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ORIGINAL ARTICLE

# Relationship between Physical Activity and Physical and Mental Functioning in Older Women Living in the Community

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## ABSTRACT

Healthy Japan 21 (second term) in Japan's health policy sets a target of 6,000 steps per day for women aged 65 years and older. In 2019, the average number of steps taken per day by Japanese women aged 65 years and older was 4,656. This study used the above average number of steps as the standard and examined the differences in physical and mental functioning between those who walked more than the standard and those who walked less. The hypothesis stated that the group with an average number of greater than 4,656 steps would lead a healthier life than the group with fewer steps. The participants were 52 physically independent older women living in a community. The participants' mean age was 70.94±6.01 years. They were instructed to wear an accelerometer to measure their average number of steps and physical activity (PA) over a three-month period. The Lifecorder GS (SUZUKEN) was used as the accelerometer. Physical functions (grip strength; their ability to sit-up, bend forward, stand on one leg with their eyes open, stand on a chair for 30 seconds, complete a 10-meter obstacle walk, complete a 6-minute walk test; their toe flexor strength, and hip abductor strength) were also measured. Questionnaires were used to conduct (1) Activities of Daily Living (ADL) Assessment, (2) Quality of Life Assessment, (3) Psychological Assessment, and (4) Questions about Daily Life assessment. The participants were divided into two groups [high-step group (≥4,656 steps) and low-step group (<4,656 steps)] based on the number of steps they had completed daily. There was a significant difference ($p<0.001$) in the mean number of daily steps 9186.3±2362.3 in the high-step group versus 4512.4±634.4 in the low-step group. The PA of the high-step group was higher than that of the low-step group on all items. There was a significant difference between the two groups in ADL's total score. The difference in PA intensity between the two groups was significant, and there was a significant difference in View of Health Status. This suggested that the higher the PA, the higher the self-perceived health and physical fitness. The View of Health Status' results were consistent with the MOS Short-Form 36-Item Health Survey (SF-36) General Health's results. There was a difference in the physical and mental health status between those who walked an average number of steps (4,656 steps) and those who did not. This was especially true for physical function. Therefore, the study's hypothesis was supported. The results regarding the high-step group and low-step group showed that the low-step group also reached 10 MET hours per week. When Plus Ten is considered, it is recommended that older women in Japan walk approximately 6,000 steps per day.

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## I. Introduction

According to the 2021 edition of the World Health Statistics released by the World Health Organization (WHO), Japan has the longest average healthy life expectancy of 74.1 years. Japan also ranked first in terms of longest average healthy life expectancy for the different sexes, with 72.6 years for males and 75.5 years for females[1]. Healthy life expectancy is defined as "the period of time during which a person can live independently," as proposed by the WHO[2]. Health Japan 21, launched in 2000, has as its main goals: "extension of healthy life expectancy" and "reducing health inequities"[3]. Health Japan 21 (second term) was evaluated at mid-term in 2018, and progress had been made on 21 out of 53 goals. It is very likely that these will be achieved by 2022[3]. However, more efforts are needed to strengthen health promotion programs across the country to achieve this goal. Health Japan 21 recommends physical activity (PA) and exercise to achieve the goals of "extending healthy life expectancy" and "reducing health disparities[4]." Stenholm et al. reported that leisure-time PA is associated with an increase in healthy life expectancy[5].

Substantial evidence demonstrates the profound effects of PA and exercise in protecting against many chronic diseases, especially cardiovascular diseases and cancer[6-8]. Despite the evidence supporting PA, which has been present for many decades, there remains a very high prevalence of physical inactivity (PI) and sedentary behavior worldwide[9-11]. Those who are physically active on a daily basis are considered to be able to live independently, even in old age. Older adults with high levels of PA have been reported to have higher levels of physical fitness and cognitive function[12-14].

