Adherence to Physical Activity Among Older Adults Using a Geographic Information System: Korean National Health and Nutrition Examinations Survey IV

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Purpose   The purpose of this study was to examine the adherence to physical activity (PA) among older adults in Korea using data from the Fourth Korean National Health and Nutrition Examination Survey (KNHANES IV), and to illustrate geographic variations in PA using Geographic Information Systems (GIS).
Methods   A secondary analysis of the KNHANES IV data from 2007 to 2008 was used for this study. Participants of the study included 2,241 older adults over the age of 65. Estimates on adherence to PA were obtained for vigorous, moderate, walking, strengthening, and stretching activities. All estimates were weighted to represent Korean population. The association between participants' characteristics and PA was analyzed using Wald chi-square test. Maps depicting regional variations in PA were created using GIS software.
Results   Adherence to PA among Korean older adults who met national recommendations during the period of year 2007–2008 was about 9% in vigorous activity, 10% in moderate activity, and 48% in walking. The most common type of PA was walking. A higher level of PA was associated with male gender, younger age, high level of income and education, and living with family.
Conclusion   The majority of older adults did not meet the national PA recommendations, suggesting that consistent surveillance and intervention for PA in the geriatric population are needed in the future. Maps generated using GIS visually showed regional differences in PA among the study participants.
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Key Words   aged, geographic information systems, Koreans, motor activity

ELSEVIER

INTRODUCTION

The geriatric population in Korea has grown at a steady rate. Currently persons over 65 years of age comprise 11% of the total Korean population and are expected to make up over 33% of the population by the year 2040 (Korea National Statistical Office, 2006). With the increase in the geriatric population, the prevalence of chronic diseases also has increased. As a result, national mortality data shows that the leading cause of death among Koreans was cancer, followed by cerebrovascular illnesses, cardiovascular illnesses, and diabetes mellitus in 2008 (Korea National Statistics Office, 2009).

Physical activity (PA) is one of the most widely recommended health promotion strategies for managing chronic illnesses and is known to have various health benefits (Braith & Stewart, 2006; Laaksonen et al., 2002; Laaksonen et al., 2005; Lam, Ho, Hedley, Mak, & Leung, 2004). *Healthy People 2010*, a United States (US) national health initiative, states increasing PA as one of its main goals, with the aim of reducing the prevalence of chronic illness risk factors and improving physical fitness for the nation (US Department of Heath and Human Services [USDHHS], 2000). US guidelines recommend that older adults engage in at least 150 minutes of moderate-intensity activity per week, 75 minutes of vigorous-intensity aerobic PA per week, or an equivalent combination of moderate- and vigorous-intensity aerobic activity to achieve substantial health benefits (USDHHS, 2008).

Since the establishment of the National Health Promotion Act in 1995, Korea has also been consistently updating its national health promotion strategies. Korean national health objectives recommend that adults take part in 20 minutes of vigorous PA at least 3 days per week, and 30 minutes of moderate PA or walking at least 5 days per week (Korea Ministry of Health and Welfare, 2007). However, these domestic PA guidelines have been regarded as overly general, without sufficient consideration of age-specific PA requirements (Kim, 2009). The case for developing evidence-based PA guidelines for older adults has been raised in the past, suggesting the need for research-based evidence on age-specific PA dosages.

Surveillance of PA rates among older adults in the past has shown that, despite the established guidelines and known benefits of PA, PA participation remains unsatisfactory. Approximately 28–34% of adults aged 65–74 years and 35–44% of seniors aged 75 years or older spend no time engaging in PA and inactivity is more common in women than men in the U.S. (USDHHS, 2006). Compared to the U.S., participation in regular PA is even less common in older adults in Korea. Approximately 80% of Korean older adults aged 60–70 years do not engaged in moderate PA and 90% of older adults over 71 years of age are inactive (Korea Ministry of Health and Welfare, 2007). Given the known benefits but declining rate of PA among older adults, consistent surveillance of PA adherence rate and analysis of the factors influencing PA levels in the geriatric population is needed. The rate of PA participation by older adults has been reported in the Korean National Health and Nutrition Examination Survey (KNHANES) II and III, released in 2001 and 2005, respectively; however, recent examination of PA levels using the newly released KNHANES IV data during the period of 2007 and 2008 has not been reported.

