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Association between physical activity and quality of life in Japanese adults aged 85 to 89 years: a cross-sectional study

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Abstract

Background Associations between physical activity (PA) and quality of life (QOL) have usually been studied in people in their 60s and 70s, however little is known about these associations in older age groups. We aimed to examine the association between PA and QOL in Japanese adults aged 85–89 years and investigate the types of exercises/sports in this population.

Methods This cross-sectional study ($n=914$) used baseline data from the Kawasaki Aging and Well-being Project (KAWP), a longitudinal cohort study of older adults aged 85–89 years. Health-related QOL and psychological well-being were assessed using the EuroQoL 5D-5L (EQ-5D-5L) and the WHO Five Well-Being Index (WHO-5), respectively. PA was objectively and subjectively measured using a triaxial accelerometer and modified Zutphen Physical Activity Questionnaire, respectively. Associations were analyzed using multivariable regression analysis.

Results Higher PA was significantly associated with a higher EQ-5D-5L index score (coefficient, 0.004; 95%CI [0.001, 0.008], standardized coefficient, 0.142). In contrast, no association was observed between PA and the WHO-5 total score (coefficient, 0.103; 95%CI [-0.066, 0.271], standardized coefficient, 0.068). Calisthenics were the most commonly performed sports or exercises (27.4% of male and 47.6% of female participants). The subgroup of participants with > median PA had a longer walking duration than their counterparts, and the following sports/exercises were more frequently performed in addition to calisthenics; resistance training and others among male participants: stretching/yoga among female participants.

Conclusions Our findings suggest that PA is associated with a better health-related QOL. However, no association was observed between PA and psychological well-being in this population. We found that calisthenics were the most commonly performed and that more physically active older adults performed several types of exercises/sports in addition to calisthenics and walking for longer durations. Since few studies have investigated the types of exercises/sports in this age group, these findings would be helpful for interventions to maintain PA and QOL in this age group.

Trial registration UMIN000026053.

Keywords Physical activity, Health-related quality of life, Psychological well-being, Older adults

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Background

Life expectancy has increased globally and one in six people worldwide is expected to be aged 60 years or older by 2030 [1]. Japan is one of the countries currently experiencing a super-aged society. Approximately 29% of the population is aged 65 years and older, which is the highest in the world, and life expectancy at birth is estimated to be 85 years in male and 91 years in female by 2065 [2]. Healthy aging is an urgent challenge worldwide, especially in aging societies, and it is important to maintain the functional ability and quality of life (QOL) of older adults.

QOL is a multidimensional construct that includes the self-evaluation of the physical, psychological, and social well-being of individuals [3]. Regular physical activity has been proven to help prevent and treat non-communicable diseases and improve QOL [4]. A previous systematic review showed a positive association between physical activity and QOL in older adults, and physical activity was consistently associated with various QOL domains, including general QOL, functional capacity, vitality, and psychological and mental health [5].

However, most studies were conducted in their 60s and 70s [5–10], and little is known about the association between physical activity and QOL in older age groups, especially those in their 80s. It is unclear whether the evidence obtained for the 60s and 70s can be extrapolated to the 80s for the following reasons. First, a previous study reported that the strength of the association between physical activity and QOL differed between young-old (aged 65–74 years) and old-old (aged > 75 years) individuals; shorter sitting time was associated with higher QOL with the relationship being stronger among the old-old than among the young-old [11]. Second, another study showed a significant association between physical decline in Instrumental Activities of Daily Living (IADL) and depressive symptoms in the 70s group, but not in the 80s group [12]. People may shift their mindsets in late life to embrace the changes of growing older and interpret life more maturely according to an adaptive theory of aging called gerotranscendence [13]. Apart from the uncertain association between physical activity and QOL among this older age group, the type of physical activity may matter. Certain types of physical activity (e.g. Tai Chi which is common among older age groups) help promote gerotranscendence, which is associated with changes in QOL [13]. To the best of our knowledge, only one pilot study ($N = 67$) has been conducted among over-80-year-old female in Poland [14]. In this study, a higher physical activity level, as assessed using the International Physical Activity Questionnaire, was associated with better QOL in four domains (physical, psychological, social, and environmental). However, further investigation is warranted due to the small sample size. Furthermore, data have been lacking on lifestyle patterns in terms of the type of exercises/sports performed for health in this very old-age group. This type of data is warranted to develop health promotion programs that suit this generation.

This study aimed to examine the association between physical activity and QOL in Japanese adults aged 85–89 years as the primary research question and to investigate the types of exercises/sports performed for health in this population as secondary research questions to further describe its features in detail.

Methods

Study population

This cross-sectional study used baseline data from the Kawasaki Aging and Well-Being Project (KAWP), a prospective cohort study of very old adults conducted in Kawasaki City (Kanagawa Prefecture, Japan). Baseline data were collected between March, 2017 and December, 2018. The study design and inclusion criteria have been described in a previous article [15]. The inclusion criteria were as follows: (1) being a resident of Kawasaki City and aged between 85 and 89 years, (2) having no limitations in basic activities of daily living, and (3) being able to visit the study site. To evaluate the association between accelerometer-based physical activity and QOL, three additional inclusion criteria were added as follows; (4) agreed to wear an accelerometer for seven days; (5) wearing an accelerometer for at least 3 days with ≥ 10 h per day; and (6) completed QOL questionnaires (Fig. 1). The participants provided written informed consent, and ethical approval was obtained from the Ethics Committee of the Keio University School of Medicine (ID:20160297). The KAWP is registered in the University Hospital Medical Information Network Clinical Trial Registry as observational studies (ID: UMIN000026053).

