Benefits of Sustained Physical Activity From Middle-Age To Early Old Age On Quality Of Life In Early Old Age

Mikyung Lee
Yonsei University

Hyeonkyeong Lee (hlee39@yuhs.ac)
Yonsei University

Ki Jun Song
Yonsei University

Young-Me Lee
DePaul University

Research Article

Keywords:

Posted Date: January 14th, 2022

DOI: https://doi.org/10.21203/rs.3.rs-1219812/v1

Version of Record: A version of this preprint was published at Scientific Reports on September 30th, 2022. See the published version at https://doi.org/10.1038/s41598-022-20431-0.

Abstract

This secondary data analysis study aimed to examine the changes in physical activities (PAs) over time (2009-2017) in the same participants and to determine an association between changes in PA and health-related quality of life (HRQoL) in early older adults (n=994) using data from the Korea Health Panel Survey. The HRQoL was measured using the EuroQol quality-of-life system and the amount of PA were grouped to 4 activity levels (remained inactive, became inactive, became active, and remained active). The association of changes in PA over 8 years with HRQoL was examined using logistic regression analysis while controlling for socioeconomic and behavioral factors. The total PA decreased from 1,859.72±1,760.01 MET-minutes in 2009 to 1,264.80 ±1,251.14 MET-minutes in 2017 ($P < 0.001$). In 2017, 142 (14.3%) remained inactive, whereas 419 (42.2%) remained active. The participants who remained inactive at early old age were more likely to be at the lowest 10% HRQoL of the sample (odds ratio = 1.95, 95% confidence interval = 1.09–3.48). This indicates that educating middle-aged adults who are relatively inactive must be a priority in order to maintain and improve PA, enhance HRQoL, and maximize the benefits of PA in old age.

Introduction

Older adults are the fastest growing segment of the South Korean population, making South Korea the second-fastest aging country after Japan since 2000. This rapid increase in the number of older persons is a result of a dramatic decline in fertility rates and an increase in life expectancy in South Korea [1]. The older population is expected to more than double over the next 20 years, from 8.03 million in 2020 to 16.66 million in 2040 [2]. The healthy life expectancy in Korea is 73.1 years, which has a 10.2-year gap relative to Korea's life expectancy of 83.3 years, and the gap is wider than the average gap of 8.9 years in the Western Pacific region to which Korea belongs [3]. Because life expectancy has been increasing, the most important issue facing Korean health today is how to improve the aging process and health of older adults. According to the Korea Health Panel Survey (KHPS) from 2008 to 2012, those who did not exercise regularly were 1.38 times more likely to retire due to illness and that their life expectancy decrease by 10.01 years, resulting in an increased risk of early death [4].

There is strong evidence that physical activity (PA) has an important role in the well-being of aging people. Its importance for maintaining physical capacity and its positive health effects in old age has been well documented. Earlier studies have reported that PA in early old age was associated with positive health outcomes such as improvement of metabolic syndrome, reduction of depression, improvement of cognitive function, and prevention of dementia [5, 6]. According to a systematic literature review, physically active older adults demonstrated higher levels of health-related quality of life (HRQoL) [7]. Additionally, two studies on older adults in Korea also showed consistent results: those who performed moderate- or high-intensity PA had increased quality of life compared with those who were not physically active [8, 9]. The PA of early old-age (between 55 and 64 years) workers was found to have a significant impact on improving HRQoL [10]. Such evidence emphasizes health-care providers of the importance of PA in the HRQoL of adults.

Despite the benefits of regular PA in older adults, the practice rate of the minimum recommended exercise level of 150 minutes per week of moderate-intensity PA suggested by the World Health Organization [11] was only 37.6% among older Korean adults, according to Living the Profiles of Older People Survey [12]. Compared with the previous exercise rate, which included both the rate of practicing and not practicing the recommended level, it increased to 53.7% in 2020 compared with 50.3% in 2011, but the 2020 result was slightly lower than that of 2017 (68.0%) [12]. In Korea, a current study showed that the level of PA among older Korean adults was significantly lower [13].

The problem of low PA in older adults should be addressed by encouraging a lifestyle habit starting at middle age. In a study conducted in Australia, adults who were physically active at middle age were approximately 50% more likely to have decreased mortality after 8 years [14] compared with the group that was not physically active. A longitudinal study reported that middle-aged (40–59 years) adults who had high levels of PA continued to maintain high levels of PA even in old age [15]. Even low-intensity PA at middle age contributed to a reduction of mortality in old age [16], which further emphasizes the importance of PA before old age. Although there is evidence that a higher level of PA in middle age is associated with a higher HRQoL in old age; however, our understanding of the effect on HRQoL in old age according to the level of PA in middle age is still lacking. Thus, the objectives of this secondary data analysis study were to examine the changes in PAs followed over time, from middle age to early old age, in the same participants and to determine an association of changes in PA with HRQoL among the early older adults.