While most studies on PA have focused on examining PA on an individual level, there has been little use of epidemiological approaches combined with information technology that integrate data on physical activity by geographic location. From an epidemiological standpoint, most variables are related to time, individual, or location. Of these factors, location data are considered difficult to analyze and represent graphically (Melnick & Fleming, 1999). As variations in PA may exist by geographic locations, Geographic Information Systems (GIS) was used to enhance the understanding of PA levels by geographic regions in this study. GIS is a type of information system that collects, stores, searches, and statistically analyzes data based on geographic locations (Croner, Sperling, & Broome, 1996). GIS is innovative in that it enhances the utilization of both spatial information that represents geographic location and nonspatial

information. In particular, analyzing the patterns of PA using GIS can provide information on the status of PA at a community level to researchers, community organizations, and policy makers to help them design appropriate community-based PA programs (Park, 2009). This also helps identify target regions with low PA participation but which need future PA interventions, and develop region-specific PA guidelines. Therefore, this study aimed to examine the adherence to PA among older adults residing in Korea, and to illustrate geographic variations in PA in older adults using GIS. Assessing the percentage of older adults participating in PA and whether the national PA guidelines was met by geographic regions was the main focus of this study.

METHODS

Study design and participants

This study was a secondary analysis of the primary dataset from KNHANES IV (Korea Centers for Disease Control and Prevention [KCDC], 2009a). KNHANES is a cross-sectional survey that consists of a health interview, a health behavior questionnaire, a health examination, and a nutrition survey. KNHANES subjects include a representative national sample of the Korean population who were selected using a complex, stratified, multistage probability cluster sampling design. Participants in KNHANES are noninstitutionalized civilians. KNHANES data related to PA has been released periodically between 1998 and 2005, and annually since 2007. A total of 4,594 and 9,744 people participated in KNHANES IV in 2007 and 2008, respectively. Each year, older adults aged 65 years or more made up approximately 16% of the study participation. The health behavior survey portion of KNHANES IV includes questions on PA that were adopted from World Health Organization's International Physical Activity Questionnaire (WHO's IPAQ) (KCDC, 2007). The survey included categories for vigorous and moderate intensity activities, walking, strengthening and stretching. Participants included a total of 2,241 older adults aged 65 years or more: 722 in the 2007

survey and 1,519 in the 2008 survey. The sample size for the year 2008 was more than a double of that of 2007, as the data were only collected for 6 months in 2007. We obtained a "confirmation of plan for raw data use" from KCDC through the KNHANES website as a form of data use permission.

General characteristics

Demographic data selected from KNHANES IV included age, gender, level of education, monthly average household income, living with family, residential region, and number of diseases. Number of diseases was measured by counting the total number of diagnosed illnesses reported by the participant. Residential region was where the participant's current address belonged to, which was dichotomized into whether older adults live in metropolitan cities referring to seven major cities designated by the Korean government (Busan, Daegu, Daejeon, Gwangju, Incheon, Seoul, and Ulsan) or not.

Types of physical activity

The definitions of each type of PA in KNHANES are described below (KCDC, 2009b):

- Vigorous activity: a physical effort that requires harder than normal breathing for at least 10 minutes at a time. Example activities include running, hiking or climbing, heavy lifting, fast bicycling or swimming, and playing foot-ball, basket ball, or singles tennis.
- Moderate activity: a moderate physical effort that requires somewhat harder than normal breathing for at least 10 minutes at a time. Example activities include lifting light loads, moderately paced swimming, and playing volleyball, doubles tennis, badminton, or table tennis. This category does not include walking.
- Walking: walking for at least 10 minutes at a time, either as a means of transportation (e.g., to school or work) or for recreation, sport, fitness or leisure.
- Strengthening activity: performing body weight exercises such as push-ups and sit-ups, lifting free weights (e.g., dumbbells, barbells) or using strength training machines.

