Health Promotion and Physical Activity
ISSN 2544-9117 ▪ 2024; 29 (4): 18-26
doi: 10.55225/hppa.626

HPPA • 2024; 29 (4): 18-26

Factors influencing moderate-to-vigorous intensity physical activity across different living arrangements in older adults

Suguru Ando[1,2 A-G], Yoshihiro Yamashina[1,2 A,B,F], Masaki Iwamura[1,2 A,B,F], Yosuke Yamato[1,2 A,B,F], Emiko Morita[1,2 B,F], Wataru Nanikawa[2 B,F], Yui Kikuchi[2 A,B,F], Sho Kumabe[2 B,F]

[1] Aino University, Graduate School of Health Sciences, Ibaraki City, Osaka, Japan
[2] Aino University, Faculty of Health Science, Department of Physical Therapy, Ibaraki City, Osaka, Japan

Original article

Abstract

Purpose: This study aimed to investigate the factors associated with moderate-to-vigorous physical activity (MVPA) in older adults, comparing those living in care facilities with community-dwelling individuals. Additionally, it examined diurnal variations in physical activity across different intensity levels.

Materials and methods: This cross-sectional study included 10 older adults residing in a care facility (mean age 84.0 ± 6.2 years) and 17 community-dwelling older adults (mean age 75.7 ± 4.7 years). Participants wore a triaxial accelerometer for 1 week to measure sedentary behavior (SB), light physical activity (LPA), and MVPA. Data were analyzed by dividing the 15-h period (6:00–21:00) into five 3-h intervals to examine activity patterns. Descriptive statistics, independent t-tests, and multiple regression analyses identified factors associated with MVPA.

Results: Compared with community-dwelling older adults, their counterparts in care facilities engaged in significantly less MVPA. Long-term care certification, daily step counts, and time spent in LPA were key factors associated with MVPA. Diurnal patterns revealed that community-dwelling older adults were more active from 9:00–18:00, whereas those in care facilities spent more time in SB, particularly between 9:00 and 12:00.

Conclusions: Long-term care certification, daily step counts, and LPA were key factors influencing MVPA. Furthermore, significant differences in physical activity patterns between institutionalized and community-dwelling older adults highlight the need for tailored activity promotion programs.

Approval of ethics committee

Education and Research Promotion Committee and the Research Ethics Subcommittee of Aino University (approval number: 10R-23004).

Keywords

- long-term care
- sedentary behavior
- diurnal patterns

Contribution

A – Preparation of the research project
B – Assembly of data
C – Conducting of statistical analysis
D – Interpretation of results
E – Manuscript preparation
F – Literature review
G – Revising the manuscript

Corresponding author

Suguru Ando
e-mail: s-ando@pt-u.aino.ac.jp
Aino University
Faculty of Health Science
Department of Physical Therapy
4-5-4 Higashioda, Ibaraki City
Osaka 567-0012, Japan

Article info

Article history

- Received: 2025-01-28
- Accepted: 2025-03-26
- Published: 2025-03-31

Publisher

University of Applied Sciences in Tarnow
ul. Mickiewicza 8, 33-100 Tarnow, Poland

Conflict of interest

None declared.

Financing

This research did not receive any grants from public, commercial or non-profit organizations.

Introduction

Physical activity, particularly moderate-to-vigorous intensity activity, is essential for maintaining the health of older adults.[1] Current guidelines recommend that individuals ≥65 years engage in 150 to 300 min of moderate-to-vigorous physical activity (MVPA) per week. Achieving this level of MVPA is associated with lower mortality rates,[2] reduced cardiovascular diseases,[2] improved mental health,[3] and enhanced physical function.[4] Furthermore, promoting physical activity fosters greater social participation[5] among older adults and may help prevent isolation and dementia.

Living arrangements influence physical activity levels. A disparity is observed between community-dwelling older adults and those in institutionalized care. Razaob et al. reported that compared with older adults in institutionalized care, those living independently at home demonstrate greater autonomy in self-care activities, such as oral hygiene, indoor mobility, and showering.[6] Community-dwelling older adults are more likely to engage in physical activity through daily walking or public transportation use, creating natural movement opportunities.[7] In contrast, older adults in institutional care are often restricted by physical limitations and restricted activities, reducing opportunities for movement. Additionally, the domestic roles[8] and social connections[9] in the community of older adults living at home contribute to greater physical activity, whereas those in institutional care may experience limited social support, diminishing motivation for physical activity.

