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

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

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

Introduction

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.[1)] It is divided into health-related quality of life (HRQoL) and non-health-related quality of life (NHRQoL).[2)] 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.[3)] It is important because it can be applied to actual clinical treatment through research. Tools to evaluate HRQoL include WHOQOL-BREF,[4)] Quality of Well-being Scale,[5)] 36-Item Short Form (SF-36) [6)] and Euro Quality of life-5 Dimensions (EQ-5D) [7)]. Among them, the reliability and validity of the Korean version of EQ -5D reliability and validity have been verified in several studies.[8,9)]

Physical activity is defined as any bodily movement produced by skeletal muscles that results in energy expenditure.[10)] It includes all activities such as work, housework, commuting, and leisure. Despite the fact that there are various guidelines for physical activity based on many studies, according to the Korean National Health and Nutrition Examination Survey (KNHANES) FACT SHEET issued by the Division of the Korea Centers for Disease Control and Prevention (KCDC) in September 2020, the rate of aerobic physical activity in Korea has been continuously decreasing, and the rate of aerobic physical activity among women is less than half of that (44%). There are various methods to quantify physical activity, such as self-report questionnaire, pedometer, and accelerometer. Therefore, a physical activity measurement tool should be selected in consideration of study outcomes, feasibility, practicality, available resources, patient/participant burden, available resources and study administration.[11)] Prior studies have shown that physical activity helps to improve health-related quality of life,[12)] but many studies were limited to the elderly and patients with certain diseases, and only used self-report questionnaires to measure physical activity. Studies on the association between objectively measured physical activity and quality of life are rare and have not been performed in Korea. In the previous KNHANES, only self-report questionnaires were used to measure physical activity. But in the sixth KNHANES, physical activity measured with an accelerometer was provided, making it possible to

conduct research using it.

Therefore, we analyzed the association between HRQoL and physical activity in adults 19-64 years old who participated in the sixth KNHANES and agreed to wear an accelerometer.

Methods

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

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 (nine people), non-wearers (47 people), and mechanical errors (three 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 eight people who did not respond to the health-related quality of life survey. Among them, 1,298 people were selected as subjects for final analysis, excluding two pregnant women, 24 people receiving cancer treatment, and 94 people with osteoarthritis or rheumatoid arthritis that could affect their physical activity (Figure 1).

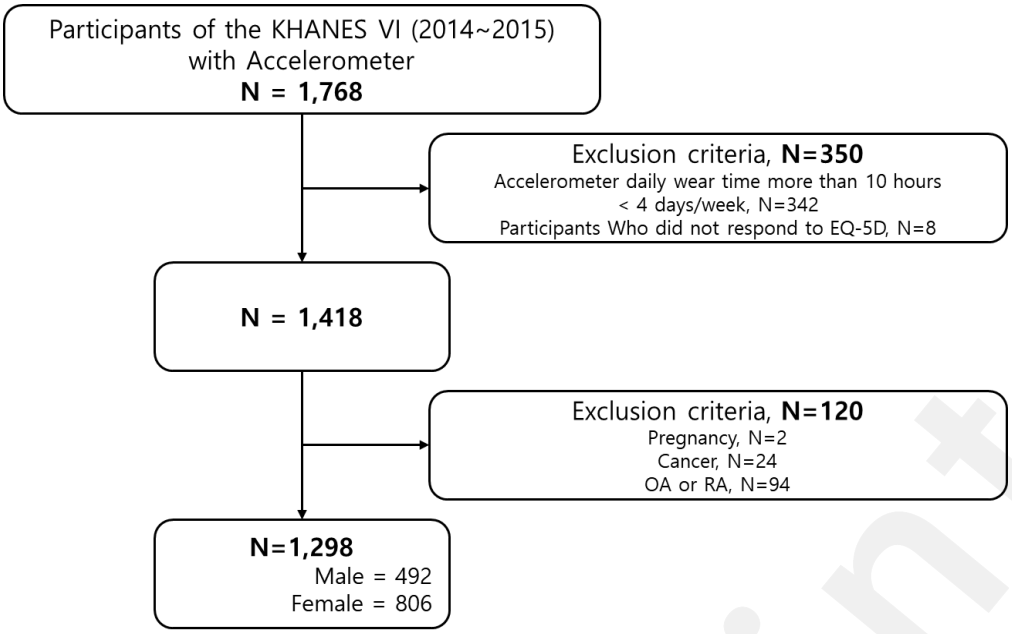

Figure 1. Flowchart of the study populations.

2. Health-related quality of life (HRQoL)

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,[3)] 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).

3. Measurements of physical activity

(1) 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[13,14]: 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.

(2) 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.

4. Measurements of socioeconomic factors, health-related lifestyle, mental health and variables related chronic disease

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.

5. Statistical analysis

Cross analysis was performed to obtain the frequency and percentage of the general characteristics of the two groups divided by the average of the health-related quality of life index, and linear regression analysis and chi-square test were performed to confirm the association. The correlation between HRQoL and physical activity measured by the accelerometer and GPAQ was expressed as an odds ratio and 95% confidence interval through logistic regression analysis.

Statistical analyses were performed using STATA version 16.1 (Stata Corporation, College Station, TX, USA) and p-values of <0.05 were considered to indicate statistical significance.