- Stretching activity: performing activities such as light gymnastics or flexibility exercise.

Study participants were asked to recall the number of days they had performed any of the five activity types in the last week. For vigorous, moderate, and walking activities, additional data on the duration of the activity were obtained from the survey participants. Using the responses to the PA questions, three types of level of adherence to PA were identified to describe an individual's PA: (a) whether or not the individual participates in each type of PA; (b) whether or not the individual meets national recommendations for three types of PA (i.e., vigorous, moderate, or walking), which was then compared with previous KNHANES data; and (c) how many minutes per week the individual spends on performing vigorous, moderate, or walking activity and how many days per week the individual spends on strengthening or stretching activity.

Data analysis

Descriptive statistics including frequency and percentage were used to describe demographic characteristics and adherence to PA among the participants. The calculated sampling weights were available from the KNHANES dataset to consider the sampling and response rates so the results are representative of the Korean population. This was particularly important for survey data because the sampling probabilities could be different among sampling clusters (Lehtonen & Pahkinen, 2004). Thus, we used the sampling weights that the KNHANES provided for all of the data analyses in this study, such that all statistical results were weighted.

Wald chi-square analysis was performed to examine possible associations between participant characteristics (gender, age, household income, education level, living with family, living in metropolitan cities, and number of diseases) and participation in vigorous, moderate, walking, strengthening, or stretching activities. All analyses were conducted using SAS 9.1. (SAS Institute, Cary, NJ, USA).

Additionally, maps depicting percentages of PA by 16 geographical regions in Korea (7 large metropolitan cities and 9 provinces) were created using GIS software. Because data on geographic information in KNAHNES IV only identify residential areas in a broad scale (i.e., province), GIS was mainly used to display geographic variations at a province level (i.e., metropolitan cities, provinces) to provide visualized information on percentage of older adults who met national PA recommendations. The percentages of older adults participating in PA were represented as a choropleth map, in which a number of categories are presented in areas shaded with different colors as a proportion of the variable of interest (Cromley & McLafferty, 2002). To match KNHANES data with geographic regions, a geographical boundary data file was obtained from the Statistical Geographic Information Service of the Korea National Statistical Office (n.d.) and was merged into the KNHANES data, then aggregated by region. The GIS software program ArcGIS 9.2 (ESRI, Redlands, CA, USA) was used to create maps.

RESULTS

Sample description

Data for a total of 2,241 survey participants were analyzed after excluding nonpositive weights. The mean age of the participants was 73 years (range: 65–103). Two thirds of the participants were between 65 and 75 years old. Women comprised approximately 60% of the sample, and less than 20% of the participants were living alone. Almost 80% of the participants reported having one or more diseases, with an average number of 2 (range: 0–9). The majority of participants had not graduated from high school (85%) and 67% had a monthly household income of 1.2 million KRW (approximately $1,100 USD at the time the survey was conducted) or less. About 40% of the participants were living in metropolitan cities (Table 1).

Adherence to physical activity

Adherence to PA was calculated using three categories: (a) percentage of older adults participating in PA, (b) percentage of older adults meeting

Table 1

Demographic Characteristics of Older Adults, KNHANES IV, 2007–2008[a] (n = 2241)

	n (%)
Gender	
Male	885 (40.4)
Female	1,356 (59.6)
Age (yr)	
65–74	1,546 (65.3)
≥ 75	695 (34.7)
$M \pm SE$[b]	72.66 ± 0.16
Household income (KRW/mo)	
≤ 12 × 10⁵	1,546 (66.5)
> 12 × 10⁵	646 (33.5)
Education	
Less than high school	1,917 (84.9)
High school or greater	315 (15.1)
Living with family	
Yes	1,819 (84.4)
No	421 (15.6)
Living in metropolitan cities	
Yes	773 (40.5)
No	1,468 (59.5)
No. of diseases	
0	441 (19.8)
1–2	1,121 (51.4)
≥ 3	679 (28.8)
$M \pm SEM$[b]	1.87 ± 0.04

Note. KNHANES IV = the Fourth Korean National Health and Nutrition Examination Survey; SE = standard error.
[a]Missing values are not included.