Understanding the determinants of MVPA is crucial for identifying environmental and social factors that influence health. Additionally, focusing on the timing and diurnal variations of MVPA provides insights into more detailed behavioral patterns and optimal intervention windows. A recent study has indicated that older adults are generally more active in the morning, but accumulating activity throughout the day is more effective than brief, isolated exercise bouts.[10] Furthermore, variations in sedentary behavior (SB) and light-intensity physical activity (LPA) throughout the day may influence overall health benefits.[11] Therefore, understanding the quantity of physical activity and its diurnal pattern is crucial for developing more effective approaches to improving health outcomes.

This study aimed to investigate the factors associated with MVPA among older adults, focusing on differences in living arrangements. Additionally, the study aimed to examine diurnal variations in physical activity across different intensity levels. The primary analysis centered on the diurnal MVPA patterns, whereas preliminary analyses explored SB and LPA.

Materials and methods

Study design and participants

This cross-sectional study included older adults residing in a care facility and community-dwelling older adults. For the older adults residing in the care facility, 30 older adults from "Care House Ikeda," located in Neyagawa City, Osaka Prefecture, participated in measurement sessions between January and February 2023. The community-dwelling older adults included 25 individuals who attended a physical measurement session held at Aino University in November 2023. Figure 1 shows the participant flow diagram. The inclusion criteria involved individuals aged ≥65 years who were capable of physical activity assessment. Individuals with severe dementia or inability to walk independently (regardless of walking aids) were excluded. In total, 31 participants met these criteria: 10 older adults residing in the care facility (mean age 84.0 ± 6.2 years, 6 women, 60.0 %) and 17 community-dwelling older adults (mean age 75.7 ± 4.7 years, 14 women, 82.4 %).

The study protocol was explained orally to all participants, and written informed consent was obtained. Ethical approval was granted by the Education and Research Promotion Committee and the Research Ethics Subcommittee of Aino University (approval number: 10R-23004).

Assessment

Basic characteristics

Baseline characteristics included age, sex, height, weight, cognitive function, depressive symptoms, the presence of long-term care or support certification, the number of medications, and current medical history (hypertension, hyperlipidemia, diabetes mellitus, articular diseases). The body mass index was calculated using the measured height and weight. The Mini-Cog was used as a screening test for cognitive function. This test is a simple assessment for distinguishing cognitive impairment, even in culturally, linguistically, and educationally diverse community samples.[12] It can be completed in less than 2 min and has been shown to have validity comparable to that of the mini-mental state examination (MMSE).[13] The Mini-Cog consists of two tasks: a three-item recall task (scored from 0–3 points) and a clock-drawing task (scored as 0–2 points). A total score of ≤2 out of 5 points indicates

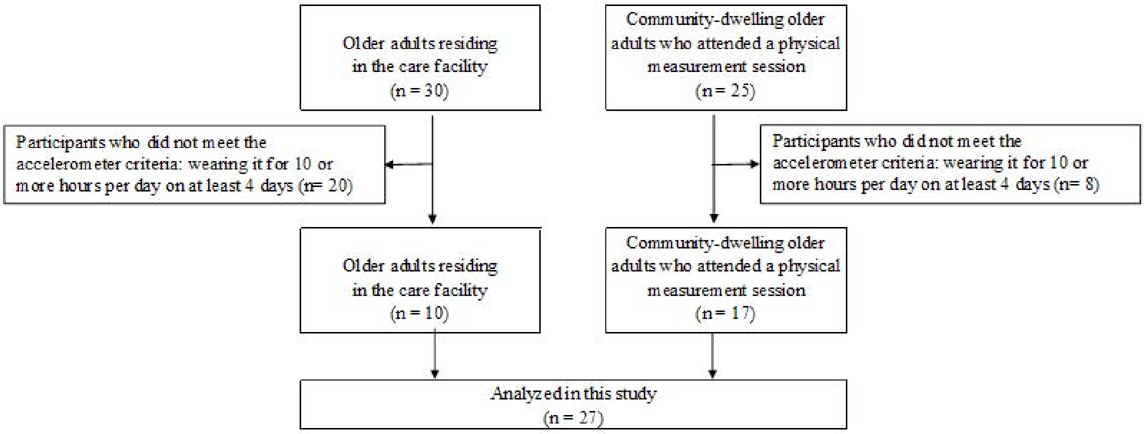


Figure 1. Flow of participants throughout the study

suspected dementia.[13] The 15-item geriatric depression scale (GDS-15) was used to assess depressive symptoms and was administered via questionnaire to all participants.[14] Scores ranged from 0 to 15, with scores of 0 to 4 considered within the normal range, 5 to 9 indicating mild depression, and 10 or more indicating moderate to severe depression.[15] In our study, a score of 5 or higher on the GDS-15 scale was defined as "with depressive symptoms". The number of medications was also assessed using a questionnaire. Participants were asked to select from five options: none, 1–2 types, 3–4 types, 5–6 types, ≥7 types of medications. For analysis, participants were categorized into two groups: those taking fewer than five different medications and those taking five or more. Compared with individuals taking fewer medications, those taking five or more medications, regardless of the type of medication, are 4.5 times more likely to experience falls over a two-year period.[16]

