to increase the intensity of any moderate physical activity by 10% during the final 4 weeks of the trial.

RESULTS

Table 3 shows the results of daily activity and weight. No significant differences were found between groups in terms of average daily steps, IT, LPAT, MPAT, VPAT, or weight in the preliminary measurements. LPAT accounted for the longest amount of time spent on physical activity followed by IT and then MPAT. Comparison of changes over the intervention trial period found significant increases in the Intervention group for average daily steps (p=0.008) as well as MPAT (p=0.008). In the Control group, LPAT decreased significantly (p=0.010) while MPAT increased significantly (p=0.017). No significant changes in weight were observed for either group.

Combining the Intervention and Control groups, we analyzed the relationship between change in time spent on physical activity by degree of intensity and the change in number of steps (Fig. 1). The change in step number was positively correlated with the change in MPAT (r=0.902, p<0.001) (Fig. 1A), while no significant relationships were found between step number and change in time spent on activities at other degrees of intensity. Furthermore, a negative correlation was found

Table 3. Effect of daily physical activity intervention on steps, activity time, and body weight

	Intervention group (N=21)				Control group (N=18)			
	Preliminary	Follow-up	Difference	95% CI	Preliminary	Follow-up	Difference	95% CI
Steps (steps/day)	6,176.7 ± 1,598.1	8,113.0 ± 2,970.2	1,936.3 ± 3,025.3**	559.1 to 3,313.4	6,377.6 ± 1,686.8	7,567.7 ± 2,737.6	1,190.0 ± 2,409.5	−8.2 to 2,388.3
IT (min)	279.7 ± 45.9	270.1 ± 56.4	−9.7 ± 44.9	−30.1 to 10.8	249.7 ± 57.7	241.7 ± 49.4	−8.0 ± 44.4	−30.1 to 14.1
LPAT (min)	349.4 ± 80.0	339.5 ± 87.8	−9.9 ± 29.3	−23.2 to 3.4	328.9 ± 65.6	301.5 ± 77.0	−27.4 ± 40.2*	−47.4 to −7.4
MPAT (min)	34.9 ± 20.7	53.0 ± 29.2	18.1 ± 28.1**	5.5 to 30.9	45.2 ± 16.9	58.4 ± 20.3	13.2 ± 21.2*	2.6 to 23.7
VPAT (min)	0.08 ± 0.13	0.40 ± 1.05	0.32 ± 1.03	−0.14 to 0.79	0.20 ± 0.43	0.14 ± 0.27	−0.06 ± 0.39	−0.26 to 0.14
Weight (kg)	59.1 ± 9.0	59.4 ± 9.0	0.3 ± 1.4	−0.3 to 0.9	58.4 ± 12.1	58.7 ± 12.0	0.3 ± 1.0	−0.1 to 0.8

Values are expressed as means ± SDs.
Significant differences between Preliminary and Follow-up survey: *p<0.05, **p<0.01.
IT: Inactivity time; LPAT: Light physical activity time; MPAT: Moderate physical activity time; VPAT: Vigorous physical activity time.
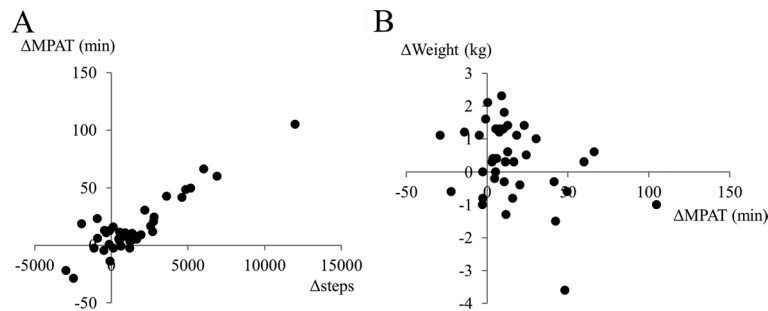

Fig. 1 Relationships between changes in MPAT and changes in steps or weight.
(A) Changes in MPAT (ΔMPAT) and changes in steps (ΔSteps), r=0.902, p<0.001;
(B) Changes in MPAT (ΔMPAT) and changes in weight (ΔWeight), r=−0.352, p=0.028; MPAT: moderate physical activity time. N=39.