national PA guidelines, and (c) duration of PA in minutes or days per week. The rates of adherence to PA among Korean older adults who reported participating in vigorous and moderate activities was 14% and 24%, respectively. The most common type of activity was walking, with more than 80% of older adults reporting it. Only 12% of older adults reported that they performed strengthening activity. The rates of adherence to PA in older adults who met national guidelines were about 9% in vigorous activity, 10% in moderate activity, and 48% in walking. Older adults reported an average weekly PA duration of 73 minutes per week for vigorous activity, 135 minutes per week for moderate activity, and 377 minutes per week for walking. The average frequencies of performing strengthening and stretching activities were 0.4 and 1.3 days per week, respectively (Table 2).
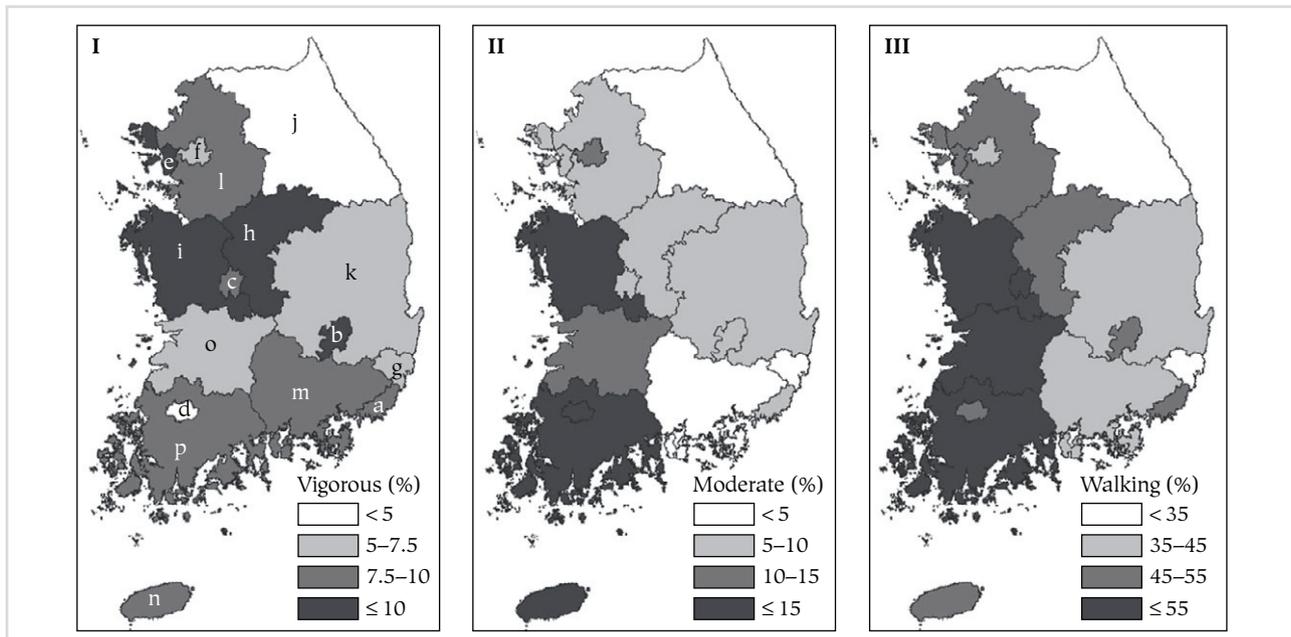
Maps depicting the weighted percentage of older adults who met the national PA recommendations (vigorous activity for 20 minutes at least 3 days/week; and moderate or walking activity for 30 minutes for at least 5 days/week) are presented in Figure 1. Darker shades on the map indicate greater PA participation rates. A total of 16 regions, including 7 metropolitan cities and 9 provinces (*do* in Korean) are included. Provinces, labeled as "8" (Chungbuk-*do*), "9" (Chungnam-*do*), and "16" (Jeonnam-*do*), showed fairly high levels of PA in all three types of physical activity, while Gangwon-*do*, labeled as "10," showed the lowest PA participation rates (Figure 1).