Methods

Research design

Secondary data analysis was conducted to examine the changes in PA over time associated with participants' recorded quality of life as middle-aged and older adults. This design was appropriate for assessing changes in PA measured at two timepoints, in 2009 and 2017, in the same participants and for observing the trends in how the level of PA changed from middle age to old age and its association with quality of life.

Data Sample

The Korea Institute for Health and Social Affairs and the National Health Insurance Service have formed a consortium to jointly conduct the nationwide KHPS V.1.6 to obtain basic data regarding health-care utilization, health expenditure level, and health-related behaviors [17]. The KHPS is a government-approved survey that can represent Koreans. It has been conducted annually since 2008, but the database from 2008 was excluded because it did not collect data for individual health-related behavioral factors such as PA, which is a key variable for our study. After finding such issues, in 2009, additional parameters, including smoking, drinking, PA, and quality of life, were added to the survey. The data of

KHPS do not include any personal identifiers and comply with the Personal Information Protection Act and Statistics Act. It was fully informed to the participants that it can be disclosed and used for research purposes as public data. Authors obtained 'Consent to Use of Data' according to KHPS guidelines and regulations. The use of data from the KHPS was approved by the institutional review board of Y Health System (no. Y-2020-0232).

Initial review of the retrospective data collected from the KHPS revealed that 7,866 households participated in the panel survey in 2008. In 2009, when questions related to health lifestyle were added, 6,798 households participated. Tracking the IDs of participants in the 2017 survey revealed that 1,322 persons aged 60–67 years had also participated in 2009. Those who participated in both surveys, in 2009 (ages 52–59 years, i.e., middle-aged adults) and 2017 (ages 60–67 years, i.e., early older adults), were selected to determine any changes in PA over time and the impact of those changes on quality of life as reported by these middle-aged to older adults. Participants who responded to the survey by indicating disability or sickness and who answered “yes” to the question of whether they had needed to “lie down almost all day due to illness or injury” in the last month were excluded. This brought the total to 1,090 participants. After excluding those with missing data on quality of life in 2009 (n = 68) and 2017 (n = 28), 994 study participants were selected for the data analysis.

Measures

Physical activity

PA was measured using the International Physical Activity Questionnaire (IPAQ), a structured questionnaire tool that calculates the sum of the amount of PA through the average number of days and duration of high- and moderate-intensity activity per day as well as walking activity for at least 10 minutes during the previous week [18]. The amount of PA was calculated using the metabolic equivalent of task (MET, in minutes) score for high-intensity activity (MET ≥8.0), moderate-intensity activity (MET of 4.0), and walking (MET of 3.3). In the KHPS, the duration of PA is a categorical variable, according to convention in previous studies; thus, it was converted to the median value of the range of each response category, for example, “more than 20 minutes to less than 30 minutes” was converted to 25 minutes [19].

The PA groups were classified into three groups (low, moderate, and high) according to the classification criteria suggested by the IPAQ [20]. The high level indicated either high-intensity activity 3 days/week and accumulating at least 1,500 MET-minutes/week or 5 days of any combination of walking, moderate-intensity, and high-intensity activities achieving at least 3,000 MET-minutes/week. The moderate level indicated 30 minutes of moderate-intensity activity 5 days/week, 20 minutes of vigorous activity 3 days/week, or a combination achieving at least 600 MET-minutes/week [18]. The low level indicated meeting neither moderate nor high PA criteria [18].

In this study, the change in PA level over 8 years was classified into four phases using the three physical groups used by Hamer *et al.* [20]. The three groups (“low,” “moderate,” and “high”) were changed to binary

variables inactive (“low”) and active (“moderate” or “high”). Then, the change in PA level over 8 years was divided to 4 levels: remained inactive, became inactive, became active, and remained active.