In daily life, PI is often measured over a long period of time, using questionnaires and/or measuring devices to measure heart rate, number of steps, and intensity of activity. Although large-scale PA surveillance data provide valuable information regarding the evolving PA/PI trends within the United States, limitations with self-reported PA habits have been regularly referenced as a primary factor that complicates our interpretation of the number of individuals meeting PA guidelines[15]. For example, objectively measured PA data from the 2005 to 2006 cycle of the National Health and Nutrition Examination Survey (NHANES) revealed that only 9.6% of the population met PA guidelines, compared to 62% when PA was self-reported. These stark differences between self-reported and device-measured PA may be related to the differences between objectively determined and individual perceptions of PA intensity. Many studies that objectively quantify PA intensities apply accelerometers and evaluate them for seven days[16-18]. However, it is considered insufficient to assess the amount of PA of participants in just seven days.

The decline in step count and physical fitness becomes significant around the age of 60-70[19,20]. Activities of Daily Living (ADL) appears earlier in women than in men, and women's independence gradually declines from around age 70 years old, due to a decline in muscle strength and motor function[21,22]. ADL is the minimum movement required in daily life, and consists of" getting up, transferring, moving, eating, changing clothes,

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excreting, bathing, and conditioning". This may be related to the fact that women require a longer period of care than men do. It is recommended to increase PA in daily life, especially walking, to prevent nursing care[23].

The relationship between the amount of PA and physical and mental functioning in older women is important, particularly from the perspective of health education in old age. Healthy Japan 21 ( second term) in Japan's health policy sets a target of 6,000 steps per day for women aged 65 years and older. In 2019, the average number of steps taken per day by Japanese women aged 65 years and older was 4,656[24]. Previous studies have not examined the differences in physical and mental functioning based on the current average number of steps. Therefore, this study aimed was to fill this gap. The study's hypothesis is that the group with an average number of steps greater than 4,656 would lead a healthier life than the group with fewer steps would.

## II. Methods

### 1. Participants

The participants were 52 older women living in Matsuyama City, Ehime Prefecture, Japan. The mean age of the participants was 70.94±6.01 years. Inclusion criteria for participation in the study were older adult females who belonged to six Matsuyama Fureai-ikiiki salons and lived independently in the community. The salon is a place for residents to visit, as judged by Matsuyama City. It is composed of a group of about 10 or more older people aged 65 years or over who reside in the city. The Matsuyama City government entrusts the Matsuyama City Council of Social Welfare with the support of salon activities. Matsuyama City opened salons for the older to maintain and improve the physical and mental functioning of older adults and prevent long-term care.

### 2. Data Collection

The study was conducted from September 2017 to December 2017. In this study, the participants' PA was measured for approximately three months using accelerometers. The participants were instructed to always wear a PA accelerometer, except when bathing, swimming or sleeping. Physical fitness tests and questionnaires were administered on December 15, 2017, when the PA accelerometers were collected.

### 3. Data Contents

#### 1) Accelerometer

The Lifecorder GS (SUZUKEN) was used as the accelerometer. The days with fewer than 500 steps per day are considered as days on which the participants forgot to wear the accelerometer and were excluded from the analyzed target days. The accelerometer used in this study detected activity intensity in 11 steps from 0, 0.5, 1, to 9. It has a function to record activity intensity every 2 minutes from the most frequent value of the

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activity intensity measured 30 times every 4 seconds, making it possible to determine the activity intensity at a certain point in time. PA intensity was expressed in metabolic equivalents (METs), with accelerometer intensities "1-3" being low intensity (<3 METs), "4-6" being moderate intensity (3-6 METs), and "7-9" being high intensity (>6 METs). The validity and reliability of the accelerometers used in this study were confirmed by Kumahara et al[25]. The average weekly PA of the participants was also analyzed as MET hours per week.