Table 4. Effects of daily physical activity intervention on physical fitness indicators

	Intervention group (N=21)				Control group (N=18)			
	Preliminary	Follow-up	Difference	95% CI	Preliminary	Follow-up	Difference	95% CI
Grip strength (kg)	28.0 ± 8.1	27.4 ± 7.3	0.6 ± 3.5	−2.2 to 1.0	27.6 ± 9.1	28.4 ± 10.0	0.8 ± 3.6	0.0 to 2.6
Functional reach (cm)	34.0 ± 6.1	32.7 ± 7.5	−1.3 ± 6.2	−4.1 to 1.6	33.0 ± 6.1	36.0 ± 10.5	2.3 ± 7.5	−1.4 to 6.0
10-m gait speed (sec)	7.3 ± 1.0	6.4 ± 0.8	−0.9 ± 0.9**	−1.3 to −0.6	7.0 ± 0.9	6.6 ± 0.9	−0.5 ± 0.8**	−0.9 to 0.0

Values are expressed as means ± SDs.
Significant differences between Preliminary and Follow-up survey: **p<0.01.

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between the change in MPAT and change in weight (r=−0.352, p=0.028) (Fig. 1B).

Table 4 shows the results for physical fitness indicators. No significant differences were observed between the two groups in the preliminary survey for grip strength, functional reach, and 10-meter gait speed. For grip strength and functional reach, no significant differences between the preliminary and the follow-up surveys were found for either group. For 10-meter gait speed, a significant increase was observed in both groups between the preliminary and the follow-up surveys. No interactions between groups were found for any items.

Table 5 shows the results for the SF-36 questionnaire. In the preliminary survey, no significant differences were found between groups for the SF-36 summary scores or sub-items. Comparison of changes over the intervention period found significant increases in the Intervention group in terms of Physical Functioning (p=0.041), Vitality (p=0.004), and Social Functioning (p=0.018). Significant interactions between groups were found for Physical Functioning, General Health, Vitality, Social Functioning, Mental Health, and MCS. As shown in Fig. 2, a combined analysis of the two groups found a positive correlation between the change in LPAT and the change in MCS (r=0.333, p=0.038).

Table 5. Effects of daily physical activity intervention on HRQOL

	Intervention group (N=21)				Control group (N=18)			
	Preliminary	Follow-up	Difference	95% CI	Preliminary	Follow-up	Difference	95% CI
Physical functioning	46.3 ± 7.3	50.1 ± 5.3	3.8 ± 7.9*†	0.2 to 7.4	48.4 ± 7.3	46.6 ± 9.1	−1.8 ± 7.7	−5.6 to 2.0
Role physical	45.1 ± 12.9	49.7 ± 8.1	4.6 ± 14.0	−1.8 to 11.0	48.0 ± 9.9	48.5 ± 10.1	0.6 ± 11.2	−5.0 to 6.1
Bodily pain	48.0 ± 8.2	51.5 ± 8.9	3.6 ± 8.3	−0.2 to 7.3	51.7 ± 7.8	51.5 ± 11.0	−0.2 ± 9.7	−5.0 to 4.6
General health	47.4 ± 6.1	50.5 ± 8.4	3.0 ± 6.7†	0 to 6.1	49.4 ± 8.3	46.7 ± 9.8	−2.7 ± 7.3	−6.4 to 0.9
Vitality	50.4 ± 9.4	56.9 ± 6.1	6.4 ± 9.0**†	2.3 to 11.0	53.8 ± 6.9	52.0 ± 10.3	−1.8 ± 10.5	−7.0 to 3.4
Social functioning	48.7 ± 8.4	53.3 ± 6.0	4.6 ± 8.2*†	0.9 to 8.3	52.7 ± 6.2	49.5 ± 9.4	−3.2 ± 10.2	−8.3 to 1.8
Role emotional	50.9 ± 8.6	51.1 ± 6.3	0.2 ± 7.8	−3.4 to 3.8	51.2 ± 7.3	50.8 ± 7.8	−0.5 ± 10.1	−5.5 to 4.5
Mental health	51.6 ± 8.1	53.2 ± 6.9	1.7 ± 6.7†	−1.4 to 4.7	53.5 ± 7.4	49.7 ± 9.1	−3.7 ± 9.4	−8.4 to 0.9
PCS	44.4 ± 8.1	47.9 ± 5.8	3.5 ± 8.2	−0.2 to 7.2	46.4 ± 8.5	46.7 ± 9.5	0.3 ± 9.0	−4.2 to 4.7
MCS	51.6 ± 7.4	55.1 ± 7.9	3.5 ± 8.0†	−0.1 to 7.1	54.2 ± 6.9	50.8 ± 8.5	−3.4 ± 9.8	−8.3 to 1.5
RCS	50.1 ± 11.5	51.1 ± 8.9	1.0 ± 11.5	−4.2 to 6.3	51.2 ± 8.1	50.8 ± 8.1	−0.4 ± 9.8	−5.2 to 4.5

