Accelerometer-Based Physical Activity and Health-Related Quality of Life in Korean Adults: an observational study using the Korea National Health and Nutrition Examination Survey

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Abstract

Background: Earlier studies primarily focused on the relationship between self-reported physical activity and health-related quality of life (HRQoL). There are few studies on objectively measured physical activity and quality of life (QoL), and none of them were conducted in Korea.

Objective: The aim of our study is to analyze the relationship between physical activity measured with an accelerometer and HRQoL.

Methods: Among those who participated in the sixth Korea National Health and Nutrition Examination Survey (KNHANES), multivariate logistic regression analysis was conducted on 1,298 people who agreed to wear accelerometer, excluding pregnant women, those currently undergoing cancer treatment, and those with osteoarthritis and rheumatoid arthritis. HRQoL was measured by the EuroQoL group's EQ-5D, and physical activity was measured with an accelerometer and self-report questionnaire.

Results: Persons who performed moderate to vigorous physical activity with an accelerometer for at least 10 minutes (MVPA-AB) ?600 METs were associated with a significantly higher odds ratio of EQ-5D than those who performed MVPA-AB <600 METs (odds ratio [95% confidence interval]: 1.45 [1.01-2.09]). However, moderate to vigorous physical activity with an accelerometer for at least 1 minute (MVPA-AT) and self-reported physical activity was not significantly associated with EQ-5D.

Conclusions: HRQoL was significantly higher in the group with more physical activity for at least 10 minutes, which was confirmed by an accelerometer in Korean adults.

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Abstract

Background: Health-related quality of life (HRQoL) reflects an individual's perception of their physical and mental health over time. Despite numerous studies linking physical activity to improved HRQoL, most rely on self-reported data, limiting the accuracy and generalizability of findings. This study leverages objective accelerometer data to explore the association between physical activity and HRQoL in Korean adults.

Objective: To analyze the relationship between objectively measured physical activity using accelerometers and HRQoL among Korean adults, aiming to inform targeted interventions for enhancing HRQoL through physical activity.

Methods: This observational study included 1,298 participants aged 19-64 years from the Korea National Health and Nutrition Examination Survey (KNHANES) VI, who wore an accelerometer for seven consecutive days. HRQoL was assessed using the EQ-5D questionnaire, and physical activity was quantified as moderate to vigorous physical activity accelerometer-total (MVPA-AT) and accelerometer-bout (MVPA-AB). Data were analyzed using logistic regression to determine the odds ratios (ORs) for low HRQoL, adjusting for socioeconomic variables and mental health factors.

Results: Participants with higher HRQoL were younger, more likely to be male, single, highly educated, employed in white-collar jobs, and had higher household incomes. They also reported less stress and better subjective health status. The high HRQoL group had significantly more participants meeting MVPA-AB ≥600 METs (p=0.010). Logistic regression showed that participants meeting MVPA-AB ≥600 METs had higher odds of high HRQoL(OR 1.55, 95% CI 1.11-2.17). Adjusted models showed consistent results, although the association weakened when adjusting for mental health factors (OR 1.45, 95% CI 1.01-2.09).

Conclusion: The study demonstrates a significant association between HRQoL and moderate to vigorous physical activity sustained for at least 10 minutes, as measured by accelerometer. These findings support promoting physical activity, particularly sustained moderate to vigorous activity, to enhance HRQoL. Further interventional studies focusing on specific physical activity domains such as occupational, leisure-time, and commuting activities are warranted.

Keywords: Health-Related Quality of Life (HRQoL); Physical Activity; Accelerometer; Korea National Health and Nutrition Examination Survey (KNHANES)

Introduction

Physical activity(PA) is defined as any bodily movement produced by skeletal muscles that results in energy expenditure [1]. It includes all activities such as work, housework, commuting, and leisure. PA is widely recognized as a critical component of healthy lifestyle, contributing significantly to the prevention and management of various chronic disease such as cardiovascular disease, diabetes, and obesity [2-4]. Despite various guidelines for PA based on many studies, the rate of aerobic PA in Korea has been continuously decreasing, with the rate among women being less than half(44%) [5].

Quality of life (QoL) is defined as an individual's perception of their position in life in the context of the culture and value systems where they live and in relation to their goals, expectations, standards and concerns [6]. It is divided into health-related quality of life (HRQoL) and non-health-related quality of life (NHRQoL) [7]. As medical technology and accessibility advances, life expectancy increases, and major health problems become chronic diseases, interest not only in treatment, but also the management and prevention of diseases is increasing. HRQoL is a concept used to help determine an individual's physical and mental health to help prevent disease and make treatment decisions [8]. It is important because it can be applied to actual clinical treatment through research.