Measurement of physical functions

Physical functions were evaluated by assessing grip strength and walking speed. Grip strength was quantified using a digital hand dynamometer (Digital Handgrip Meter KEEP; MACROSS Inc., Tokyo, Japan). Each participant performed two trials per hand, resulting in a total of four attempts, with the highest recorded value used as the representative measure.[17] Walking speed at a self-selected pace was assessed over a 6 m segment within an 8 m pathway, with a single measurement taken.[18]

Assessment of the physical activity

Physical activity was assessed using a triaxial accelerometer, the Active-style Pro HJA-750C (Omron Healthcare Corporation, Kyoto, Japan). Participants were instructed to wear the accelerometer on their waist for 1 week, from waking up in the morning until going to bed at night. They were advised to keep the device on at all times except during activities such as showering or swimming. This device was worn on the left (or right) side of the waist, positioned at the level of the umbilicus. This triaxial accelerometer was used to measure daily step counts, SB (1.0–1.5 metabolic equivalents [METs]), LPA (1.6–2.9 METs), and MVPA (≥3 METs), with these values evaluated every 10 s. In this study, moderate and vigorous activities were consolidated as MVPA because of the negligible amount of vigorous activity. Data were included for analysis on days when the accelerometer was worn for at least 600 min,[19] and daily physical activity levels were calculated. Data were collected for at least 4 days per week.[20] In calculating the daily averages, no weighting was applied for weekdays and holidays, as the focus was on comparing different living environments and to avoid equalizing the sample sizes and activity patterns.

As part of the preparation for secondary analysis, the 15-h period from 6:00 to 21:00 was divided into five 3-h intervals, categorized by three levels of activity intensity. This timeframe was selected, as over 90% of participants consistently wore accelerometers during these hours. The specific intervals for monitoring diurnal changes are as follows: 6:00–9:00, 9:00–12:00, 12:00–15:00, 15:00–18:00, and 18:00–21:00.

Statistical analysis

Descriptive statistics were calculated for all variables, and normality was assessed using the Shapiro–Wilk test. Initially, independent *t*-tests and χ^2 tests were conducted to compare the two groups. Next, multiple regression analysis was performed to examine factors associated with MVPA. The dependent variable was MVPA, and the independent variables included each measurement item, with age and residence as covariates. Owing to the small sample size, a forced entry approach was used, controlling for age and living arrangement. To reduce model overfitting, independent variables were analyzed individually in separate models. As a secondary analysis, comparisons between the two groups for each intensity level and time were made using an independent *t*-test. Effect sizes were calculated using Cohen's d and φ. Effect sizes were categorized as small, medium, or large based on Cohen's d values of 0.2, 0.5, and 0.8, and φ values of 0.1, 0.3, and 0.5, respectively.

All statistical analyses were performed using SPSS, Windows version 28.0 (IBM Japan Corporation, Tokyo, Japan). Statistical significance was set at $p < 0.05$.

Results

Table 1 presents the characteristics of the participants. Compared with community-dwelling older adults, those residing in care facilities were significantly older, exhibited a higher prevalence of cognitive decline, and had a greater proportion of individuals with the presence of long-term care or support certification. Additionally, they demonstrated lower physical function and spent significantly less time in MVPA.

Table 2 displays the results of the multiple regression analysis. Significant associations were observed between MVPA duration and the presence of long-term care or support certification, daily step counts, and time spent in LPA.

Figure 2 illustrates the diurnal patterns of activity across three intensity levels. Community-dwelling older adults exhibited significantly longer MVPA durations during the 9:00–18:00 period. In contrast, older adults in care facilities engaged in more SB between 9:00 and 12:00. For LPA, community-dwelling older adults had longer activity durations between 18:00 and 21:00.