**2) Physical functioning assessment**

Measurements included height, weight, and physical function (grip strength, sit-up, forward bending, one-leg standing with eyes open, 10-m obstacle walk, 6-minute walk test, toe flexor strength, hip abductor strength, and 30-second chair stand). Grip strength was measured twice on both the right and left sides, with the higher value on each side being used to determine the average of the right and left sides. The average was used to determine grip strength. Sit-ups were measured by the number of sit-ups performed in 30 seconds. Forward bending was performed twice, with the higher value being used for the study. Standing on one-leg with eyes open was performed for a maximum of 120 seconds. The 10-m obstacle walk was performed twice, and the faster result of the two was recorded. In the 6-minute walk test, participants walked around the perimeter of a 50-m circle, and the distance walked in six minutes was recorded. Toe flexor strength was measured twice on both the left and right, with the higher value of each being used to obtain the average of the two. Abductor strength was measured twice on both the right and left sides using a hand-held dynamometer. The higher value of each was used to get the average of the two. The 30-second chair stand was measured as the number of times the participant could sit and stand up in 30 seconds.

The PA criteria (living activity or exercise) for people aged 65 years and over in Health Japan 21 (second term) is “PA 10 METs per hour per week regardless of intensity” based on previous research[26-29]. PA 10 METs per hour per week is specifically 40 minutes of daily PA, which qualifies as any movement if it does not involve lying down or sitting. The PA’s intensity at rest is one MET. METs were calculated by considering the intensity of PA at rest as one MET and how many times more calories are burned during exercise. For example; walking slowly is about two METs, walking is three METs, and jogging is seven METs.

**3) Questionnaire Survey**

① ADL Assessment

The ADL test is a self-administered questionnaire. ADL is translated as the ability to perform daily living activities. ADL is an important indicator in assessing older individuals’ physical and mental functions. It is a major factor that defines their way of life[30]. The ADL test (Ministry of Education, Culture, Sports, Science, and Technology) was conducted to evaluate ADL. The ADL test consisted of 12 items representing the ADL

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capability domains of walking ability, changing and holding posture, balance, muscular strength, and dexterity (manual activity). The options are listed as one, two, and three.

② Quality of Life Assessment

This study used the MOS Short-Form 36-Item Health Survey version 2 (SF-36v2), which has excellent validity and reliability and is widely used internationally, to assess Health-Related Quality of Life (HRQOL). SF-36 is based on a universal concept for measuring. It can measure the QOL of patients with various diseases as well as that of healthy people. The scoring of the SF-36v2 subscales is as follows: (1) Physical functioning (2) Role physical, (3) Bodily pain, (4) General health, (5) Vitality, (6) Social functioning, (7) Role emotional, and (8) Mental health. The scores of the SF-36v2 subscales and the deviation scores based on the national average were calculated according to the SF-36v2tTM Japanese manual HRQOL scale. The higher the score for all items, the higher the QOL.

③ Psychological Assessment

The Japanese version of the Profile of Mood States (POMS) was used to assess mood and emotion. The reliability and validity of this scale have been verified[31]. This scale consists of six subscales: (1) tension-anxiety, (2) depression-dejection, (3) anger-hostility, (4) vigor-activity, (5) fatigue-inertia, and (6) confusion-bewilderment. It can comprehensively capture mood and emotions. The obtained values were evaluated according to the mood-profile conversion table. Owing to the characteristics of the evaluation, higher scores are preferred only for "vigor-activity," while lower scores are preferred for the other items.

④ Questions about Daily Life

The participants were asked three questions about their daily lives. For "view of own health status," participants were asked to choose from the following options: 1. very healthy, 2. fairly healthy, 3. not very healthy, or 4. not healthy at all. For "view of own physical fitness," the participants were asked to choose from the following options: 1. very confident, 2. fairly confident, 3. not very confident, and 4. not confident at all. For "frequency of exercise," the participants were asked to choose from the following options: 1. almost every day (3 days per week or more), 2. sometimes (1–2 days per week), 3. occasionally (1–3 times per month), and 4. never.

**4. Statistical Analysis**

The participants were divided into two groups based on the number of steps day had per day. The two groups were the high-step group (≥4,656 steps) and low-step group (<4,656 steps). Two independent groups of comparison tests were used to test for significant differences. The results are presented as the average ± standard deviation. An independent sample t-test was used to compare the step volume, PA intensity and physical function assessments between the two groups. The Mann-Whitney U test was used to

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compare the two groups in the questionnaire survey. The statistical software IBM SPSS Statistics 27.0 was used, and the significance level was set at less than 5%.