Previous studies have shown a positive association between PA and HRQoL, emphasizing the importance of maintaining active lifestyle for overall well-being. For instance, a study by Scarabottolo et al.(2022) found that different domains of PA (occupational PA & leisure-time sports practice) were significantly associated with improved HRQoL [9]. Similarly, Puciato et al.(2018) reported that PA positively influenced the QoL in working-age people in Poland [10]. However, many of studies have predominantly focused on elderly populations or patients with specific diseases [11-15]. Furthermore, the majority of these studies have relied on self-reported questionnaires to measure physical activity [9, 10, 13, 15-17].

In recent years, the use of accelerometers to objectively measure physical activity levels has gained popularity, offering more accurate and reliable data compared to self-reported measures [18-21]. This advancement provides deeper insights into the relationship between PA and various health outcomes. However, studies investigating the association between objectively measured PA using devices such as accelerometers and HRQoL are relatively scarce, especially in Korea.

Therefore, the aim of this study was to analyze the association between objective PA, as measured by accelerometers, and HRQoL in Korean adults using data from the KNHANES. By analyzing this relationship, we anticipate to contribute to the development of evidence-based strategies to promote PA and enhance HRQoL.

Methods

Data source and study population

This study was based on data from the sixth Korea National Health and Nutrition Examination Survey (KHNANES VI) conducted from 2014 and 2015 by the KCDC. KHNANES is a legal survey conducted annually on the level of health of the public, health-related awareness and behaviors, chronic diseases and food and nutrition intake.

Among the participants of the KHANES VI (2014-2015), 1,827 people participated in the accelerometer survey, but 59 people were excluded due to loss of the accelerometer (9 people), non-wearers (47 people), and mechanical errors (3 people). 1,418 people were selected first, excluding 342 people who did not meet the minimum wearing time and number of days of the accelerometer used in the previous study for more than 10 hours a day, 4 days a week, and 8 people who did not respond to the health-related quality of life survey (EQ-5D). Among them, 1,298 people were selected as subjects for final analysis, excluding 2 pregnant women, 24 people receiving cancer treatment, and 94 people with osteoarthritis or rheumatoid arthritis that could affect their physical activity (Figure 1).

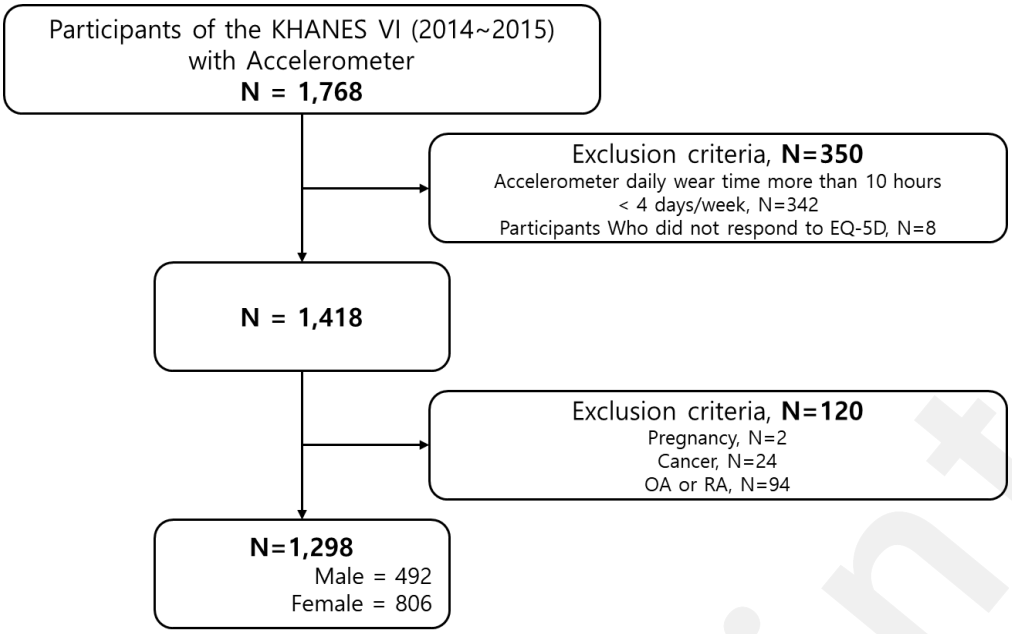

Figure 1. Flowchart of the study populations.