Values are expressed as means ± SDs.
Significant differences between Preliminary and Follow-up survey: *p<0.05, **p<0.01.
Significant time ×group interaction: †p<0.05.
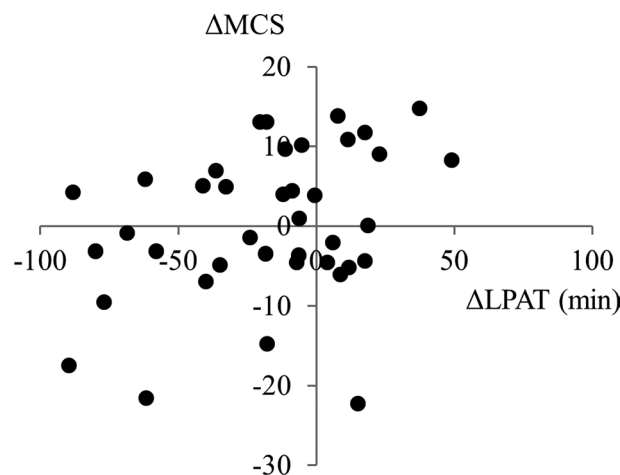PCS: Physical component summary; MCS: Mental component summary; RCS: Role/Social component summary.

Fig. 2. Relationship between changes in LPAT (ΔLPAT) and changes in MCS (ΔMCS).
r=0.333, p=0.038; LPAT: light physical activity time; MCS: mental component summary. N=39.

DISCUSSION

We used a non-randomized control trial to examine the effects of a daily physical activity intervention, tailored to individual living situations, on physical and mental health.

In this trial, the change in the average daily steps for the Intervention group between the preliminary and follow-up surveys was $1,936 \pm 3,025$ steps, which was significant (95% CI: 559 to 3,313). In a systematic review, the increase in average daily steps for participants (average age: 49 years) over an average intervention period of 18 weeks was 2,491 steps (95% CI: 1,098 to 3,885)[20]. Most trials used in this review also involved target-setting, daily recording, and counselling components. Although the change in physical activity in this trial was slightly lower compared with the previous study, this may be owing to the older age of participants in this trial (aged over 60 years). Therefore, we believe that the increase in steps in the present study meets an equivalent standard. On the other hand, the change in the average daily steps for the Control group between the preliminary and follow-up surveys was $1,190 \pm 2,410$ steps, which while not significant here showed an increasing trend (95% CI: −8 to 2,388). This result of an increasing trend might be the effect of the health-related lectures on both groups. While the lectures did not offer information on specific measures for proactively increasing levels of physical activity, it is conceivable that parts of the lecture raised health consciousness and prompted the healthy lifestyle choice of walking. The same reasoning may also be considered to explain the significant increase in MPAT observed in both groups.