### 5. Ethical Considerations

The staff of the Matsuyama Social Welfare Council explained this study to the participants at each salon. All participants provided written informed consent before participating in the study, and the study protocol was designed according to the Declaration of Helsinki.

## III. Results

The high-step group had 39 participants (n=39), and the low-step group had 13 participants (n=13). The mean for age, height, weight, and body mass index (BMI) of the high-step group was 70.1±5.89 years, 151.2±5.83 cm, 50.2±9.65 kg, and 21.8±3.67, respectively. The mean for the low-step group was 73.5±5.65 years, 151.5±5.58 cm, 53.3±10.43 kg, and 23.2±4.15. There were no significant differences between the two groups. The effective number of days for the analysis of the number of steps was 95.0 ± 9.89 days for the high-step group and 89.1±11.0 days for the low-step group. The mean number of steps per day was 9186.3±2362.3 in the high-step group and 4512.4±634.4 in the low-step group, a significant difference ($p<0.001$). The results obtained from the accelerometers in the high-and low-step groups are presented in Table 1. The results of the physical functioning assessment for both groups are presented in Table 2. The results of the ADL test are presented in Table 3, and those of the SF-36v2TM and POMS are presented in Table 4. Lastly, the results of the daily life questionnaire survey are presented in Table 5.

<Table 1> Results of the PA by the Steps Volume Group

| | | Step group, step/d | | P-value |
|---|---|---|---|---|
| | Total | High : ≧4,656 | Low : <4,656 | |
| | (n=52) | (n=39) | (n=13) | |
| Step volume | 7250.2 (2831.3) | 9186.3 (2362.3) | 3905.1 (634.4) | 0.001*** |
| PA intensity | | | | |
| Low intensity (<3 METs), (time) | 46.6(17.3) | 55.5(16.1) | 29.7(5.9) | 0.001*** |
| Moderate intensity (3-6 METs), (time) | 18.3(13.2) | 25.6(12.9) | 6.2(2.5) | 0.001*** |
| High intensity (>6 METs), (time) | 1.1(1.4) | 13.9(1.5) | 0.4(0.3) | 0.001*** |
| Mets·hour/week | 24.5(1.5) | 31.4(8.7) | 12.5(2.2) | 0.001*** |

*P<0.05, **P<0.01, ***P<0.001 An independent sample t-test High : ≧4,656 vs Low : <4,656

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<Table 2> Results of their physical functioning by the Steps Volume Group

| | Total (n=52) | Step group, step/d High: ≧4,656 (n=39) | Low: <4,656 (n=13) | P-value |
|---|---|---|---|---|
| Grip strength, (kg) | 21.1(4.2) | 21.6(3.9) | 18.4(3.9) | 0.01** |
| Sitting-up, (times) | 7.5(6.0) | 9.2(5.8) | 2.4(3.2) | 0.001*** |
| Bending forward, (cm) | 36.5(8.0) | 37.7(6.0) | 32.3(11.2) | 0.12 |
| Standing on one leg with their eyes open, (time) | 70.6(44.5) | 76.9(41.3) | 34.6(33.0) | 0.001*** |
| 10-m obstacle walk, (time) | 8.2(1.2) | 8.0(1.1) | 8.9(1.2) | 0.01** |
| 6-minute walk test, (m) | 515.8(59.6) | 537.0(43.6) | 460.8(66.8) | 0.01** |
| Toe flexor strength, (kg) | 6.8(2.5) | 7.1(2.6) | 5.4(1.7) | 0.01** |
| Hip abductor strength, (kg) | 23.2(6.9) | 24.2(6.7) | 19.0(5.7) | 0.01** |
| 30-second chair stand test, (times) | 18.2(4.1) | 19.1(3.9) | 15.0(2.9) | 0.001*** |

*P<0.05, **P<0.01, ***P<0.001 An independent sample t-test High: ≧4,656 vs Low: <4,656