Ethical Approval

It was approved by the Research Ethics Review Committee of the KCDC. (Approval No. 2013-12 EXP-03-5C, 2015-01-02-6C).

Variables and Measurements

* Health-related quality of life (HRQoL)

Tools to evaluate HRQoL include WHOQOL-BREF [6], Quality of Well-being Scale [22], 36-Item Short Form (SF-36) [23] and Euro Quality of life-5 Dimensions (EQ-5D) [24]. Among them, the reliability and validity of the Korean version of EQ -5D reliability and validity have been verified in several studies [25, 26].

EQ-5D, a self-report questionnaire, was used for measurement of HRQoL. The survey questions were answered on a three-step scale (no problem, moderate problem, severe problem) with five questions: mobility, self-care, usual activity, pain/disability, and anxiety/depression. The KCDC calculated the EQ-5D index using the following formula to express it as a single index.

EQ-5D index = 1–(0.050+0.096×M2+0.418×M3+0.046×SC2+0.136×SC3+0.051×UA2 +0.208×UA3+0.037×PD2+0.151×PD3+0.043×AD2+0.158×AD3+0.050×N3)

Based on previous research methods [8], the EQ-5D index was divided into two groups, below average (low quality of life, low QoL) and above average (high quality of life, high QoL).

* Physical activity

- Physical activity measured by accelerometer

The accelerometer used in KNHANES is the wGT3X+ (ActiGraph LLC, Pensacola, FL, USA), and it is a device that converts the acceleration of movement displayed by physical activity into an electrical signal. The accelerometer and a written consent form were provided to adults 19-64 years old who consented to wear the accelerometer. Measurements were programmed to record from midnight (AM 12:00) on the next day after delivery, and they were instructed to wear the accelerometer on the waist for 7 consecutive days except for swimming, showering, and sleeping.

The following criteria were applied with reference to previous studies [18, 27] : 1) Data summary cycle (60 seconds), 2) Intensity of physical activity (Count per minute; CPM, sedentary behavior<100; 2000≤moderate physical activity≤5998; vigorous physical activity≥5999), 3) Determination algorithm of accelerometer wearing or non-wearing time (If CPM is 0 and lasts longer than 60 minutes, it is considered non-wearing time. However, if CPM is less than 100 and lasts less than 2 minutes, it is acceptable.) 4) Accelerometer minimum wearing time and days (10 hours per day, 4 days per week), 5) Criteria for meeting physical activity guidelines (600 MET-minutes/week: [(moderate physical activity × 4 METs) + (vigorous physical activity × 8 METs)] ≥ 600 METs)

Physical activity measured with an accelerometer was quantified in two ways: 1) Moderate to vigorous physical activity accelerometer-total (MVPA-AT, for at least 1 minute), and 2) Moderate to vigorous physical activity accelerometer-bout (MVPA-AB, for at least 10 minutes; if the time when the corresponding strength number of cutting points has not been reached is less than 2 minutes, it is acceptable). One minute of vigorous physical activity was counted as two minutes of moderate physical activity.

- Self-reported physical activity

Self-reported physical activity was collected by using the Global Physical Activity Questionnaire (GPAQ), divided into three categories: leisure, occupation, and commuting physical activity. Since the physical activity measured with the accelerometer was collected for most of the time while wearing the accelerometer, all three physical activities (leisure, occupation, comminuting) were summed up. After that, the same criteria for the physical activity measured by accelerometer were applied.

* Covariates

Socioeconomic factors such as age, sex, marital status, education level, employment, household income, and residence were investigated. Employment was classified according to occupational reclassification and unemployment and economic inactivity status codes. After that, it was divided into three groups: White collar (managers, experts, related workers, office workers), blue collar (service/sales workers, skilled workers in agriculture, forestry and fisheries, craftsmen, workers in machine operation/assembly, simple labor workers), and unemployed (housewives, students, etc.). Household income level was classified into two groups: the bottom 50% (Low) and the top 50% (High) of household income. Residence was classified into *dong* (urban) and *eup*/*myeon* (rural).