Measurements

QOL questionnaire assessment

Two QOL questionnaires were used in this study. Health-related QOL (HRQOL) was measured using the Japanese version of EuroQoL 5D-5L (EQ-5D-5L), as reported in our previous study [16]. The EQ-5D-5L consists of five questions that evaluate five dimensions: mobility, self-care, daily activities, pain/discomfort, and anxiety/depression [17]. The validity and reliability of the EQ-5D-5L have been reported previously [17]. Each dimension was assessed using a single question with five response levels: no problems, slight problems, moderate problems, severe problems, and extreme problems. The EQ-5D index score was calculated based on responses to each question using the Japanese tariff ranging from −0.025 to 1.000 [18]. Each EQ-5D dimension was recoded into two levels based on the reports of previous studies [8, 11]: no problems and with problems.

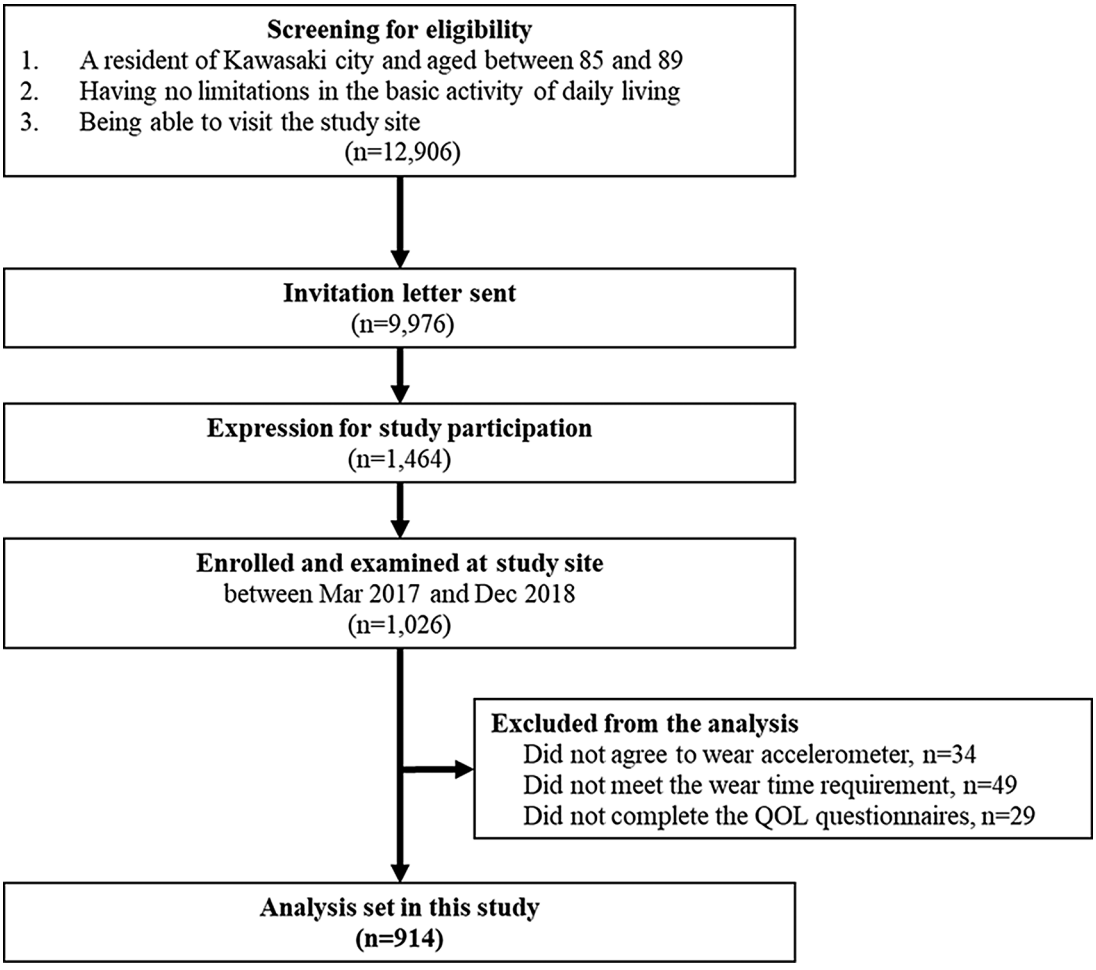

Fig. 1 Flow chart detailing recruitment and participation

Psychological well-being was measured using the Japanese version of the WHO Five Well-Being Index (WHO-5). The WHO-5 items are: "I have felt cheerful and in good spirits"; "I have felt calm and relaxed"; "I have felt active and vigorous"; "I woke up feeling fresh and rested"; and "My daily life has been filled with things that interest me" [19]. The validity and reliability of the WHO-5 have been reported previously [19]. Each of the five items is scored from 5 (All the time) to 0 (At no time). The raw score is calculated by totaling the scores of the five items, ranging from 0 (worst possible QOL) to 25 (best possible QOL). The answer to each WHO-5 item was re-coded into two levels: Yes (i.e., all the time, most of the time, and more than half of the time) and No (i.e., less than half of the time, some of the time, and at no time).