<Table 3> Results of ADL testing by the Steps Volume Group

| | Total (n=52) | Step group, step/d High: ≧4,656 (n=39) | Low: <4,656 (n=13) | P-value |
|---|---|---|---|---|
| 1. Walking | 2.5(0.6) | 2.5(0.6) | 2.3(0.7) | 0.39 |
| 2. Running | 1.9(0.7) | 2.0(0.7) | 1.7(0.6) | 0.21 |
| 3. Jumping over a ditch | 2.4(0.7) | 2.5(0.7) | 2.0(0.6) | 0.01** |
| 4. Climbing up the stairs | 2.3(0.7) | 2.4(0.6) | 1.9(0.8) | 0.07 |
| 5. Standing from a sitting posture (Seiza) | 2.4(0.7) | 2.5(0.7) | 2.3(0.6) | 0.35 |
| 6. Balancing on one-leg with eyes open | 2.2(0.7) | 2.2(0.7) | 2.2(0.7) | 0.90 |
| 7. Standing in a bus or train | 2.3(0.6) | 2.5(0.5) | 1.9(0.6) | 0.01** |
| 8. Putting on pants or a skirt while standing | 2.7(0.5) | 2.7(0.5) | 2.6(0.5) | 0.32 |
| 9. Buttoning or unbuttoning shirts | 2.2(0.6) | 2.2(0.6) | 2.1(0.5) | 0.45 |
| 10. Folding a futon up and down | 2.6(0.5) | 2.7(0.4) | 2.3(0.5) | 0.01** |
| 11. Carrying an object | 2.6(0.5) | 2.8(0.4) | 2.1(0.5) | 0.001*** |
| 12. Sitting-up | 1.7(0.8) | 1.7(0.8) | 1.5(0.5) | 0.20 |
| Total score | 27.7(4.7) | 28.8(4.4) | 24.8(4.2) | 0.01** |

*P<0.05, **P<0.01, ***P<0.001 Mann-Whitney U test High: ≧4,656 vs Low: <4,656

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<Table 4> Results of the SF-36v2TM and POMS by the Steps Volume Group

| | Total (n=52) | Step group, step/d High: ≧4,656 (n=39) | Low: <4,656 (n=13) | P-value |
|---|---|---|---|---|
| SF-36v2TM (score) | | | | |
| Physical functioning | 47.4(10.9) | 50.8(8.4) | 40.2(13.8) | 0.01** |
| Physical Role | 47.3(10.0) | 49.1(8.3) | 41.9(14.4) | 0.08 |
| Body pain | 50.8(9.2) | 52.3(9.0) | 56.5(8.5) | 0.05* |
| General health | 52.8(7.9) | 53.8(7.5) | 48.7(7.9) | 0.05* |
| Vitality | 52.6(7.5) | 53.5(6.6) | 49.5(9.2) | 0.18 |
| Social functioning | 50.9(7.9) | 50.5(8.3) | 50.0(6.6) | 0.38 |
| Emotional Role | 49.1(10.2) | 51.2(8.2) | 42.5(12.3) | 0.05* |
| Mental health | 53.5(7.4) | 54.3(7.3) | 50.7(7.0) | 0.12 |
| POMS (score) | | | | |
| Tension-anxiety | 44.3(6.3) | 44.2(7.0) | 44.7(3.4) | 0.32 |
| Depression-dejection | 44.8(5.7) | 44.2(5.6) | 45.8(5.7) | 0.46 |
| Anger-hostility | 43.9(5.2) | 43.3(5.5) | 44.8(4.0) | 0.23 |
| Vigor-activity | 48.1(9.3) | 48.9(9.5) | 47.4(8.5) | 0.73 |
| Fatigue-inertia | 44.6(6.1) | 44.5(6.7) | 44.4(4.1) | 0.54 |
| Confusion-bewilderment | 48.8(6.3) | 47.5(5.7) | 52.1(6.8) | 0.05* |