Table 2

Adherence to Physical Activity by Types Among Older Adults, KNHANES IV, 2007–2008 (n = 2241)

	Vigorous	Moderate	Walking	Strengthening	Stretching
No. of people doing PA (%)	355 (13.8)	630 (24.2)	1,794 (80.6)	240 (12.1)	652 (32.5)
No. of people reaching recommendations for PA (%)[a]	226 (8.7)	278 (10.1)	1,087 (48.4)	n/a[b]	n/a[b]
Average time spent/wk (SE)[c]	73.4 (6.2)	135.2 (8.9)	377.3 (16.3)	0.4 (0.0)	1.3 (0.1)

Note. KNHANES IV = the Fourth Korean National Health and Nutrition Examination Survey; SE = standard error.
[a]Vigorous activity refers to at least 20 minutes/session for 3 or more days/week; moderate activity refers to at least 30 minutes/session for 5 or more days/week; Walking refers to at least 30 minutes/session for 5 or more days/week. [b]No governmental recommendations are available for strengthening and stretching activities. [c]Minutes/week for vigorous, moderate and walking activity; days/week for strengthening and stretching activities.

Figure 1. Maps showing weighted percentage of older adults performing the recommendations for physical activity in Korea from the Fourth Korean National Health and Nutrition Examination Survey 2007–2008.
Note. The numbers labeled in (I) correspond to the numbers and names as follows. The number in parenthesis is the sample size of the region. a-Busan (159); b-Daegu (86); c-Daejeon (66); d-Gwangju (51); e-Incheon (138); f-Seoul (295); g-Ulsan (22); h-Chungbuk (135); i-Chungnam (178); j-Gangwon (98); k-Gyeongbuk (226); l-Gyeonggi (360); m-Gyeongnam (189); n-Jeju (73); o-Jeonbuk (85); p-Jeonnam (183).
Note. Vigorous: 20 minutes for 3 or more days; Moderate: 30 minutes for 5 or more days; Walking: 30 minutes for 5 or more days.

Differences in physical activity by general characteristics

The results of the associations between each type of PA and general characteristics are presented in Table 3. Physical activity in older adults was associated with gender, age, income status, educational level, living with family, and living in metropolitan cities. Older adults aged less than 75 years and who had education of high school or greater were more physically active than were their counterparts in all five types of PA. PA was higher in males than females in all types of PA except in moderate activity. Those living with family and with monthly household incomes greater than 1.2 million KRW were more physically active than those not living with family and those whose income was less than

1.2 million KRW in all types of PA except in walking (Table 3).

DISCUSSION

This study aimed to examine the adherence to PA among a national sample of 2,241 older adults based on results from KNHANES IV. The results of this study show that less than 10% or less of older adults meet the national recommendations for vigorous and moderate intensity PA. This participation rate is actually lower than the national objectives of Health Plan 2010 which are set at 20% and 30%, respectively (Korea Ministry of Health and Welfare, 2007). This gap between current participation rates

Table 3

Differences in Physical Activity by Participant Characteristics, KNHANES IV, 2007–2008 (n=2241)[a]