The two questionnaires were used for different purposes. The EQ-5D-5L assessed the overall health-related QOL, whereas the WHO-5 evaluated subjective psychological well-being, which is a component of QOL. The EQ-5D-5L provides a comprehensive view of overall health-related QOL, but may have a lower sensitivity for specific QOL components. Given the importance of psychological well-being, especially in older adults, we used the WHO-5 to investigate its association with PA.

Physical activity assessment

Physical activity was measured objectively and subjectively. For objective measurements, the participants were instructed to wear a triaxial accelerometer (Active style Pro, HJA-750 C, Omron Healthcare Corporation, Kyoto, Japan) on their waist for seven consecutive days during waking hours. The epoch length was 60 s. The absence of acceleration signal detection for more than 60 consecutive minutes was defined as non-wear, and a valid day was defined as wearing the device for at least 10 h per day. Participants with at least 3 valid dates were included in the analyses [20]. Physical activity intensity (i.e., metabolic equivalents (METs)) was calculated using an established algorithm [21] and was used to calculate the physical activity index (PAI, METs*h/day) and the intensity of physical activity. The intensity of physical activity was defined based on the METs cutoff-points as follows:

sedentary behavior (SB), 1.5 METs or less; light intensity physical activity (LPA), 1.6 to 2.9 METs; and moderate-to-vigorous intensity physical activity (MVPA), 3 METs or more [22]. The PAI and number of minutes spent on each intensity of physical activity were summed over valid days, and the mean values were then calculated. For subjective measurements, trained researchers asked participants to complete a modified Zutphen Physical Activity Questionnaire [20]. In this study, answers to the question "Do you play sports or exercise for your health or leisure activities?" was used to identify the types of sports and exercises performed by participants during their leisure time. If the participant answered "yes", they named the sport or exercise. Walking duration per day and frequency per week were determined using a separate set of questions administered prior to querying the types of sports and exercises, and the walking duration per week was calculated.

Table 1 Characteristics of the study participants

	Total (*n* = 914)	Male (*n* = 452)	Female (*n* = 462)
Age, years, mean (SD)	86.6 (1.4)	86.5 (1.4)	86.6 (1.4)
Alcohol intake, n (%)			
Never/Former	549 (60.1)	198 (43.8)	351 (76.0)
Current	365 (39.9)	254 (56.2)	111 (24.0)
Smoking status, n (%)			
Never/Former	876 (95.8)	420 (92.9)	456 (98.7)
Current	35 (3.8)	32 (7.1)	3 (0.6)
Missing data	3 (0.3)	0	3 (0.6)
Education			
Years of education, mean (SD)	11.4 (3.3)	12.3 (3.7)	10.6 (2.5)
Living situation, n (%)			
With others	660 (72.2)	384 (85.0)	276 (59.7)
Alone	241 (26.4)	62 (13.7)	179 (38.7)
Missing data	13 (1.4)	6 (1.3)	7 (1.5)
Marital status, n (%)			
Married	465 (50.9)	360 (79.6)	105 (22.7)
Single	21 (2.3)	3 (0.7)	18 (3.9)
Divorced	27 (3.0)	4 (0.9)	23 (5.0)
Widowed	399 (43.7)	84 (18.6)	315 (68.2)
Missing data	2 (0.2)	1 (0.2)	1 (0.2)
Perceived household income level, n (%)			
Very good or Good	547 (59.8)	273 (60.4)	274 (59.3)
Neutral, Bad, or Very bad	344 (37.6)	175 (38.7)	169 (36.6)
Missing data	23 (2.5)	4 (0.9)	19 (4.1)
BMI, mean (SD)	23.2 (3.1)	23.6 (2.9)	22.9 (3.3)
<18.5 kg/m^2, n (%)	55 (6.0)	19 (4.2)	36 (7.8)
≥ 18.5 kg/m^2, <25.0 kg/m^2, n (%)	612 (67.0)	305 (67.5)	307 (66.5)
≥ 25.0 kg/m^2, n (%)	247 (27.0)	128 (28.3)	119 (25.8)
Comorbidities			
Number of comorbidities per participant, mean (SD)	2.4 (1.4)	2.3 (1.4)	2.6 (1.4)
Hypertension, n (%)	592 (64.8)	286 (63.3)	306 (66.2)
Dyslipidemia, n (%)	374 (40.9)	154 (34.1)	220 (47.6)
Osteoarthritis, n (%)	346 (37.9)	139 (30.8)	207 (44.8)
Heart disease, n (%)	242 (26.5)	147 (32.5)	95 (20.6)
Osteoporosis, n (%)	200 (21.9)	21 (4.6)	179 (38.7)
Cancer, n (%)	188 (20.6)	123 (27.2)	65 (14.1)
Diabetes, n (%)	127 (13.9)	73 (16.2)	54 (11.7)
Stroke, n (%)	94 (10.3)	64 (14.2)	30 (6.5)
Collagen disease, n (%)	29 (3.2)	9 (2.0)	20 (4.3)
Dementia, n (%)	19 (2.1)	11 (2.4)	8 (1.7)

Abbreviations: BMI, body mass index; IQR, interquartile range; SD, standard deviation

Covariates

Information on covariates was collected from the KAWP Baseline Survey. The detailed procedure was described previously [15]. Briefly, the following covariates were obtained: age, sex (male or female), body mass index (BMI) (weight in kilograms divided by height in meters squared), years of education, living situation (with others or alone), marital status (married, single, divorced, or widowed), smoking status (never, former, or current), current alcohol intake (never, former, or current), self-rated economic status (very good, good, neutral, bad, or very bad), and comorbidities. Comorbidity was ascertained for the 10 diseases listed in Table 1. The number of diseases (0–10) was calculated as an index of comorbidity. Number of body weight and height were measured objectively, comorbidities were assessed by trained physicians, and other covariates were self-reported using a pre-mailed questionnaire and confirmed by trained researchers. We considered these covariates as potential confounders that may affect the association between PA and QOL and adjusted for them in the multivariable linear regression models.