Quality of life

HRQoL was measured using the EuroQol quality-of-life system, 5-dimension, 3-level version (EQ-5D-3L). The EQ-5D was developed by the EuroQol Group, established in 1987 [21], and it consists of five areas: mobility, self-care, usual activity, pain/discomfort, and anxiety/depression. Each area is measured on a nominal scale of one question and three responses. Each question has three levels describing the health condition: “no problem (1)”, “some problem (2)”, and “serious problem (3).” The three responses to the five questions were derived from 243 combinations of responses to each question regarding different health levels [16]. The EQ-5D index, a single index calculated by applying the EQ-5D question, can be calculated using the calculation formula. In this study, the EQ-5D index was calculated using the Korean quality weighting formula, and a value closer to 1 indicates a better HRQoL [22]. In this study, as there was no fixed cutoff point to define poor quality of life, a cutoff point from another study was used [23]: the lower 10% fractile of the control group representing poor HRQoL. In the case of regression analysis in the evaluation of effect size, an effect size ≥0.35 was classified as large. The participants were allocated to the lower and upper HRQoL groups with a ratio of 10/90, accounting for an effect size of 40%.

Personal factors

Personal factors, including gender, marital status, educational level, economic activity, presence of chronic diseases, body mass index (BMI), smoking status, and alcohol consumption, were measured and considered as covariates. BMI (weight [kg]/height [m]^2) was divided into three sequence scales: underweight (<18.5), normal weight (18.5–24.9), and overweight (≥25). Smoking status was identified as “no,” “past,” or “current.” Alcohol consumption was classified as “no,” “less than three times a month,” “less than three times a week,” or “almost every day.”

Statistical analyses

All data and statistical analyses were performed with SPSS version 25.0 (IBM Corp., Armonk, NY, USA) for Windows and Stata IC version 16 (StataCorp, College Station, TX, USA). The descriptive statistics were calculated to analyze the demographics and key variables related to quality of life. To compare the level of PA and HRQoL in middle (2009) and early old age (2017), including health-related behavioral factors and demographic variables, χ^2 test and t-test were performed. Lastly, logistic regression analysis was used to identify factors independently associated with quality of life, including BMI, drinking, smoking, demographic questions, and changes in PAs. We calculated the weighted percentages, odds ratios (ORs), and 95% confidence intervals (CIs). Results with P-value ≤0.05 were deemed statistically significant.

Results

Comparison of the HRQoL in a dichotomous manner based on the lower 10% (Table 1) showed that the proportion of HRQoL in the lower 10% was 13.4% higher for women (n = 78) than for men (n = 29) (c^2 =

10.17, P < 0.001). Regarding the marital status, the percentage of the HRQoL in the lower 10% was the highest at 21.3% (n = 10) in divorced/separated participants and was statistically significant (c^2 = 8.38, P = 0.039). In terms of educational level, the percentage of HRQoL in the lower 10% accounted for 14.4% (n = 35) of middle school graduates and was statistically significant (c^2 = 15.21, P = 0.002). Compared with participants with no chronic disease (6.6%; n = 18), the proportion of HRQoL in the lower 10% increased to 12.3% (n = 89) and was statistically significant (c^2 = 6.59, P = 0.010). In underweight participants, the percentage of HRQoL at the lower 10% was the highest at 33.3% (n = 5) and was statistically significant (c^2 = 11.70, P = 0.003). Drinking was not statistically significant (c^2 = 2.86, P = 0.414).

Dividing PA in 2009 and 2017 into low, moderate, and high by based on the IPAQ (Figure 1) revealed that 142 (47.3%) participants who had low PA in 2009 maintained low PA in 2017. Meanwhile, 225 (47.8%) participants who had moderate PA in 2009 maintained moderate PA in 2017 and 110 (49.3%) participants who had high PA in 2009 reduced to moderate PA in 2017.

The changes in PA and HRQoL in 2009 and 2017 are presented in Table 2. Vigorous intensity activity had sharply declined from 630.50 ± 1,142.08 MET-minutes in 2009 to 267.81 ± 742.80 MET-minutes in 2017. Walking had slightly decreased from 745.09 ± 574.41 MET-minutes in 2009 to 685.36 ± 565.77 MET-minutes in 2017. The total PA also sharply declined from 1,859.72 ± 1,760.01 MET-minutes in 2009 to 1,264.80 ± 1,251.14 MET-minutes in 2017. The HRQoL decreased from 0.96 ± 0.07 in 2009 to 0.94 ± 0.08 in 2017, and the increase was statistically significant.

Table 3 presents the results of the binary logistic regression analysis based on the lower 10% of HRQoL. Analysis of the changes in the PA categories in 2009 and 2017 showed that the probability of HRQoL belonging to the lower 10% increased when the participants remained inactive (OR = 1.95, 95% CI = 1.09–3.48) and became inactive (OR = 1.67, 95% CI = 1.01–2.75). Among the sociodemographic characteristics in 2009, those who were divorce/separated (OR = 2.39, 95% CI = 1.12–5.12), middle school graduates (OR = 2.64, 95% CI = 1.04–6.69), and with chronic diseases (OR = 1.82, 95% CI = 1.05–3.18) were more likely to belong to the lower 10% in 2017.