Table 1. Summary of participant characteristics

Category	Overall (n = 27)		Care facility (n = 10)		Community-dwelling (n = 17)		*p*-value	Effect size*
Age (years)	78.8	±6.6	84.0	±6.2	75.7	±4.7	<0.001	1.56
Women (n, %)	20	(74.1)	6	(60.0)	14	(82.4)	0.365	0.25
Height (cm)	155.4	±7.3	154.5	±7.6	156.0	±7.3	0.614	0.20
Weight (kg)	53.7	±7.0	53.8	±5.7	53.6	±7.8	0.960	0.02
BMI kg/m^2	22.2	±2.5	22.5	±1.7	22.1	±2.9	0.650	0.18
Mini-Cog (score)	4.5	±1.0	3.7	±1.3	4.9	±0.2	0.006	1.60
GDS-15 (score)	3.1	±3.9	3.5	±3.0	2.9	±4.5	0.351	0.15
Certification of needed support (yes, %)	10	(37.0)	7	(70.0)	3	(17.6)	0.013	0.52
Number of medications (5 or more, %)	6	(22.2)	4	(40.0)	2	(11.8)	0.153	0.33
Medical history (n, %)								
Hypertension	5	(18.5)	1	(10.0)	4	(23.5)	0.621	0.17
Hyperlipidemia	4	(14.8)	2	(20.0)	2	(11.8)	0.613	0.11
Diabetes mellitus	1	(3.7)	1	(10.0)	0	(0.0)	0.370	0.26
Articular diseases	7	(25.9)	1	(10.0)	6	(35.3)	0.204	0.28
Grip strength (kg)	20.3	±10.0	10.2	±0.8	26.2	±8.0	<0.001	2.50
Walking speed (minutes/second)	1.1	±0.5	0.6	±0.04	1.4	±0.3	<0.001	4.18

Category	Overall (n = 27)		Care facility (n = 10)		Community-dwelling (n = 17)		*p*-value	Effect size*
Daily step counts (step/day)	5611.2	±4287.8	4155.1	±5674.2	6467.8	±3108.1	0.181	0.55
SB (minutes/day)	422.3	±10.5.2	430.9	±89.4	417.3	±115.8	0.752	0.13
LPA (minutes/day)	288.8	±84.1	269.9	±105.3	300.0	±70.0	0.380	0.36
MVPA (minutes/day)	73.0	±43.2	42.0	±33.1	91.2	±38.4	0.002	1.34

Note: Data are presented as the mean ± standard deviation, or frequency (percentage). BMI – Body Mass Index; GDS – Geriatric Depression Scale; SB – sedentary behavior; LPA – light-intensity physical activity; MVPA – moderate to vigorous physical activity. *Effect size is Cohen's d for continuous measures and φ for proportions.