Statistical analysis

Multivariable linear regression models were used to examine the associations between physical activity metrics, including the PAI and time spent on each physical activity type, and the EQ-5D index score and WHO-5 total score. Each physical activity metric was entered into a separate model. Subgroup analysis stratified by sex was also conducted, as conducting a subgroup analysis by sex is considered standard practice because of the observed differences in PA and QOL between the sexes based on previous studies. In addition, multivariable logistic regression models were used to further investigate the associations between the PAI and the binary outcomes of each EQ-5D dimension and each dichotomized WHO-5 subitem to better understand which dimension and subitem contributed to the result. A higher odds ratio (OR) indicates higher odds of having no problems in particular EQ-5D dimensions or subitem of WHO-5. The model was adjusted for age, sex, accelerometer wear

time, current smoking status, current alcohol intake, years of education, living situation, self-rated economic status, BMI, and number of comorbidities. The types of sports and exercises performed and the walking duration per week were summarized descriptively. These activities were stratified by sex as they may vary between males and females and by the median PAI to investigate the differences between active and inactive participants. Complete case analyses ($n=876$) were performed for multivariable linear and logistic regression, and no imputation was performed for missing data. All the statistical analyses were performed using SPSS Statistics version 29.0 (IBM Japan, Tokyo, Japan). Results were considered statistically significant at a p-value of 0.05, and two-sided tests were performed.

Table 2 Distribution of physical activity and QOL scores of the study participants

	Total ($n=914$)	Male ($n=452$)	Female ($n=462$)
Physical Activity, mean (SD)			
PAI (METs*h/day)	21.5 (3.3)	20.3 (3.1)	22.6 (3.1)
Time spent for SB (min/day)	562.5 (121.5)	586.5 (118.5)	538.9 (119.9)
Time spent for LPA (min/day)	291.1 (93.7)	247.1 (80.9)	334.2 (85.0)
Time spent for MVPA (min/day)	20.4 (18.0)	21.5 (19.7)	19.3 (16.1)
Accelerometer wear time (min/day)	873.9 (108.5)	855.1 (108.7)	892.4 (105.3)
Steps (/day)	3631 (2288)	4004 (2549)	3266 (1935)
QOL			
EQ-5D index score, median (IQR)	**0.895 (0.831, 1.000)**	**0.895 (0.831, 1.000)**	**0.895 (0.831, 1.000)**
EQ-5D dimensions, n (%)			
Mobility (no problem)	701 (76.7)	346 (76.5)	355 (76.8)
Self-care (no problem)	899 (98.4)	444 (98.2)	455 (98.5)
Usual activities (no problem)	809 (88.5)	398 (88.1)	411 (89.0)
Pain/Discomfort (no problem)	490 (53.6)	271 (60.0)	219 (47.4)
Anxiety/Depression (no problem)	737 (80.6)	373 (82.5)	364 (78.8)
WHO-5 total score, median (IQR)	**19.0 (15.0, 22.0)**	**19.0 (15.0, 22.0)**	**20.0 (16.0, 22.0)**
WHO-5 each question, n (%)			
I have felt cheerful and in good spirits. (Yes)	796 (87.1)	385 (85.2)	411 (89.0)
I have felt calm and relaxed. (Yes)	819 (89.6)	402 (88.9)	417 (90.3)
I have felt active and vigorous. (Yes)	758 (82.9)	373 (82.5)	385 (83.3)
I woke up feeling fresh and rest. (Yes)	773 (84.6)	373 (82.5)	400 (86.6)
My daily life has been filled with things that interest me. (Yes)	754 (82.5)	371 (82.1)	383 (82.9)

Abbreviations: IQR, interquartile range; LPA, light-intensity physical activity; MVPA, moderate-to vigorous-intensity physical activity; PAI, physical activity index; QOL, quality of life; SB, sedentary behavior; SD, standard deviation

Notes: Each EQ-5D dimension was recoded in two levels: no problems and with problems. The answer to each WHO-5 question was recoded into two levels: yes (including all the time, most of the time, and more than half of the time) versus no (including less than half of the time, some of the time, and at no time)

Results

Characteristics of the study participants

The characteristics of the participants are shown in Table 1. The mean (standard deviation [SD]) age was 86.6 (1.4) years, and about half (49.5%) of the participants were male. Overall, 72.2% of the participants lived with others, and more than half (59.8%) of them reported that their household income level was very good or good. The mean (SD) number of comorbidities was 2.4 (1.4).

The participants wore the accelerometer for a mean (SD) of 6.7 (1.0) days with ≥ 10 h per day, and the mean (SD) wear time was 873.9 (108.5) minutes per day. Among the wear time, the mean (SD) time spent for SB, LPA, and MVPA were 562.5 (121.5), 291.1 (93.7), and 20.4 (18.0) minutes per day, respectively (Table 2). The mean (SD) PAI was 21.5 (3.3) METs*h/day.