*P<0.05, **P<0.01 Mann-Whitney U test High: ≧4,656 vs Low: <4,656

<Table 5> Results of the survey on daily life by the Steps Volume Group

| | Total (n=52) | Step group, step/d High: ≧4,656 (n=39) | Low: <4,656 (n=13) | P-value |
|---|---|---|---|---|
| View of own health status | 3.2(0.5) | 3.3(0.5) | 2.8(0.4) | 0.01** |
| View of own physical fitness | 2.7(0.5) | 2.8(0.5) | 2.5(0.5) | 0.13 |
| Frequency of exercise | 2.8(1.2) | 2.9(1.2) | 2.8(1.1) | 0.89 |

** P<0.01 Mann-Whitney U test High: ≧4,656 vs Low: <4,656

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## IV. Discussion

PA was higher in the high-step group in all items, and a significant difference was observed between the high- and low-step groups. The difference in PA intensity between the two groups was remarkable. It was revealed that the high-step group spent a longer time exercising at a high PA intensity. The mean value of the low-step group was 12.5 MET hours per week. The average number of steps (3,905.1 steps) in the low-step group was lower than the current average number of steps (4,656 steps) for Japanese women aged 65 years and older, but it reached the 10 MET hours per week.

The physical functioning assessment showed a significant difference between the mean values of both groups in all items other than forward bending. Older people with high PA have been reported to be more flexible[32,33]. The results of this study were not consistent with those findings. However, as for overall physical strength, the high-step group had higher physical strength than the low-step group. In the ADL test, there were significant differences between the two groups in "Jumping a ditch," "Standing on the bus or train," "Folding up and down a futon," “Carrying," and "Total score." It was speculated that most of the items' significant differences were because they required dynamically exerted strength, which was related to the PA's daily level. A significant difference was also found in the total score, and older people with high PA had high physical functioning and ADL.

The SF-36v2 revealed significant differences in physical function, body pain, general health, and role-emotional. Of the four items, only bodily pain was preferred in the low-step group. It is considered that the difference in the numerical values of this item indicate the results of physical function assessment, such as grip strength. The actual amount of PA is shown in Figure 1. In role-emotional, the low-step group scored much lower than the national average. Reading from the role-emotional indicators of SF-36v2, the low-step group may have psychological difficulties during work and/or regular activities. It was inferred that the high-step group was more likely to engage in social participation. Bodily pain was similar to the national average in the high-step group, but much better in the low-step group. It was speculated that the low-step group of these particular participants was not associated with physical pain and low PA. People who achieve the recommended level of PA are reported to have higher HRQOL than those who do not[34]. In this study, the values in the high-step group were higher in the items for which no significant differences were found, and they generally supported previous studies. The POMS results showed a significant difference only in confusion-bewilderment. The low-step group was not considered depressed. Aoyagi et al.[35] reported that depression is less likely if an individual walks an average of 4,000 or more steps per day. It is estimated that if you do not lead a secluded life, you can maintain a PA level of approximately 4,000 steps per day. The study's participants seemed to be related to the fact that no people who were withdrawn from the salon on a regular basis.

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The results of the daily life questionnaire survey revealed a significant difference in terms of health status. Although there was no significant difference in the participants' view of their physical fitness, there was a difference in the scores. The higher the PA, the healthier and physically stronger one feels. The participants' view of their health status was consistent with the SF-36v2TM general health results.

We gather from this study that there is a difference in the mental and physical condition of 65 year old Japanese women who walk an average number of steps (4,656 steps) and those who do not. Therefore, this study's hypothesis was supported.

According to Health Japan 21 (second term), the target number of steps per day for women over 65 years of age is 6,000. Older women can expect to achieve this goal by walking 10 minutes more than we currently do. In general, an increase in the amount of PA in older individuals improves their physical functioning[36,37]. It also improves their QOL[38]. Health 21 (2nd edition), the Active Guide based on "PA reference 2013" introduced "Plus Ten" as a tagline for encouraging daily PA[39]. Plus Ten involves 10 minutes of increasing daily PA, especially walking. The results regarding the high-step group and low-step group showed that the low-step group also reached 10 MET hours per week. When Plus Ten is considered, it is recommended that older women in Japan walk approximately 6,000 steps per day.

## Declaration of Conflicting Interests

The author declares that there is no conflict of interest.

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