Health-related lifestyle factors including smoking, drinking, and average daily sleep time were investigated. Smoking was classified into three groups: non-smoker (person who never smoked or smoked less than five packs or 100 cigarettes in their lifetime), past smoker (person who smoked in the past but not now), and smoker (person who currently smokes). Alcohol use was classified into three groups according to the WHO high-risk drinking standards: heavy drinker (14 or more drinks per week for men/10 or more drinks per week for women), adequate drinker (annual drinker, not heavy drinker), and abstainer (those who have not drunk alcohol in their lifetime).

Mental health factors including stress perception rate and subjective health status were investigated. Stress was classified into two categories with answers to the question “How much stress do you usually feel in your daily life?”: Stressful (I feel a lot, I feel a little), little stress (I hardly feel it). Subjective health status was classified into three categories with answers to the question “How do you usually feel about your health?”: Good (very good, good), Normal (average), Poor (bad, very bad).

Variables related to chronic disease, the prevalence of cardiovascular disease, diabetes, and depression was investigated. Cardiovascular disease includes stroke, angina, and myocardial infarction. The prevalence of each disease was classified into those diagnosed by a doctor.

Statistical analysis

Data are presented as the mean±SD for continuous variables, and presented as number and percent for categorical variables. We analyzed the study participants’ characteristics according to the EQ-5D index, using t-test to compare continuous variables, chi-square test for categorical variables.

Additionally, adjusted odds ratio(ORs) and 95% confidence intervals(CI) for the risk of low HRQoL according to physical activity measured by the accelerometer and GPAQ were calculated using logistic regression after adjusting the socioeconomic variables(age, sex, marital status, education, employment and income) for model 1, covariates in model 1 plus mental health-related variables(stress, subjective health status and depression) for model 2.

All statistical analyses were performed using STATA version 18.0 (Stata Corporation, College Station, TX, USA) and *p*-values of <.05 were considered to indicate statistical significance.

Results

General characteristics

Table 1 shows the baseline characteristics of the below-average (low QoL) and above-average (high QoL) groups of the EQ-5D index. Age was significantly lower in the high QoL group. In addition, males, singles, highly educated people, office workers, and high-income earners were more common in the high QoL group. Those who usually feel less stress and those whose subjective health was good were more common in the high QoL group. There was no significant difference between the two groups in some health-related lifestyle variables such as smoking, drinking, and average sleep time. Among chronic disease-related variables, cardiovascular disease and diabetes were not significantly different between the two groups.

Table 1. Baseline characteristics of the study population by quality of life

Variable	Low QoL (n=293)	High QoL (n=1,005)	*P*-value
Age in years	45.43±11.72	43.18±12.34	.006
Sex			<.001
Male	84 (28.67)	408 (40.60)	
Female	209 (71.33)	597 (59.40)	
Marital status			<.001
Single	46 (15.70)	216 (21.51)	
Married	216 (73.72)	740 (73.71)	
Separated/Divorced/Widowed	31 (10.58)	48 (4.78)	
Education			<.001
Middle school or less	67 (22.08)	139 (13.83)	
High school	119 (40.61)	410 (40.80)	
College or more	107 (36.52)	456 (45.37)	
Employment			.003
White collar	68 (23.29)	339 (33.80)	

Blue collar	118 (40.41)	361 (35.99)	
Unemployed	106 (36.30)	303 (30.21)	
Household income			.009
Low	110 (37.54)	296 (29.51)	
High	183 (62.46)	707 (70.49)	
Residence			.453
Urban	237 (80.89)	832 (82.79)	
Rural	56 (19.11)	173 (17.21)	
Smoking			.275
Non-smoker	218 (74.66)	702 (69.85)	
Past smoker	38 (13.01)	151 (15.02)	
Smoker	36 (12.33)	152 (15.12)	
Alcohol use			.553
Abstainer	60 (20.55)	234 (23.28)	
Adequate drinker	197 (67.47)	664 (66.07)	
Heavy drinker	35 (11.99)	107 (10.65)	
Sleep duration (h)	6.82±1.33	6.86±1.18	.600
Stress			<.001
Little stressful	176 (60.27)	788 (78.41)	
Stressful	116 (39.73)	217 (21.59)	
Subjective health status			<.001
Poor	89 (30.38)	79 (7.86)	
Normal	157 (53.58)	545 (54.23)	
Good	47 (16.04)	381 (37.91)	
Cardiovascular disease			.918
No	290 (98.98)	994 (98.91)	
Yes	3 (1.02)	11 (1.09)	
Diabetes			.744
No	281 (95.90)	968 (96.32)	
Yes	12 (4.10)	37 (3,68)	
Depression			<.001
No	267 (91.13)	979 (97.41)	
Yes	26 (8.87)	26 (2.59)	
Sedentary time (min)	3194.75±766.72	3258.27±764.79	.212

Data are shown in mean ± standard deviation for continuous variables and n (%) for categorical variables.