The median (interquartile range [IQR]) EQ-5D index score was 0.895 (0.831, 1.000). The percentage of respondents in full health (EQ-5D index score of 1.000) was 40.1%, indicating skewed distribution. The median (IQR) WHO-5 total score was 19.0 (15.0, 22.0) among the study participants. The answers to each EQ-5D dimension and WHO-5 item were binarily categorized, and their distributions are presented in Table 2.

Associations between physical activity and EQ-5D scores

Higher PAI was significantly associated with higher EQ-5D index score (coefficient, 0.004; 95%CI [0.001, 0.008], standardized coefficient, 0.142) (Table 3). Among the variables, standardized coefficient of PAI was the second largest following that of number of comorbidities (-0.230). In addition, sex, perceived household income level, and number of comorbidities were significantly associated with the EQ-5D index score (Table 3). Similar results were obtained in male and female subgroups (Additional file 1). Higher PAI was associated with higher odds of having no problems with mobility (OR, 1.201; 95%CI [1.098, 1.312]) and usual activities (OR, 1.155; 95%CI [1.029, 1.296]) (Additional file 2). No association was observed between the PAI and the EQ-5D dimensions of self-care (OR, 1.018; 95%CI [0.762, 1.359]), pain/discomfort (OR, 1.036; 95%CI [0.964, 1.113]) and anxiety/depression (OR, 0.988; 95%CI [0.905, 1.079]). Regarding the intensity of physical activity, time spent for MVPA was also positively associated with EQ-5D index

Table 3 Associations between PAI and QOL

	Coefficient (95% CI)	Standardized Coefficient	*p*-value
EQ-5D index score			
PAI (METs*h/day)	0.004 (0.001, 0.008)	0.142	0.010
Age (years)	0.001 (-0.004, 0.006)	0.015	0.661
Sex	-0.018 (-0.034, -0.002)	-0.089	0.026
Accelerometer wear time (min/day)	0.000 (0.000, 0.000)	-0.034	0.514
Current alcohol intake	0.005 (-0.009, 0.020)	0.026	0.457
Current smoking status	-0.019 (-0.055, 0.017)	-0.035	0.298
Education (years)	0.000 (-0.002, 0.003)	0.015	0.671
Living situation	-0.011 (-0.026, 0.005)	-0.046	0.172
Perceived household income level	-0.009 (-0.015, -0.003)	-0.096	0.004
BMI	0.000 (-0.002, 0.003)	0.011	0.755
Number of comorbidities	-0.016 (-0.021, -0.012)	-0.230	< 0.001
R^2	0.093		
WHO-5 total score			
PAI (METs*h/day)	0.103 (-0.066, 0.271)	0.068	0.232
Age (years)	0.136 (-0.106, 0.379)	0.037	0.269
Sex	0.465 (-0.337, 1.266)	0.046	0.256
Accelerometer wear time (min/day)	0.001 (-0.004, 0.005)	0.011	0.830
Current alcohol intake	-0.169 (-0.880, 0.541)	-0.017	0.640
Current smoking status	-2.042 (-3.832, -0.251)	-0.077	0.025
Education (years)	0.042 (-0.065, 0.150)	0.028	0.440
Living situation	-0.796 (-1.572, -0.021)	-0.070	0.044
Perceived household income level	-0.319 (-0.628, -0.010)	-0.068	0.043
BMI	0.194 (0.083, 0.305)	0.120	< 0.001
Number of comorbidities	-0.385 (-0.620, -0.151)	-0.110	0.001
R^2	0.048		

Abbreviations: BMI, body mass index; CI, confidence interval; PAI, physical activity index; QOL, quality of life

Notes: Multivariable linear regression models with QOL values (i.e., EQ-5D index score and WHO-5 total score) as the dependent variable. The model was adjusted for age (years), sex (male: 0, female: 1), accelerometer wear time (min/day), current alcohol intake (never/former: 0, current: 1), current smoking status (never/former: 0, current: 1), education (years), living situation (alone: 0, with others: 1), perceived household income level, BMI, and number of comorbidities

score (coefficient, 0.012; 95%CI [0.008, 0.016], standardized coefficient, 0.211), however, no statistically significant association was observed between time spent for SB and EQ-5D index score (coefficient, 0.000; 95%CI [−0.001, 0.000], standardized coefficient, -0.052) and that for LPA and EQ-5D index score (coefficient, 0.000; 95%CI [−0.001, 0.001], standardized coefficient, -0.010) (Table 4).

Associations between physical activity and WHO-5 scores

No association was observed between PAI and WHO-5 total score (coefficient, 0.103; 95%CI [-0.066, 0.271], standardized coefficient, 0.068) (Table 3). Current smoking status, living situation, perceived household income level, BMI, and the number of comorbidities were significantly associated with the WHO-5 total score. Similar results were obtained in male and female subgroups (Additional file 1). When further investigated the association between PAI and answers to each WHO-5 item, higher PAI was associated with higher odds of better answers to item of "I have felt active and vigorous." (OR, 1.273; 95%CI [1.150, 1.410]) and "My daily life has been filled with things that interest me." (OR, 1.186; 95%CI [1.077,1.307]) (Additional file 2). No association was observed between PAI and answers to the following questions: "I have felt cheerful and in good spirits." (OR, 0.989; 95%CI [0.891, 1.097]), "I have felt calm and relaxed." (OR, 0.925; 95%CI [0.826, 1.034]), and "I woke up feeling fresh and rested." (OR, 0.992; 95%CI [0.899, 1.094]). With regard to the intensity of physical activity, only MVPA was associated with WHO-5 total score (coefficient, 0.256; 95%CI [0.068, 0.444], standardized coefficient, 0.091) (Table 4).