Discussion

The current study examined the longitudinal changes in PA that influenced HRQoL in middle age and early old age over 8 years of follow-up. The results showed that elderly participants who continued to be inactive or became inactive, compared with their PA during middle age, had increased likelihood of worsened quality of life.

PA improves the HRQoL by improving physical function and lowering the risk of chronic diseases such as obesity and various diseases, thereby inducing fundamental health benefits [24], as reported in earlier studies. An analysis of older adults 65 years and older in Korea showed that the physically active group had lower pain, pain interference, and fatigue than the inactive group [25]. HRQoL decreased linearly with decreasing PA, with participants showing weakened physical and mental health such as bodily pain,

physical role limitation, and emotional role limitation [26]. Consistent with the findings of enhanced HRQoL with PA [11, 27], the current study observed a positive effect of PA on the quality of life in old age while re-emphasizing the importance of being physically active throughout life.

A strength of this study is that it considered the changes in the PA level of the elderly in a period of 8 years. In a similar study [14] with a large sample of middle-aged and older Australian adults, the group that reported any PA or vigorous activity had associated risk reductions in mortality as well as positive effect of PA on health. In a large study in England [20], both becoming and remaining active were associated with healthy aging, compared with remaining inactive, over an 8-year follow-up, and its impact was higher in the group that remained active than in the group that became active. This requires the attention of practitioners in terms of achieving the goal of extension of healthy life rather than simply extending life expectancy in an aging society. The recommended amount of PA for the adult population should be more actively accepted from the viewpoint of not only preventing chronic diseases but also preparing for a healthy life in the elderly. Extending a healthy lifespan without the burden of disease has become a health goal for many countries; hence, the benefits of physically active life from adulthood should be emphasized in terms of preparing for a healthy quality of life in old age.

The phenomenon of the rapidly increased aging population led health researchers to give more attention on frailty, which is one of the determinants of HRQoL. The high prevalence of frailty, a dynamic state of experiencing declines in least one of the human function domains (physical, psychological, and social) [28], is among the major problems of older adults, and earlier studies showed the negative influence of frailty on the HRQoL of older adults [29, 30]. Importantly, PA is considered an important component that can help prevent or improve frailty of older adults, with the evidence of 19 interventional studies [31]. In this study, the effect of changes in PA with frailty as an outcome variable was not analyzed, but in light of the relationship with HRQoL, the changes in PA from middle age to old age can have a possible relationship with frailty. Hence, the state of frailty according to the stages of PA is suggested to examine in future research.

Despite the benefits of PA, most people find it difficult to start and maintain PA [32, 33]. Health behavior is not easy to modify because of long-term habits; furthermore, it is difficult to influence simply by value judgment and norms that say PA is beneficial to health [33]. A step-by-step intervention program is important to improve motivation, intention, and practice. A 12-week intervention study with older Korean-Americans[34] showed that PA, walking endurance, and flexibility were higher in the group that received PA motivational intervention that incorporated social support, empowering education, and motivational education. A systematic literature review of motivational studies for PA using behavior change techniques (BCTs) showed the effectivity of BCT in improving PA. Therefore, we recommend a motivational method through BCT for a PA intervention in older adults.

Similar to the results of the earlier studies, the current study revaled the influence of social economic status on HQoRL among older adults. It seems that the strategy of physical activity intervention or the priority of the population group should be different by the education level, which is among most

commonly operationalized social economics status variables, Recent literature shows that a lower level of education was strongly related to reported a lower level of physical functioning [35] and daily life activities [36], and a decrease in quality of life [35, 36, 37]. According to the Korea National Health and Nutrition Examination Survey published recently [38], older adults with a higher level of education showed higher walking adherence to “more than 5 days a week and more than 30 minutes a day,” whereas older adults with a low educational level (did not graduate from elementary school) did not practice recommended walking. This suggests that interventions aimed at changing individuals' behavior to increase physical activity should be prioritized for populations with lower socioeconomic status to reduce existing health inequalities.