Table 2. Multiple regression analysis of factors associated with MVPA

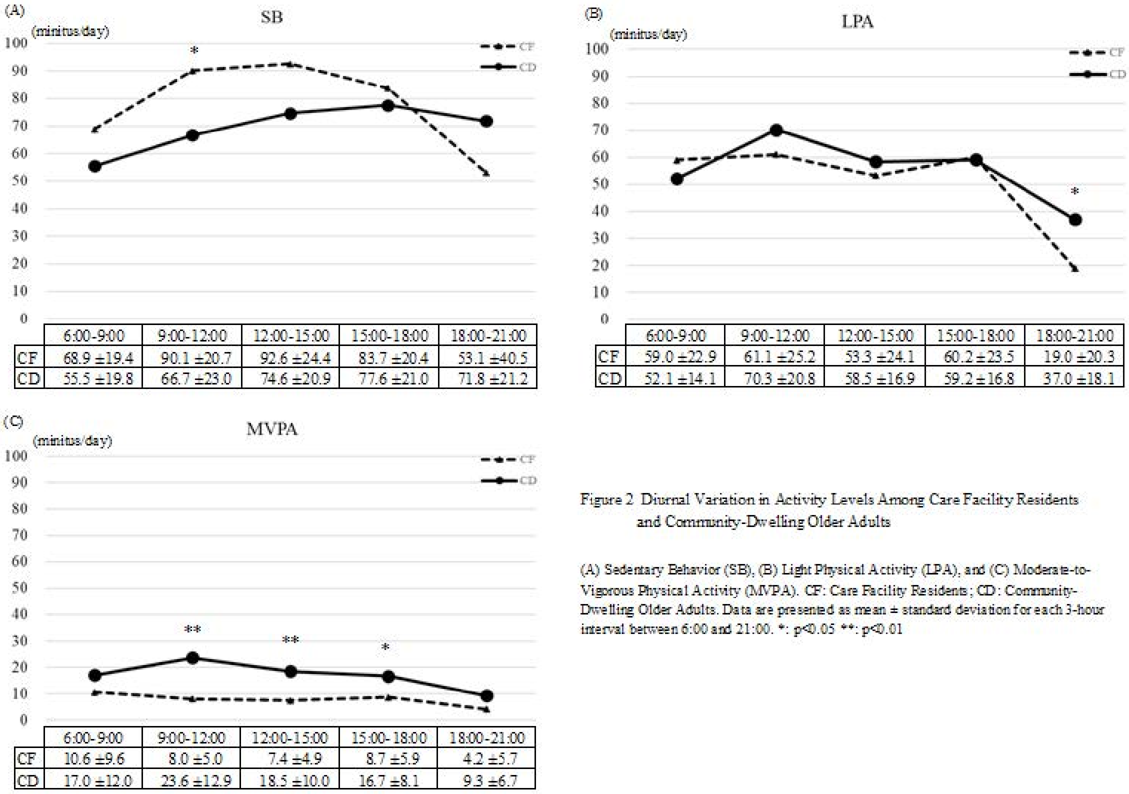
Independent Variable	B	SE	β	*p*-value	Adjusted R^2
Mini–Cog	–1.485	8.656	–0.033	0.865	0.411
GDS–15	1.505	1.627	0.137	0.365	0.431
Certification of needed support	–38.705	13.762	–0.440	0.010	0.561
Number of medications	–17.658	16.933	–0.173	0.308	0.437
Medical history: Hypertension	0.263	18.222	0.002	0.989	0.410
Medical history: Hyperlipidemia	–7.754	19.352	–0.065	0.692	0.414
Medical history: Diabetes mellitus	–23.861	34.660	–0.106	0.498	0.498
Medical history: Articular diseases	–12.090	15.580	–0.125	0.446	0.425
Grip strength	0.575	1.043	0.133	0.587	0.418
Walking speed	20.885	32.647	0.224	0.529	0.420
Daily step counts	0.003	0.001	0.329	0.033	0.518
SB	–0.031	0.062	–0.074	0.629	0.416
LPA	0.220	0.065	0.429	0.002	0.608

Note: Adjusted for covariates (age and living arrangement) for each measurement item. SE – standard error; GDS – Geriatric Depression Scale; SB – sedentary behavior; LPA – light-intensity physical activity; MVPA – moderate-to-vigorous physical activity.

Discussion

This study identified key factors associated with MVPA, including the presence of long-term care or support certification, daily step counts, and LPA. Additionally, significant differences in physical activity patterns were observed between institutionalized and community-dwelling older adults. Community-dwelling older adults engaged in significantly longer durations of MVPA during the daytime, whereas institutionalized older adults exhibited consistently lower levels of MVPA across all time periods, with a higher proportion of SB.

Makino et al. reported that in multivariate Cox regression analysis, daily step counts and MVPA were significantly associated with the incidence of disability, even after adjusting for age, sex, medication, gait speed, MMSE score, GDS score, pain severity, and pain location.[21] The relationship between daily step counts and MVPA is complex and influenced by multiple factors. First, an increase in daily step counts is associated with longer MVPA durations. Greater walking frequency may lead to higher-intensity movement that meet MVPA criteria.[22] However, an increase in daily step counts did not always translate into a corresponding increase in MVPA, particularly when considering the influence of age and health status. For instance, in older adults or individuals with physical limitations, even if daily step counts increase, the intensity may not reach the threshold required for MVPA.[23] These findings highlight the practical significance of promoting walking as a straightforward and accessible strategy to enhance MVPA among older adults, including those with



(A) SB	6:00-9:00	9:00-12:00	12:00-15:00	15:00-18:00	18:00-21:00
CF	68.9 ±19.4	90.1 ±20.7	92.6 ±24.4	83.7 ±20.4	53.1 ±40.5
CD	55.5 ±19.8	66.7 ±23.0	74.6 ±20.9	77.6 ±21.0	71.8 ±21.2

(B) LPA	6:00-9:00	9:00-12:00	12:00-15:00	15:00-18:00	18:00-21:00
CF	59.0 ±22.9	61.1 ±25.2	53.3 ±24.1	60.2 ±23.5	19.0 ±20.3
CD	52.1 ±14.1	70.3 ±20.8	58.5 ±16.9	59.2 ±16.8	37.0 ±18.1

(C) MVPA	6:00-9:00	9:00-12:00	12:00-15:00	15:00-18:00	18:00-21:00
CF	10.6 ±9.6	8.0 ±5.0	7.4 ±4.9	8.7 ±5.9	4.2 ±5.7
CD	17.0 ±12.0	23.6 ±12.9	18.5 ±10.0	16.7 ±8.1	9.3 ±6.7