Type of sports and exercises performed and walking duration per week

Among the 452 male and 462 female participants, 261 (57.7%) and 340 (73.6%) performed any type of sport or exercise as leisure activities for their health, respectively. The most commonly performed sports or exercises among male were calisthenics ($n = 124$, 27.4%), resistance training ($n = 40$, 8.8%), and ground golf ($n = 33$, 7.3%) (Fig. 2). The most frequently performed sport or exercise among female was calisthenics ($n = 220$, 47.6%), followed by stretching/yoga ($n = 57$, 12.3%) and dancing ($n = 50$,

Table 4 Associations between time spent on each physical activity type and QOL

	Coefficient (95% CI)	Standardized Coefficient	*p*-value	R^2
EQ-5D index score				
Time spent for SB (10 min/day)	0.000 (-0.001, 0.000)	-0.052	0.280	0.088
Time spent for LPA (10 min/day)	0.000 (-0.001, 0.001)	-0.010	0.806	0.087
Time spent for MVPA (10 min/day)	0.012 (0.008, 0.016)	0.211	< 0.001	0.128
WHO-5 total score				
Time spent for SB (10 min/day)	-0.008 (-0.047, 0.031)	-0.019	0.690	0.046
Time spent for LPA (10 min/day)	-0.004 (-0.046, 0.039)	-0.007	0.869	0.046
Time spent for MVPA (10 min/day)	0.256 (0.068, 0.444)	0.091	0.008	0.054

Abbreviations: CI, confidence interval; LPA, light-intensity physical activity; MVPA, moderate-to-vigorous-intensity physical activity; QOL, quality of life; SB, sedentary behavior

Notes: Multivariable linear regression models with QOL values (i.e., EQ-5D index score and WHO-5 total score) as the dependent variable. Each physical activity metric was included separately in each model as an independent variable. The model was adjusted for age, sex, accelerometer wear time, current alcohol intake, current smoking status, education, living situation, perceived household income level, BMI, and number of comorbidities

10.8%). When stratified by the median PAI, the frequency of calisthenics was similar between the subgroups regardless of PAI: 27.4% vs. 27.4% among male, and 48.5% and 46.8% among female. In addition, the following sports or exercises were more frequently performed (i.e., ≥ 3% difference in the frequency) in the subgroup of participants with ≥ median PAI than in those with < median PAI; resistance training (10.6% vs. 7.1%) and other (11.9% vs. 8.4%) among male participants; stretching/yoga (15.2% vs. 9.5%) among female participants.

The median (IQR) walking durations per week were 210.0 (105.0, 420.0) minutes among male and 210.0 (118.1, 360.0) minutes among female. When stratified by the median PAI, the median walking duration per week was longer among participants with ≥ median PAI than among those with < median PAI in both male (180.0 [80.0, 350.0] minutes vs. 210.0 [140.0, 420.0] minutes) and female (180.0 [90.0, 300.0] minutes vs. 270.0 [140.0, 420.0] minutes).

Discussion

This study examined the association between physical activity and QOL among people aged 85–89 in Japan. Our study suggests that PAI is associated with better HRQOL in this very old population. In particular, time spent on MVPA was positively associated with better HRQOL. However, no association was found between the PAI and psychological well-being in this population. Furthermore, more than half of the participants engaged in some type of sport or exercise as a leisure activity for their health. Compared with the less active participants, the more active participants performed several kinds of sports or exercises in addition to calisthenics and had a longer walking duration per week.

In Japan, the population of adults aged 85 years and older was 6.16 million in 2020 and is estimated to exceed 10 million by 2030 [23]. Approximately 58% of the population require nursing care [24]. The study participants were older adults aged 85–89 years without limitations in basic activities of daily living; thus, the study population was healthier than the general Japanese population aged 85–89 years. Indeed, the median EQ-5D index score in this study (0.895) exceeded the Japanese population norms in the 80–89-year age group (0.821 in male and 0.774 in female) [25], which is consistent with our previous findings in a smaller sample [16]. To investigate the factors of healthy aging, descriptive analyses of healthier older adults are important. The primary objective of KAWP is to explore trajectories of functional decline, frailty, and cognitive impairment and identify factors that delay or modify this deteriorating process, and substantial evidence has been reported from KAWP [15, 16, 26–29]. Our preliminary report documented that drug burden exerted a significant negative association with EQ-5D score [16]. Further investigations are warranted to enrich the evidence regarding the methods to promote healthy aging.

The results of our study conducted among older adults in their 80s were consistent with the reports of previous studies conducted among those in 60s and 70s, not only for the EQ-5D index score but also the EQ-5D dimension score (e.g. mobility, usual activities) [5, 18]. Our results suggest that physical activity is necessary to maintain better HRQOL, even in adults aged 85 years and older. In addition, the time spent on MVPA was positively associated with HRQOL, whereas the time spent on SB or LPA was not. Conflicting findings have been reported in several studies in terms of the time spent performing different intensities of physical activity. One study reported that less time spent on SB was associated with better QOL [11], while another study reported that more time spent on LPA was associated with better QOL [30]. Therefore, only the time spent performing intensive physical activity (i.e. MVPA) was associated with