Since these secondary data were obtained from people at home, excluding members from branch or dead households at the time of the survey, there is a possibility that the group with low quality of life and high probability of dying from severe illness may have been excluded. Most of the HRQoL responses were concentrated in ≥0.9 in the range of 0–1; therefore, the logistic regression value was estimated by dividing the 10% lower cutoff point. In future research, we recommend comparing the amount of PA according to the five dimensions of the EuroQol quality-of-life system or analyzing the quality of life more discriminatively through other research tools. In addition to analyzing the effect of PA frequency and intensity analysis on quality of life in more detail, future studies should analyze both aerobic PA and strength exercise because they have a positive effect on health in older adults.

Explanatory variables for the association between PA and quality of life through mediators such as self-efficacy and social support should be identified. In the survey data of this study, the responses regarding PA were subjective and memory-dependent; thus, recall bias may occur. Thus, we recommend that more objective data be collected through wearable devices and that experimental research be conducted to supplement the evidence for PA and quality of life.

Data availability

All data from which the conclusion of this study can be made are included in this manuscript and no data is deposited in any public data repository.

Declarations

Acknowledgements

This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education(No. 2020R1A6A1A03041989)” and by Brain Korea 21 FOUR Project funded by National Research Foundation(NRF) of Korea, Yonsei University College of Nursing.

Author contributions

Conceptualization, M.L., H,L.; Methodology, M.L.; Formal analysis, M.L., G.S.; Funding acquisition, H.L.; Investigation, M.L.; Writing—original draft preparation, M.L., H,L.; writing—review and editing, H.L., Y.L. . All authors have read and agreed to the published version of the manuscript

Competing interests

The authors declare no competing interest

References

1. Choi, S. J. (2015). Active ageing in South Korea. *Active Ageing in Asia*.
2. Statistics Korea. Prospects of domestic and foreign populations reflecting the 2019 Special Population. *Prospect*, 2017–2040 (2020).
3. World Health Organization. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/gho-ghe-hale-healthy-life-expectancy-at-age-60, (2019).
4. WHO. 2019. https://www.who.int/data/gho/data/indicators/indicator-details/GHO/life-expectancy-at-birth-(years)
5. Kang, Y. J. & Kang, M. Y. Chronic diseases, health behaviors, and demographic characteristics as predictors of ill health retirement: findings from the Korea health panel survey (2008–2012). *PLOS ONE* **11**, e0166921 (2016). 10.1371/journal.pone.0166921, Pubmed:27930661.
6. Bhamani, M. A., Khan, M. M., Karim, M. S. & Mir, M. U. Depressionand its association with functional status and physicalactivity in the elderly in Karachi, Pakistan. *Asian J. Psychiatr* **14**, 46–51 (2015). 10.1016/j.ajp.2014.12.004, Pubmed:25554666.
7. Wilder, R. P. *et al.* Physical fitness assessment: an update. *J. Long Term Eff. Med. Implants* **16**, 193–204 (2006). 10.1615/jlongtermeffmedimplants.v16.i2.90, Pubmed:16700660.
8. Yang, G. *et al.* Impact of physical activity and performance on medical care costs among the Japanese elderly. *Geriatr. Gerontol. Int.* **11**, 157-165 (2011). 10.1111/j.1447-0594.2010.00651.x, Pubmed:20874840.
9. Roberts, C. E., Phillips, L. H., Cooper, C. L., Gray, S. & Allan, J. L. Effect of different types of physical activity on activities of daily living in older adults: systematic review and meta-analysis. *J. Aging Phys. Act.* **25**, 653-670 (2017). 10.1123/japa.2016-0201, Pubmed:28181837.
10. Park, M. J. & Choi, S. E. The effects of health behavior and health status on heath-related quality of life in older people: gender analysis by using the 2012 Korea health panel data. *J. Korean Acad. Community Health Nurs.* **28**, 118–128 (2017). 10.12799/jkachn.2017.28.2.118.
11. Puciato, D., Borysiuk, Z. & Rozpara, M. Quality of life and physical activity in an older working-age population. *Clin. Interv. Aging* **12**, 1627–1634 (2017). 10.2147/CIA.S144045, Pubmed:29042763.
12. World Health Organization (WHO). Global recommendations on physical activity for health [Internet]. *Geneva, CH:WHO; 2010*. https://www.who. int/publications/i/item/9789241599979.
13. Ministry of Health and Welfare. *Living the Profiles of Older People Survey [LPOPS]*, 2020, (2021).