Figure 2 Diurnal Variation in Activity Levels Among Care Facility Residents and Community-Dwelling Older Adults

(A) Sedentary Behavior (SB), (B) Light Physical Activity (LPA), and (C) Moderate-to-Vigorous Physical Activity (MVPA). CF: Care Facility Residents; CD: Community-Dwelling Older Adults. Data are presented as mean ± standard deviation for each 3-hour interval between 6:00 and 21:00. *: $p<0.05$ **: $p<0.01$

physical or health limitations. Even modest increases in daily step count may reflect greater engagement in moderate-to-vigorous activities and contribute meaningfully to functional and health outcomes. Setting step count goals may be an especially feasible intervention target, particularly in resource-limited settings or care facilities. Moreover, while replacing SB or LPA with MVPA is associated with superior health benefits, LPA may be a more realistic and beneficial goal for frail older adults. Interventions tailored to functional capacity—such as structured walking routines or supervised mobility sessions—could effectively support incremental gains in physical activity across diverse living arrangements. According to Spartano, only 38% of adults aged 50–64 years and 15% of those aged ≥75 years met the recommended 150 min of MVPA per week.[24] These findings highlight the need to account for age, health status, and physical capacity when examining the association between daily step counts and MVPA. LPA did not have the same intensity as MVPA; however, it slowed the progression of arteriosclerosis,[25] and reduced depressive symptoms,[26] providing health benefits similar to those of MVPA. Fishman et al. reported that replacing 10 min of sedentary time with LPA or MVPA reduced mortality, with LPA reducing mortality by 9% and MVPA by 30%.[27] Additionally, del Pozo-Cruz et al. discovered that substituting SB with LPA or MVPA in older adults residing in long-term care facilities improved physical function and disability risk.[28] For older adults or individuals with health limitations who struggle to engage in MVPA, LPA serves as a more realistic and achievable goal.

This study clarified the diurnal variations in activity patterns of MVPA, SB, and LPA. Understanding why activity peaks during specific periods is crucial for designing targeted physical activity intervention. First, MVPA significantly increased between 9:00 and 18:00. This period is generally considered the peak time for activity, and physical function might be the most active during the morning to noon hours for community-dwelling older adults, which may influence this pattern.[10,29] Next, regarding SB, longer sitting times were observed in older adults residing in care facilities between 9:00 and 12:00. This period may be related to morning routines and the time following breakfast in the facility. The increase in SB has detrimental effects on physical function and health in the long term.[30] Therefore, interventions to reduce SB during this time window may be necessary. Older adults in the community were more active between 18:00 and 21:00, likely owing to the fact that, especially in the evening, they tend to engage in light tasks such as household chores. These results suggest that diurnal activity patterns are influenced by physiological and psychological states at different times of the day. The characteristics of activity periods for MVPA and LPA were important factors in determining the timing of interventions aimed at maximizing health benefits. For example, increasing MVPA during the morning and promoting LPA in the evening may contribute to overall health improvements. Building on these findings, future interventions should prioritize the promotion of MVPA during peak activity periods—typically from morning to early afternoon—when older adults tend to be more physically active. For institutionalized populations, implementing structured activity programs during these hours may help reduce prolonged sedentary time and optimize engagement. In parallel, tailored strategies that encourage LPA in the evening—such as light household chores or guided stretching—may support the maintenance of physical function, especially among those with mobility limitations. Future studies are warranted to assess the effectiveness of such time-specific interventions and to examine their sustained impact on health and functional outcomes over time.