Results

1. General characteristics

Table 1 shows the characteristics of the below-average (low QoL) and above-average (high QoL) groups of the health-related quality of life index. Age was significantly lower in the high QoL group. In addition, males, singles, highly educated people, office workers, and high household incomes were more common in the high QoL group. Those who usually feel less stress and those whose subjective health was good were more in the high QoL group. There was no significant difference between the two groups in 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 (y)	45.43±11.72	43.18±12.34	.006
Sex			
Male	84 (28.67)	408 (40.60)	.000
Female	209 (71.33)	597 (59.40)	
Marital status			
Single	46 (15.70)	216 (21.51)	.000
Married	216 (73.72)	740 (73.71)	
Separated/Divorced/Widowed	31 (10.58)	48 (4.78)	
Education			
Middle school or less	67 (22.08)	139 (13.83)	.000
High school	119 (40.61)	410 (40.80)	
College or more	107 (36.52)	456 (45.37)	
Employment			
White collar	68 (23.29)	339 (33.80)	.003
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			
Urban	237 (80.89)	832 (82.79)	.453
Rural	56 (19.11)	173 (17.21)	
Smoking			
Non-smoker	218 (74.66)	702 (69.85)	.275
Past smoker	38 (13.01)	151 (15.02)	
Smoker	36 (12.33)	152 (15.12)	
Alcohol use			
Abstainer	60 (20.55)	234 (23.28)	.553
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			
Little stressful	176 (60.27)	788 (78.41)	.000
Stressful	116 (39.73)	217 (21.59)	
Subjective health status			
Poor	89 (30.38)	79 (7.86)	.000
Normal	157 (53.58)	545 (54.23)	
Good	47 (16.04)	381 (37.91)	
Cardiovascular disease			
No	290 (98.98)	994 (98.91)	.918
Yes	3 (1.02)	11 (1.09)	
Diabetes			
No	281 (95.90)	968 (96.32)	.744
Yes	12 (4.10)	37 (3,68)	
Depression			
No	267 (91.13)	979 (97.41)	.000
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.

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)			
< 600 METs	243 (82.94)	762 (75.82)	.010
≥600 METs	50 (17.06)	243 (24.18)	
MVPA-AT (Total bouts)			
< 600 METs	127 (43.34)	400 (39.80)	.277
≥600 METs	166 (56.66)	605 (60.20)	
MVPA-S (Self-reported)			
< 600 METs	127 (43.34)	447 (44.48)	.731
≥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 chi-square test.

2. 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. Model 1 was corrected for socioeconomic variables such as age, gender, marital status, education level, occupation, and household income among possible confounders. Model 2 was further corrected with mental health-related variables such as stress perception rate and subjective health status perception from model 1. 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

This study was designed to confirm the relationship between HRQoL and physical activity measured by an accelerometer using national survey data. As a result of the analysis, HRQoL was significantly increased in the group with more moderate to vigorous physical activity for at least 10 minutes measured by the accelerometer. But there was no statistical significance with HRQoL for moderate to vigorous physical activity for at least 1 minute measured by the accelerometer.

Research on physical activity and HRQoL is being actively conducted. In particular, the relationship between physical activity and improvement of HRQoL in the elderly is well known,[16,17] and this study showed a correlation between physical activity and improved quality of life in adults. Physical activity improves self-efficacy,[17] physical self-esteem, and positive affect,[17,18] which can lead to improvement of HRQoL.

This study can serve as a basis for recommending at least 10 minutes of moderate to vigorous physical activity to improve health-related quality of life. But the phrase “at least 10 minutes” was deleted[19] from the physical activity guidelines published by the U.S. Department of Health and Human Services in 2018, as moderate to vigorous physical activity for less than 10 minutes can benefit health. Therefore, in order to compare this with other health-related variables not considered in this study, it is necessary to measure

moderate to vigorous physical activity for at least 1 minute. Nevertheless, since the physical activity questionnaire used in the KNHANES says “usually continued physical activity for at least 10 minutes during a week,” it is more appropriate to compare it with physical activity for more than 10 minutes measured with an accelerometer in this study.[20)]

Earlier, it was mentioned that the GPAQ calculates physical activity that has been continued for at least 10 minutes, so it is appropriate to compare it with physical activity measured with an accelerometer for at least 10 minutes. However, in previous studies[21)] it was found that there was no correlation between the accelerometer and the questionnaire's satisfaction with the physical activity guidelines, and the results of the accelerometer and the questionnaire were not consistent in this study as well. This is because it may include subjectively different criteria for physical activity continued for at least 10 minutes in the questionnaire, or may include activity for less than 10 minutes. Also, there is a possibility of bias in the self-report questionnaire when considering previous studies[22)] since people who engage in moderate to vigorous physical activity may over-report their level of physical activity. In addition, since an accelerometer was provided after filling out the questionnaire, it is necessary to consider that the data measurement period is different, and the location movement physical activity of the GPAQ may be underestimated or overestimated by setting it as moderate to vigorous physical activity without considering the movement speed. Therefore, in order to measure physical activity more accurately, there is a need for a specific method that can complement this in two or more ways.

In previous studies,[23)] stress and subjective health status perception had a negative correlation with health-related quality of life, and in one study,[24)] it was reported that stress had the greatest influence on the deterioration of women's quality of life. In this study, when socioeconomic variables were corrected for the group with a lot of physical activity 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 health-related quality of life.

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, hundreds of related studies have been published annually.[25)] In addition, the era has come when it is possible to measure physical activity using wearable devices such as smartphones and smart watches. It is thought that various follow-up studies using tools that can quantify physical activity are possible in the future. Based on this, we expect the growth of fields related to physical activity aimed at promoting health.

In 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 physical activity 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