14. Cho, J., Jin, Y. & Kang, H. Weight status, physical activity, and depression in Korean older adults. *J. Epidemiol.* 28, 292–299 (2018). 10.2188/jea.JE20170083, Pubmed:29353866.
15. Gebel, K. *et al.* Effect of moderate to vigorous physical activity on all-cause mortality in middle-aged and older Australians. *JAMA Intern. Med.* **175**, 970–977 (2015). 10.1001/jamainternmed.2015.0541, Pubmed:25844882.
16. Aggio, D. *et al.* Association between physical activity levels in mid-life with physical activity in old age: a 20-year tracking study in a prospective cohort. *BMJ Open* **7**, e017378 (2017). 10.1136/bmjopen-2017-017378, Pubmed:28935690.
17. Mok, A., Khaw, K. T., Luben, R., Wareham, N. & Brage, S. Physical activity trajectories and mortality: population based cohort study. *BMJ* **365**, l2323 (2019). 10.1136/bmj.l2323, Pubmed:31243014.
18. Jung, Y., Seo, N. & Go, S. *A Report on the Korea Health Panel Survey of 2008. 38* (Korea Inst. for Health and Social Affairs, Seoul, 2010).
19. IPAQ Research Committee. *Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ)-Short and Long Forms*, (2005). http://www. ipaq. ki. se/scoring. pdf.
20. Bae, Y. J. & Han, E. A. Association between physical activity and medication adherence in Korean adults with chronic diseases. *J. Korean Acad. Soc. Manag. Care Pharm.* **6**, 1–21 (2017).
21. Hamer, M., Lavoie, K. L. & Bacon, S. L. Taking up physical activity in later life and healthy ageing: the English longitudinal study of ageing. *Br. J. Sports Med.* **48**, 239-243 (2014). 10.1136/bjsports-2013-092993, Pubmed:24276781.
22. EuroQol Group. EuroQol a new facility for the measurement of health-related quality of life. *Health Policy* **16**, 199–208 (1990). 10.1016/0168-8510(90)90421-9, Pubmed:10109801.
23. Lee, Y. K. *et al.* South Korean time trade-off values for EQ-5D health states: modeling with observed values for 101 health states. *Value Health* **12**, 1187-1193 (2009). 10.1111/j.1524-4733.2009.00579.x, Pubmed:19659703.
24. Kim, H. & Roh, S. Relationship between residential district and health-related quality of life in Chungnam industrial complex area. *Environ. Health Toxicol.* **31**, e2016017 (2016). 10.5620/eht.e2016017, Pubmed:27608718.
25. Warburton, D. E., Nicol, C. W. & Bredin, S. S. Health benefits of physical activity: the evidence. *CMAJ* **174**, 801–809 (2006). 10.1503/cmaj.051351, Pubmed:16534088.
26. Cha, B. K. & Park, C. S. A Comparison of Pain, Pain Interference and Fatigue according to the Level of Physical Activity in the Elderly with Chronic Pain. *J. Korean Acad. Community Health Nurs.* **22**, 162–172 (2011). 10.12799/jkachn.2011.22.2.162.
27. Häkkinen, A. *et al.* Health-related quality of life and physical activity in persons at high risk for type 2 diabetes. *Disabil. Rehabil.* **31**, 799-805 (2009). 10.1080/08916930802354930, Pubmed:19034723.
28. Vagetti, G. C. *et al.* Association between physical activity and quality of life in the elderly: a systematic review, 2000-2012. *Braz. J. Psychiatry* **36**, 76-88 (2014). 10.1590/1516-4446-2012-0895, Pubmed:24554274.