QoL, quality of life.

P-value is from t-test for continuous variables and chi-square test for categorical variables.

Physical activity

Table 2 presents physical activity measured by the accelerometer and GPAQ in the two groups divided by the average of the EQ-5D index. There were significantly more persons who met MVPA-AB ≥600 METs in the high QoL group (p=0.010). There was no significant difference between high and low QoL groups for MVPA-AT and self-reported physical activity.

Table 2. Comparison of physical activity by health-related quality of life

Variable	Low QoL (n=293)	High QoL (n=1,005)	*P*-value
MVPA-AB (10 min bouts)			.010
< 600 METs	243 (82.94)	762 (75.82)	
≥600 METs	50 (17.06)	243 (24.18)	
MVPA-AT (Total bouts)			.277
< 600 METs	127 (43.34)	400 (39.80)	
≥600 METs	166 (56.66)	605 (60.20)	
MVPA-S (Self-reported)			.731
< 600 METs	127 (43.34)	447 (44.48)	
≥600 METs	166 (56.66)	558 (55.52)	

Data are shown in n (%) for categorical variables.

MVPA, moderate to vigorous physical activity; AB, accelerometer-bout; AT, accelerometer-total; METs, metabolic equivalents

P-value is from the chi-square test.

Association between domains of physical activity and health-related quality of life

In Table 3, logistic regression analysis was performed to determine the correlation between HRQoL and physical activity measured by the accelerometer and GPAQ, and marked with an odds ratio and 95% confidence interval. Compared with the low QoL group, the crude odds ratio of the HRQoL was 1.55 (95% CI, 1.11-2.17) in MVPA-AB ≥600 METs. After adjusting for the socioeconomic variables (model 1), the odds ratio of the HRQoL was 1.60 (95% CI, 1.13-2.27). After adjusting model 1 for the mental health-related variables (model 2), the odds ratio was 1.45 (95% CI, 1.01-2.09), which weakened the statistical significance compared with model 1. There was no statistical significance between the two QoL groups for MVPA-AT and self-reported physical activity.

Table 3. Association between domains of physical activity and health-related quality of life

Domains of physical activity	Number	Crude OR	Model 1[a]	Model 2[b]
MVPA-AB(10min bouts)				
< 600 METs	1,005	1	1	1
≥600 METs	239	1.55 (1.11-2.17)	1.60 (1.13-2.27)	1.45 (1.01-2.09)
MVPA-AT(Total bouts)				
< 600 METs	527	1	1	1
≥600 METs	771	1.15 (0.89-1.51)	1.07 (0.82-1.41)	0.91 (0.68-1.22)
MVPA-S(Self-reported)				

< 600 METs	574	1	1	1
≥600 METs	724	0.96 (0.73-1.24)	0.86 (0.66-1.13)	0.79 (0.59-1.06)

Data are shown as odds ratio (95% confidence intervals).

OR, odds ratio; MVPA, moderate to vigorous physical activity; AB, accelerometer-bout; AT, accelerometer-total; METs, metabolic equivalents; M, mean value.

[a] Adjusted for age (continuous), sex, marital status, education, employment, income.

[b] Further adjusted for stress, subjective health status, depression.

Discussion

Principle findings

This study was designed to confirm the relationship between HRQoL and PA measured by an accelerometer using national survey data. As a result of the analysis, HRQoL was significantly associated with the group that engaged in more MVPA for at least 10 minutes, as measured by the accelerometer. However, there was no statistical significance with HRQoL for MVPA measured for at least 1 minute by the accelerometer. In the previous KNHANES, only self-report questionnaires were used to measure PA [8]. However, in the sixth KNHANES(2014-2015), PA measured with an accelerometer was provided, making it possible to conduct studies [28-30] like ours.