This study had some limitations. First, its cross-sectional design only provided insights into activity patterns at a single point in time. Consequently, the causal relationship between activity patterns and health outcomes remains unclear. However, this design allowed for the acquisition of initial insights into activity patterns within a limited timeframe. Future research should consider using longitudinal designs to establish clearer causal relationships. Second, the sample size was small and may not represent the broader population of older adults. The sample size was determined based on the availability of eligible participants in both the care facility and community settings, as well as ethical and logistical constraints related to recruitment. Importantly, this study was designed as an exploratory analysis to identify factors associated with MVPA, rather than to test a specific hypothesis requiring a larger sample for statistical power. While the limited sample size restricts the generalizability of the findings, the results nonetheless offer valuable insights into the distinct physical activity patterns of institutionalized versus community-dwelling older adults. Additionally, participants were drawn from specific regions and facilities, limiting the generalizability of the findings. Expanding the sample size and including a more diverse range of participants would enhance the robustness of the study. Moreover, the generalizability of this study's findings is constrained by cultural and regional factors, as participants were recruited from a limited number of communities and care facilities within a specific geographic area. Consequently, the results may not be fully applicable to other cultural contexts or regions. Future studies should account for regional and cultural differences in physical activity patterns and consider conducting cross-cultural comparative research to enhance the external validity of findings. Additionally, several external influences—such as differences between institutional and community settings, levels of local community engagement, individual motivation, and opportunities for social interaction—were not systematically assessed. These contextual factors likely influence physical activity behavior but were beyond the scope of the current analysis. Future investigations should incorporate such variables to provide a more nuanced understanding of how environmental and social determinants shape physical activity in older adults. Finally, applying a theoretical framework, such as the Social Ecological Model or behavior change theories (e.g., Theory of Planned Behavior), may facilitate a more structured and multidimensional approach to studying physical activity. These frameworks can support the design of targeted interventions by elucidating the complex interplay between individual, interpersonal, and environmental factors.

Conclusions

This study identified key factors associated with MVPA, including long-term care or support certification, daily step counts, and LPA duration. Additionally, significant differences in physical activity patterns were observed between older adults living in community settings and those residing in care facilities. Community-dwelling older adults engaged in significantly more MVPA during the day, whereas institutionalized older adults exhibited lower MVPA levels and higher SB. These findings suggest that interventions aimed at promoting physical activity may be more effective when tailored to specific time periods, such as promoting MVPA in the morning for community-dwelling older adults and reducing SB in care facility residents.

References

[1] World Health Organization. *WHO guidelines on physical activity and sedentary behaviour*. Geneva: World Health Organization; 2020.

[2] Fukushima N, Kikuchi H, Sato H, et al. Dose-response relationship of physical activity with all-cause mortality among older adults: An umbrella review. *J Am Med Dir Assoc*. 2024;25(3):417-430. DOI: 10.1016/j.jamda.2023.09.028.

[3] Bernard P, Doré I, Romain AJ, et al. Dose response association of objective physical activity with mental health in a representative national sample of adults:

A cross-sectional study. *PLoS One*. 2018;13(10):e0204682. DOI: 10.1371/journal.pone.0204682.

[4] Edholm P, Nilsson A, Kadi F. Physical function in older adults: Impacts of past and present physical activity behaviors. *Scand J Med Sci Sports*. 2019;29(3):415-421. DOI: 10.1111/sms.13350.

[5] Kikuchi H, Inoue S, Fukushima N, et al. Social participation among older adults not engaged in full-or part-time work is associated with more physical activity and less sedentary time. *Geriatr Gerontol Int*. 2017;17(11):1921-1927. DOI: 10.1111/ggi.12995.

[6] Razaob NA, Kadar M, Rashdi HFM, et al. Self-care skills between institutionalised and home dwelling older adults: A preliminary study. *J Sains Kesihatan Malaysia*. 2021;19(2):1-6. DOI: 10.17576/jskm-2021-1902-15.

[7] Voss C, Sims-Gould J, Ashe MC, et al. Public transit use and physical activity in community-dwelling older adults: Combining GPS and accelerometry to assess transportation-related physical activity. *J Transp Health*. 2016;3(2):191-199. DOI: 10.1016/j.jth.2016.02.011.

[8] Martínez-Gómez D, Guallar-Castillón P, León-Muñoz LM, Rodríguez-Artalejo F. Household physical activity and mortality in older adults: A national cohort study in Spain. *Prev Med*. 2014;61:14-19. DOI: 10.1016/j.ypmed.2014.01.006.

[9] Zimmer C, McDonough MH, Hewson J, et al. Social support among older adults in group physical activity programs. *J Appl Sport Psychol*. 2023;35(4):658-679. DOI: 10.1080/10413200.2022.2055223.

[10] Lai TF, Liao Y, Lin CY, et al. Moderate-to-vigorous physical activity duration is more important than timing for physical function in older adults. *Sci Rep*. 2020;10(1):21344. DOI: 10.1038/s41598-020-78072-0.

[11] Shi H, Hu FB, Huang T, et al. Sedentary behaviors, light-intensity physical activity, and healthy aging. *JAMA Netw Open*. 2024;7(6):e2416300-e2416300. DOI: 10.1001/jamanetworkopen.2024.16300.

[12] Borson S, Scanlan J, Brush M, Vitaliano P, Dokmak A. The Mini-Cog: A cognitive 'vital signs' measure for dementia screening in multilingual elderly. *Int J Geriatr Psychiatry*. 2000;15(11):1021-1027. DOI: 10.1002/1099-1166(200011)15:11<1021::aid-gps234>3.0.co;2-6.