29. Gobbens, R. J. J., Luijkx, K. G., Wijnen-Sponselee, M. T. & Schols, J. M. Towards an integral conceptual model of frailty. *J. Nutr. Health Aging* **14**, 175–181 (2010). 10.1007/s12603-010-0045-6, Pubmed:20191249.
30. Papathanasiou, I. V. *et al.* Frailty and quality of life Among community-dwelling older adults. *Cureus* **13**, e13049 (2021). 10.7759/cureus.13049, Pubmed:33680593.
31. Henchoz, Y., Büla, C., Guessous, I. & Santos-Eggimann, B. Association between physical frailty and quality of life in a representative sample of community-dwelling Swiss older people. *J. Nutr. Health Aging* **21**, 585–592 (2017). 10.1007/s12603-016-0772-4, Pubmed:28448091.
32. Oliveira, J. S. *et al.* Evidence on physical activity and the prevention of frailty and sarcopenia Among older people: A systematic review to inform the World Health Organization physical activity guidelines. *J. Phys. Act. Health* **17**, 1247–1258 (2020). 10.1123/jpah.2020-0323, Pubmed:32781432.
33. Schwarzer, R. Modeling health behavior change: how to predict and modify the adoption and maintenance of health behaviors. *Appl. Psychol.* **57**, 1–29 (2008). 10.1111/j.1464-0597.2007.00325.x.
34. Bae, S. *Theory and Approach Method of Health Promotion* (Gyechuk Munwhasa, Seoul, Korea, 2012).
35. Yeom, H. A. & Fleury, J. A motivational physical activity intervention for improving mobility in older Korean Americans. *West. J. Nurs. Res.* **36**, 713-731 (2014). 10.1177/0193945913511546, Pubmed:24221953.
36. Medhi, G. K. *et al.* A community-based study on functional disability and its associated factors Among elderly individuals in a rural setting in Northeastern India. *Cureus* **13** (2021). 10.7759/cureus.13309.
37. Somrongthong, R. *et al.* Influence of socioeconomic factors on daily life activities and quality of life of Thai elderly. *J. Public Health Res.* **6**, 862 (2017). 10.4081/jphr.2017.862, Pubmed:28785548.
38. Lim, H. S. & Yoo, J. J. Association between Health Indicators and Health-Related Quality of Life according to Physical Activity of Older Women in *Healthcare* (Vol. 8, No. 4, p. 507) (Multidisciplinary Digital Publishing Inst., 2020).
39. Kim, S.-K., Cho, D.-H., Shim, J.-R. & Ha, J.H. Factors affecting physical activity and health-related quality of life in the elderly. http://www.dbpia.co.kr/journal/articleDetail?nodeId=NODE09217785 (Assoc. of Physical Education and Sport for Girls and Women, 2019) 33(3) 129-141. 2019.9.

Tables

Table 1. Comparison of the lower 10% of HRQoL (2017) according to general characteristics (2009)

Variables	Lower HRQoL		χ^2	P-value
	Yes	No		
Sex			10.17	<0.001
Male	29 (7.0)	383 (93.0)		
Female	78 (13.4)	504 (86.6)		
Marital status			8.38	0.039
Married	80 (9.6)	751 (90.4)		
Single	1 (16.7)	5 (83.3)		
Widow/widower	16 (14.5)	94 (85.5)		
Divorce/separated	10 (21.3)	37 (78.7)		
Education			15.21	0.002
≤Elementary school	42 (13.9)	260 (86.1)		
Middle school	35 (14.4)	208 (85.6)		
High school	24 (7.6)	291 (92.4)		
≥University	6 (4.5)	128 (95.5)		
Economic activity			3.39	0.066
Yes	69 (9.6)	647 (90.4)		
No	38 (13.7)	240 (86.3)		
Chronic diseases			6.59	0.010
Yes	89 (12.3)	634 (87.7)		
No	18 (6.6)	253 (93.4)		
BMI			11.70	0.003
<18.5	5 (33.3)	10 (66.7)		
18.5–24.9	61 (9.1)	607 (90.9)		
≥25.0	41 (13.2)	270 (86.8)		
Smoking			3.43	0.188
No	74 (11.7)	557 (88.3)	631	
Past	12 (6.9)	162 (93.1)	174	
Current	21 (11.1)	168 (88.9)	189	

Drinking			2.86	0.414
No	32 (10.8)	265 (89.2)		
1–3 times/month	52 (12.3)	371 (87.7)		
1–3 times/week	15 (7.8)	177 (92.2)		
Almost every day	8 (9.8)	74 (90.2)		
HRQoL	107 (10.8)	887 (89.2)		

Values are presented as *n* (%).

HRQoL, health-related quality of life; BMI, body mass index.

Table 2. Comparison of PA and HRQoL between 2009 and 2017

Variables	2009	2017	P-value
Amount of PA types			
Vigorous intensity (MET-minutes)	630.50 ± 1,142.08	267.81 ± 742.80	<0.001
Moderate intensity (MET-minutes)	484.12 ± 657.26	311.63 ± 551.39	<0.001
Walking (MET-minutes)	745.09 ± 574.41	685.36 ± 565.77	<0.001
Total PA (MET-minutes)	1,859.72 ± 1,760.01	1,264.80 ± 1,251.14	<0.001
HRQoL	0.96 ± 0.07	0.94 ± 0.08	<0.001

Values are presented as mean ± standard deviation.

PA, physical activity; HRQoL, health-related quality of life.