Our findings align with previous research demonstrating the beneficial effects of PA on HRQoL across various populations [31, 32]. For example, multiple studies have reported that increased PA is associated with improved HRQoL. A study by Brown et al.(2014) found that adults who engaged in regular MVPA had significantly higher HRQoL scores compared to those who were inactive [16]. Similarly, a review by Marquez et al.(2020) synthesized evidence from numerous studies and concluded that PA interventions can effectively enhance HRQoL across various populations [33]. PA has been shown to enhance self-efficacy, physical self-esteem, and positive affect [32, 34], which collectively contribute to improvements in HRQoL. Overall, our results are consistent with the majority of previous literature on the positive relationship between PA and HRQoL. This study further supports these findings by using objective measures of PA, thus providing a more accurate assessment of its impact on HRQoL.

This study can serve as a basis for recommending at least 10 minutes of MVPA to improve HRQoL. However, the phrase “at least 10 minutes” was deleted from the PA guidelines published by the U.S.

Department of Health and Human Services in 2018, as MVPA for less than 10 minutes can benefit health. Therefore, to compare this with other health-related variables not considered in this study, it is necessary to measure MVPA for at least 1 minute. Nevertheless, since the PA questionnaire used in the KNHANES specifies “usually continued PA for at least 10 minutes during a week,” it is more appropriate to compare it with PA for more than 10 minutes, as measured with an accelerometer in this study [35].

Earlier, it was mentioned that the GPAQ calculates PA that has been continued for at least 10 minutes, so it is appropriate to compare it with PA measured with an accelerometer for at least 10 minutes. However, previous studies [28, 36-38] found no correlation between accelerometer data and the questionnaire's satisfaction with the PA guidelines, and the results were not consistent in this study as well. This inconsistency may arise because the questionnaire’s criteria for “PA continued for at least 10 minutes” are subjective or may include PA lasting less than 10 minutes. Additionally, there is a possibility of bias in the self-report questionnaire, as people engaging in MVPA may over-report their activity levels [37-39]. Furthermore, since the accelerometer was provided after filling out the questionnaire, the data measurement periods differ, and the GPAQ may misclassify location movement PA as MVPA without considering movement speed. Therefore, to measure PA more accurately, a specific method that can complement both approaches is necessary.

In previous studies [40-42], stress and subjective health status perception had a negative correlation with HRQoL, and in one study [43], it was reported that stress had the greatest influence on the deterioration of women's QoL. In this study, when socioeconomic variables were corrected for the group with a lot of PA measured with an accelerometer, the statistical significance was stronger than before the correction. But when stress and subjective health status perception were additionally corrected, the degree of statistical significance decreased. Similar to previous studies, this can be interpreted as having a greater effect on stress and subjective health status perception on HRQoL.

Limitations

This study has the following limitations. First, it is difficult to generalize the study results since it is a non-probability sample composed of study subjects selected through convenience sampling. Second, variables including EQ-5D are investigated through a self-report questionnaire, so there is a possibility of social desirability bias, misclassification bias, and recall bias. Third, since it was conducted as an observational

cross-sectional study, it is not possible to know the causal relationship between HRQoL and variables. Nevertheless, it is significant that the study was conducted using national health and nutrition survey data of about 1,300 adults aged 19-64. Also, since it is a study using data obtained using an accelerometer, it has an advantage in being able to compare it with other domestic and foreign studies conducted in a similar way. Research using accelerometers began to increase in the 2000s, and since the beginning of 2010, nearly 100 related studies have been published annually [44, 45]. In addition, the era has come when it is possible to measure PA using wearable devices such as smartphones and smart watches. It is thought that various follow-up studies using tools that can quantify PA are possible in the future. Based on this, we expect the growth of fields related to PA aimed at promoting health.

Conclusion

Our study shows the association between HRQoL and MVPA, which is significantly higher in the group with more PA for at least 10 minutes, using the KNHANES. The study emphasizes the need for promoting PA and interventions focusing specifically on continuing at least 10 minutes. We expect further interventional studies to focus on the specific PA time period such as occupational PA, leisure-time PA and commuting PA.

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Not applicable

Conflicts of Interest

The authors declare that they have no competing interests

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Abbreviations

KNHANES: Korea National Health and Nutrition Examination Survey

KCDC: Korea Centers for Disease Control and Prevention

QoL: Quality of Life

HRQoL: Health-related Quality of Life

GPAQ: Global Physical Activity Questionnaire

CPM: Count per Minute

MVPA-AB: moderate to vigorous physical activity with an accelerometer for at least 10 minutes

MVPA-AT: moderate to vigorous physical activity with an accelerometer for at least 1 minute

MVPA-S: moderate to vigorous physical activity with self-report questionnaire

Supplementary Files

Figures

Flowchart of the study populations.