[13] Borson S, Scanlan JM, Chen P, Ganguli M. The Mini-Cog as a screen for dementia: Validation in a population-based sample. *J Am Geriatr Soc*. 2003;51(10):1451-1454. DOI: 10.1046/j.1532-5415.2003.51465.x.

[14] Yesavage JP, Sheikh JI. Geriatric Depression Scale (GDS): Recent evidence and development of a shorter version. *Clin Gerontol*. 1986;5(1-2):165-173. DOI: 10.1300/J018v05n01_09.

[15] Almeida OP, Almeida SA. Short versions of the geriatric depression scale: A study of their validity for the diagnosis of a major depressive episode according to ICD-10 and DSM-IV. *Int J Geriatr Psychiatry*. 1999;14(10):858-865. DOI: 10.1002/(sici)1099-1166(199910)14:10<858::aid-gps35>3.0.co;2-8.

[16] Kojima T, Akishita M, Nakamura T, et al. Polypharmacy as a risk for fall occurrence in geriatric outpatients. *Geriatr Gerontol Int*. 2012;12(3):425-430. DOI: 10.1111/j.1447-0594.2011.00783.x.

[17] Isen J, McGue M, Iacono W. Genetic influences on the development of grip strength in adolescence. *Am J Phys Anthropol*. 2014;154(2):189-200. DOI: 10.1002/ajpa.22492.

[18] Muir-Hunter SW, Clark J, et al. Identifying balance and fall risk in community-dwelling older women: The effect of executive function on postural control. *Physiother Can*. 2014;66(2):179-186. DOI: 10.3138/ptc.2013-16.

[19] Cain KL, Sallis JF, Conway TL, Van Dyck D, Calhoon L. Using accelerometers in youth physical activity studies: A review of methods. *J Phys Act Health*. 2013;10(3):437-450. DOI: 10.1123/jpah.10.3.437.

[20] Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc*. 2005;37(11):S531. DOI: 10.1249/01.mss.0000185657.86065.98.

[21] Makino K, Lee S, Lee S, et al. Daily physical activity and functional disability incidence in community-dwelling older adults with chronic pain: A prospective cohort study. *Pain Med*. 2019;20(9):1702-1710. DOI: 10.1093/pm/pny263.

[22] Amagasa S, Fukushima N, Kikuchi H, et al. Older adults' daily step counts and time in sedentary behavior and different intensities of physical activity. *J Epidemiol*. 2021;31(5):350-355. DOI: 10.2188/jea.JE20200080.

[23] Blair CK, Morey MC, Desmond RA, et al. Light-intensity activity attenuates functional decline in older cancer survivors. *Med Sci Sports Exerc*. 2014;46(7):1375. DOI: 10.1249/MSS.0000000000000241.

[24] Spartano NL, Lyass A, Larson MG, et al. Objective physical activity and physical performance in middle-aged and older adults. *Exp Gerontol*. 2019;119:203-211. DOI: 10.1016/j.exger.2019.02.003.

[25] Gando Y, Yamamoto K, Murakami H, et al. Longer time spent in light physical activity is associated with reduced arterial stiffness in older adults. *Hypertension*. 2010;56(3):540-546. DOI: 10.1161/HYPERTENSIONAHA.110.156331.

[26] Jung S, Lee S, Lee S, et al. Relationship between physical activity levels and depressive symptoms in community-dwelling older Japanese adults. *Geriatr Gerontol Int*. 2018;18(3):421-427. DOI: 10.1111/ggi.13195.

[27] Fishman EI, Steeves JA, Zipunnikov V, et al. Association between objectively measured physical activity and mortality in NHANES. *Med Sci Sports Exerc*. 2016;48(7):1303. DOI: 10.1249/MSS.0000000000000885.

[28] del Pozo-Cruz J, Irazusta J, Rodriguez-Larrad A, et al. Replacing sedentary behavior with physical activity of different intensities: Implications for physical function, muscle function, and disability in octogenarians living in

long-term care facilities. *J Phys Act Health*. 2022;19(5):329-338. DOI: 10.1123/jpah.2021-0186.

[29] Davis MG, Fox KR. Physical activity patterns assessed by accelerometry in older people. *Eur J Appl Physiol*. 2007;100:581-589. DOI: 10.1007/s00421-006-0320-8.

[30] Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: A systematic review and meta-analysis. *Ann Intern Med*. 2015;162(2):123-132. DOI: 10.7326/M14-1651.