Table 3. Effect of changes in the PA groups from 2009 to 2017 and general characteristics in 2009 on poor health-related quality of life in 2017

Variables	Odds ratio	95% CI	P-value
Change of level of physical activity			
Remained inactive	**1.95**	1.09–3.48	0.025
Became inactive	**1.67**	1.01–2.75	0.045
Became active	0.66	0.32–1.40	0.280
Remained active	Ref.		
Sex			
Male	Ref.		
Female	1.55	0.95–2.53	0.076
Marital status			
Married	Ref.		
Single	4.07	0.40–41.54	0.240
Widow/widower	1.18	0.64–2.18	0.589
Divorce/separated	**2.39**	1.12–5.12	0.025
Education			
≤Elementary school	2.40	0.95–6.02	0.063
Middle school	**2.64**	1.04–6.69	0.041
High school	1.46	0.57–3.76	0.436
≥University	Ref.		
Chronic diseases			
Yes	**1.83**	1.05–3.18	0.033
No	Ref.		
BMI			
<18.5	2.60	0.78–8.63	0.119
18.5–24.9	0.72	0.47–1.12	0.147
≥25.0	Ref.		

PA, physical activity; 95% CI, 95% confidence interval; BMI, body mass index.

Boldface p-values indicate significance level < .05.

Figures

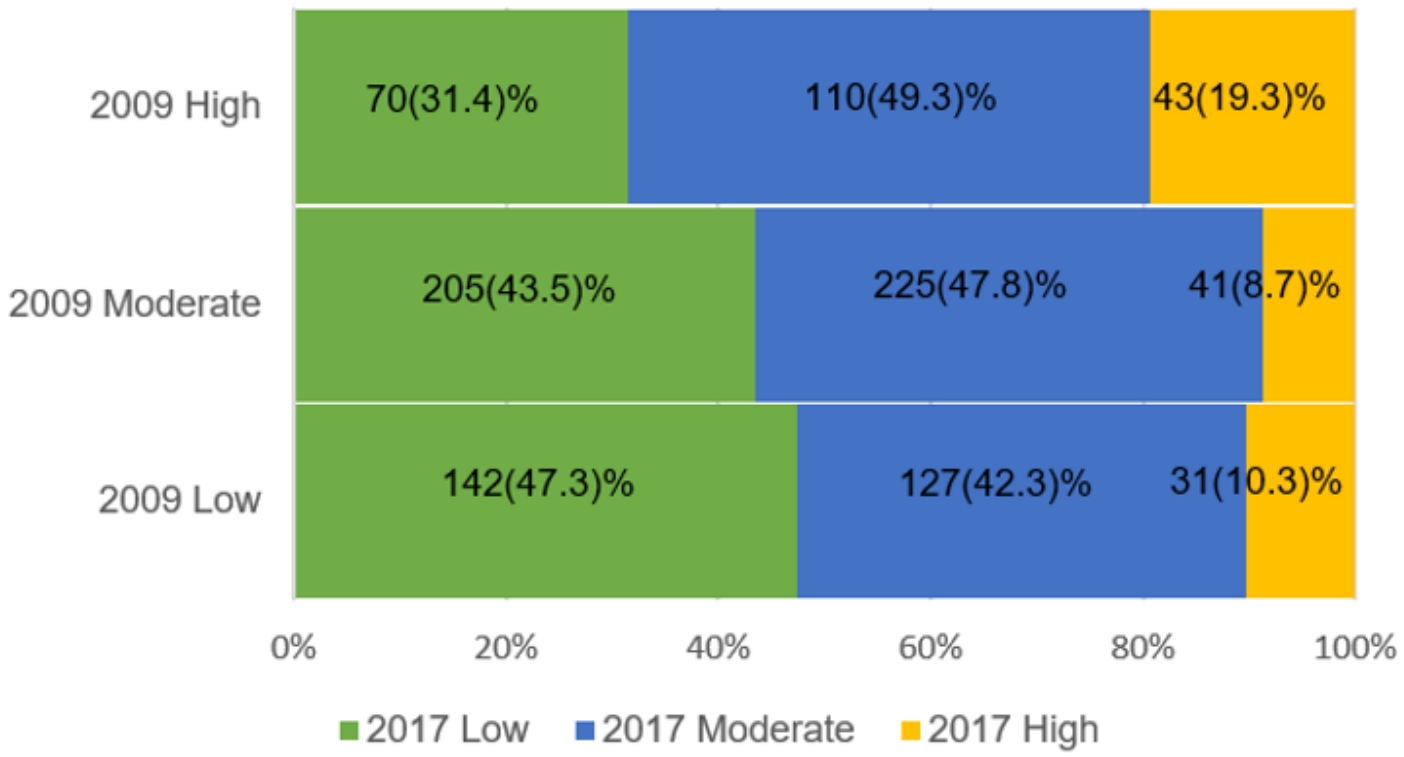

Figure 1

Physical activity categories in 2009 and 2017