Because an increase in daily physical activity was also suggested in the Control group, we examined the relationship between change in physical activity time and change in average daily steps for both groups combined and compared the results with those in previous studies. We found that while a significant positive correlation was confirmed between change in MPAT and change in average daily steps, no significant relationship was found with change in LPAT. Murakami et al., in a cohort study of 1,837 participants (23–69 years), found a significant positive correlation between average daily steps and weekly moderate-to-vigorous physical activity using a similar accelerometer as in the present study[15]. These results suggest that recommending an increase in daily physical activity can lead to an increase in MPAT. Also, in this trial, a negative correlation was observed between change in MPAT and weight change, suggesting that moderate-intensity activity may contribute to weight management. Hara et al., in a trial using the same accelerometer as in this trial, reported that the weight-loss effect of exercise classes is related to the change in physical activity time of at least 3 METs[21]. These results may correspond with the results in the present study.

While a relationship between daily activity levels and physical fitness indicators has been suggested in several gerontological observation studies[22, 23], for the most part, this has not yet been adequately verified by intervention studies. In the results of this trial, no intervention effect was observed with regard to grip strength, functional reach, or gait speed, and it was suggested that the daily activity intervention did not have any impact on physical fitness indicators during the intervention period. Brach et al. reported that simply increasing daily activity is inadequate for improving physical fitness indicators and noted the importance of calisthenics and other exercises[24]. Improving fitness indicators through an intervention for older participants such as those in our study would appear to require a higher-intensity activity load.

An improvement effect during the trial period was recognized in the Intervention group for some SF-36 sub-items. Furthermore, a between-groups interaction effect was observed for Physical Functioning, General Health, Vitality, Social Functioning, Mental Health, and MCS. A positive relationship between amount of physical activity and HRQoL has frequently been reported in some cross-sectional studies[25–27]. In a study of healthy older adults, Shibata et al. report that, in a trial involving 1,211 participants, when respondents were divided into three groups by amount of physical activity as determined by a questionnaire, in terms of HRQoL (evaluated by SF-8), the amount of physical activity was found to be significantly associated with some SF-8 sub-items[28]. Furthermore, Murata et al. reported that community-living elderly individuals improved their psychological well-being, life satisfaction, and motivation in life after a walking intervention[29]. These results seem to be partially in accordance with the result in this intervention study.

Additionally, because change in MCS was found to have a positive correlation with change in LPAT, and no significant association was found with MPAT, a relationship was suggested between light physical activity and mental QoL. While details concerning the reasons for this are unclear, Takada et al. reported on the effectiveness of moderate physical activity based on their analysis of the effect of physical activity on cognitive function among older adults, going on to note that more intense physical activity may induce stress, which might serve to inhibit improvements in cognitive function[30]. The suggestion that the change in LPAT may be more closely related to improvement in QoL than change in MPAT is conceivably related to the possibility that even moderate physical activity may have been perceived as stressful by some participants. This suggests that, at the introductory stage of a health promotion and maintenance program, working to promote even light physical activity could contribute to an improvement in mental QoL. However, further studies are needed to better understand whether light physical activity shows a stronger positive association with mental QoL than other activity intensity types. From a public health perspective, it would be particularly useful to know whether there are thresholds below and above certain light physical activity levels that have no benefits on mental QoL.

This trial has a number of limitations, including a relatively small sample size, meaning that no sub-analyses were possible with regard to factors such as living situation, environment, family composition, or even physical condition. Additionally, possible factors affecting the improvement in participants' daily activities observed during this trial include provision of

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methods that suited the lifestyle habits of each individual, goal-setting, differences in activity meter mounting times, and guidance and assistance provided at regular intervals. In future, studies could examine the nature of changes in activity volume in the course of daily living among participants grouped together with the same activity meter mounting time and frequency of guidance.

We used counselling sessions with public health nurses based on activity data from accelerometers to carry out an intervention trial promoting daily activity based on the individual living situations for 39 males and females aged 60 and over. The intervention for increasing physical activity in daily life used in this trial can be considered to be effective for the maintenance and promotion of mental health among older adults. In addition, in a combined analysis of the Intervention and Control groups, a significant positive correlation was observed between change in LPAT and change in MCS, suggesting a relationship between light physical activity and mental QoL.

Conflict of interest

None.

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