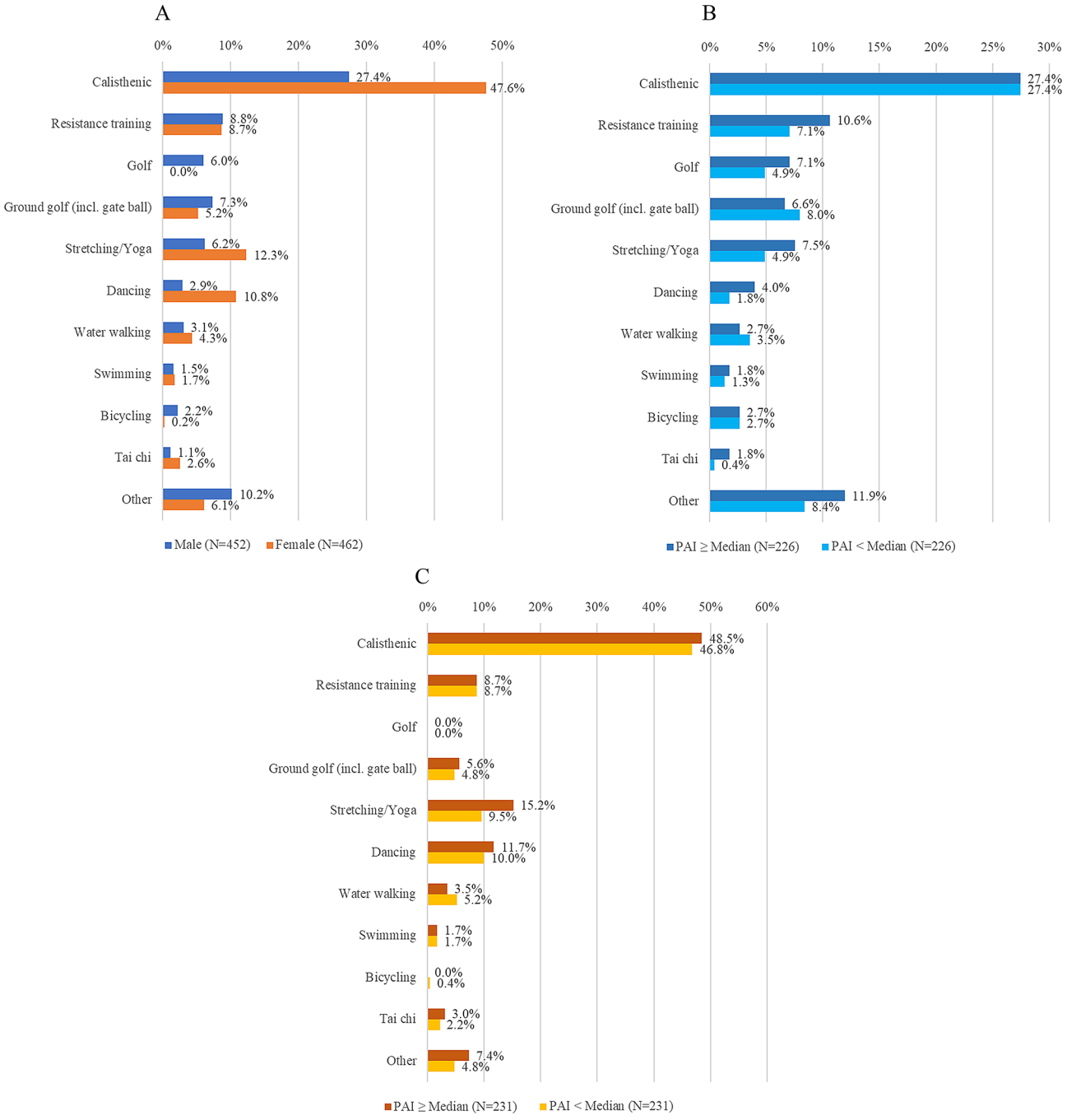

Fig. 2 Types of sports and exercises performed by the participants. Legend: Descriptive summary of sports and exercise types: (**A**) performed by participants stratified by sex; (**B**) performed by male participants stratified by the median PAI of male participants; (**C**) performed by female participants stratified by the median PAI of female participants. Abbreviations: PAI, physical activity index; incl., including

HRQOL, considering that the participants in this study were healthy people with higher QOL and the MVPA time exhibited substantial variability. In addition, factors other than physical activity (e.g., hobbies) also contribute to QOL in older adults [31], which may have a greater impact on QOL than time spent on SB and LPA. Owing to the potential risk of falls or injuries when older adults, especially those who are relatively inactive, perform high levels of MVPA, further investigations are warranted to determine the optimal frequency, intensity, duration, and type of physical activity in this population.

PAI and the number of comorbidities were strong predictors of EQ-5D index scores; however, with an R2 value of less than 10%, it was suggested that the magnitude of the influence of these factors on variability in HRQOL among individuals may be less significant. While it is

important to assess physical activity objectively, it may also be necessary to investigate further aspects that cannot be captured by the PAI, such as the quality and context of physical activity, including activities of daily living.

In this study, no association was found between the PAI and psychological well-being in the 80s. A systematic review reported inconsistent results, indicating an intermediate-to-consistent association between physical activity and mental health or psychological well-being [5]. Physical activity has been reported to reduce anxiety in older population [32]. Another study reported that functional decline had less impact on psychological well-being of older adults in their 80s compared with older adults in their 60s and 70s [33]. According to gerotranscendence theory, very older adults shift their mindset, and consequently, factors other than physical activity may have stronger associations with psychological well-being. Psychological well-being has six core dimensions (purpose in life, autonomy, personal growth, environmental mastery, positive relationships, and self-acceptance), and physical activity is associated with life satisfaction and self-esteem [34]. In our study, PAI was associated with better answers to two questions regarding positive emotion (i.e., "I have felt active and vigorous." and "My daily life has been filled with things that interest me.") among the WHO-5 questions, indicating that PAI partially contributes to the psychological well-being of older adults in their 80s.

To the best of our knowledge, this is the first study to reveal the types of sports and exercises performed in this very old population. Calisthenics were the most commonly selected sports and exercises by both male and female in this population. Participants in this study performed calisthenics anywhere, including at home, in a park, and at a rehabilitation center. In Japan, various calisthenic programs are available via TV and radio, and calisthenics are easy to start anywhere, anytime, and with anyone. Thus, calisthenics may be one of the best options for people who do not perform any exercise to start some kind of exercise. The secondary- and tertiary-selected sports and exercises differed by sex; male participants preferred resistance training and ground golf, whereas female participants preferred stretching/yoga and dancing. This difference may be partially due to gender preference; it has been reported that older Japanese female prefer to participate in regular group activities compared with older Japanese male [35]. Previous studies have reported that these sports and exercises are also associated with better HRQOL in the older population [36–39]. Based on the findings of this study and those of previous studies, these types of exercises should be considered for inclusion in health promotion programs for this population. Although no significant difference was found in the proportion of participants performing calisthenics regardless of PAI, more active participants tended to perform several sports or exercises in addition to calisthenics. Walking is the most frequently performed sport/exercise among older Japanese adults [40], with more active participants walking for longer durations than the inactive participants. Furthermore, more active participants may walk longer to attend sports or exercise programs. To promote physical activity and maintain QOL even at an advanced age, it is essential to cultivate an environment and community in which individuals can easily explore sports or exercises that interest them and begin exercising in a manner suitable for this generation.

Strength and limitations

The major strengths of our study are as follows: first, this study used a large community-based cohort with an older population aged between 85 and 89 years; second, physical activity was objectively assessed using an accelerometer to minimize recall bias, overestimation, and underestimation [41] and was also subjectively assessed using a questionnaire to provide qualitative insights into specific types of physical activities. However, this study has several limitations. First, causal relationships could not be established due to the cross-sectional study design. Further investigation using follow-up data from the KAWP is warranted. Second, the study was conducted among residents of Kawasaki City who visited the study site and did not require nursing care. As the study participants represented a healthier population with a higher QOL, the generalizability of the results warrants further investigation. Third, not all variables, including unobserved ones, were fully adjusted in this study. Residual confounding factors, including sleep and diet, may have existed and were not adjusted for in this model. Sleep and diet are important in assessing the relationship between PA and QOL. However, in this study, the accelerometer was worn during waking hours, which precluded the inclusion of sleep data in the analysis. While diet is also important, this study primarily focused on the relationship between PA and QOL, and specific types of PA in this very old population. The impact of diet should be considered in future studies. Polypharmacy was not adjusted in the model; instead, it was adjusted for the number of comorbidities, as older patients received standard medical care, including drugs, under the Japanese universal care system. Fourth, although the validity of the accelerometer was confirmed in the older population, the mean errors and degree of underestimation were greater in the older population, especially for higher-intensity activities, than in the younger population [42]. Fifth, owing to the use of complete case analysis, the study findings were limited to participants with no missing data. In the complete case analysis dataset ($n = 876$) and the excluded individuals ($n = 38$), age, alcohol intake, smoking

status, years of education, perceived household income level, BMI, and the number of comorbidities were similar. The percentages of female participants (73.7% vs. 49.5%) and those living alone (44.0% vs. 26.3%) were higher in the excluded group than in the group with complete case analysis dataset. This could have led to an overestimation of the association between PA and QOL, but given the small percentage of excluded individuals, we believe that the likelihood of such bias is low. The median EQ-5D index score (0.895 vs. 0.895), median WHO-5 total score (19.0 vs. 20.0), and mean PAI (21.5 METs*h/day vs. 22.2 METs*h/day) were similar among the complete case analysis dataset and the excluded groups.

Conclusion

This cross-sectional study suggested that physical activity is associated with better HRQOL in adults aged 85–89 years, whereas no association was observed between PAI and psychological well-being in this population. More than half of the population performs some type of sport or exercise for their health. Moreover, active older adults perform several kinds of sports or exercises in addition to calisthenics and have longer walking durations.

Abbreviations

BMI	body mass index
CI	confidence interval
EQ 5D-5L	EuroQoL 5D-5L
HRQOL	health-related quality of life
IQR	interquartile range
KAWP	the Kawasaki Aging and Well-Being Project
LPA	light intensity physical activity
METs	metabolic equivalents
MVPA	moderate-to-vigorous intensity physical activity
PA	physical activity
PAI	physical activity index
OR	odds ratio
QOL	quality of life
SB	sedentary behavior
SD	standard deviation
WHO-5	WHO Five Well-Being Index

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Author contributions

All authors contributed to the conception and design of this study. The material preparation and analysis were performed by YM and YO. YO and YA participated in data collection. The first draft of the manuscript was written by YM, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the principles of the Declaration of Helsinki and all relevant regulations and guidelines for working with human subjects. The KAWP was approved by the Ethics Committee of the Keio University School of Medicine (ID:20160297). Written informed consent was obtained from all individual participants included in the study.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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