Characteristics[a]	Vigorous			Moderate			Walking			Strengthening			Stretching		
	No	Yes	χ² (p)	No	Yes	χ² (p)	No	Yes	χ² (p)	No	Yes	χ² (p)	No	Yes	χ² (p)
Gender															
Male	707 (80.7)	175 (19.3)	23.4 (<.001)	630 (73.9)	252 (26.1)	2.0 (.162)	138 (15.0)	741 (85.0)	11.7 (<.001)	707 (78.2)	176 (21.8)	72.6 (<.001)	584 (62.5)	299 (37.5)	9.9 (.002)
Female	1172 (89.9)	180 (10.1)		974 (77.0)	378 (23.0)		296 (22.3)	1053 (77.7)		1289 (94.6)	64 (5.4)		1000 (70.8)	353 (29.2)	
Age (yr)															
65–74	1249 (82.8)	294 (17.2)	33.7 (<.001)	1069 (73.0)	474 (27.0)	13.6 (<.001)	254 (15.6)	1286 (84.4)	19.2 (<.001)	1335 (84.4)	210 (15.6)	36.3 (<.001)	1047 (64.0)	498 (36.0)	13.8 (<.001)
≥75	630 (92.6)	61 (7.4)		535 (81.1)	156 (18.9)		180 (26.5)	508 (73.5)		661 (94.6)	30 (5.4)		537 (74.0)	154 (26.0)	
Education															
Less than high school	1631 (87.8)	280 (12.2)	13.7 (<.001)	1382 (77.2)	529 (22.8)	5.7 (.017)	399 (21.1)	1507 (78.9)	23.3 (<.001)	1778 (92.1)	135 (7.9)	54.3 (<.001)	1446 (72.4)	467 (27.6)	66.1 (<.001)
High school or greater	239 (76.9)	75 (23.1)		218 (69.3)	96 (30.7)		35 (10.1)	278 (89.9)		210 (64.8)	104 (35.2)		133 (40.6)	181 (59.4)	
Household income (KRW/mo)															
≤12×10⁵	1308 (87.3)	233 (12.7)	4.8 (.028)	1128 (77.6)	413 (22.4)	7.9 (.005)	324 (20.3)	1212 (79.7)	1.6 (.204)	1412 (90.4)	131 (9.6)	13.5 (<.001)	1153 (72.0)	390 (28.0)	21.1 (<.001)
>12×10⁵	524 (82.7)	120 (17.3)		433 (70.4)	211 (29.6)		96 (17.1)	547 (82.9)		538 (82.5)	106 (17.5)		397 (58.5)	247 (41.5)	
Living with family															
No	365 (90.2)	55 (9.8)	6.4 (.012)	324 (80.7)	97 (19.3)	5.3 (.022)	97 (22.2)	322 (77.8)	1.6 (.202)	401 (94.7)	20 (5.3)	21.2 (<.001)	310 (70.6)	111 (29.4)	1.5 (.222)
Yes	1513 (85.5)	300 (14.5)		1279 (74.9)	533 (25.1)		337 (18.9)	1471 (81.1)		1594 (86.7)	220 (13.3)		1273 (66.9)	541 (33.1)	
Living in metropolitan cities															
No	1219 (85.7)	246 (14.3)	0.5 (.486)	1007 (73.3)	459 (26.7)	7.8 (.005)	290 (20.2)	1171 (79.8)	0.9 (.346)	1325 (89.0)	141 (11.0)	1.9 (.166)	1090 (70.7)	376 (29.3)	8.9 (.003)
Yes	660 (87.0)	109 (13.0)		597 (79.5)	171 (20.5)		144 (18.1)	623 (81.9)		671 (86.4)	99 (13.6)		494 (62.7)	276 (37.3)	
No. of diseases															
0	359 (82.0)	80 (18.0)	4.8 (.092)	322 (75.7)	117 (24.3)	0.6 (.756)	93 (19.9)	345 (80.1)	3.9 (.145)	388 (85.8)	51 (14.2)	14.9 (<.001)	321 (69.8)	118 (30.2)	1.2 (.537)
1–2	952 (87.5)	165 (12.5)		815 (76.5)	303 (23.5)		200 (17.5)	915 (82.5)		982 (86.2)	137 (13.8)		787 (66.2)	332 (33.8)	
≥3	568 (86.7)	110 (13.3)		467 (74.6)	210 (25.4)		141 (22.5)	534 (77.5)		626 (92.4)	52 (7.6)		476 (68.1)	202 (31.9)	

Note. KNHANES IV = the Fourth Korean National Health and Nutrition Examination Survey. All percentages are weighted.

[a]Values expressed as *n* (%) unless otherwise indicated.

and the recommended values suggests that ongoing community and governmental efforts for developing feasible PA programs are needed.

The most common type of PA was walking, consistent with the findings of a previous study (Hughes, McDowell, & Brody, 2008). In this study, only one in eight older adults reported performing daily strengthening activities. This might be due to multiple factors, including a lack of the necessary equipments needed to perform strengthening activity, natural frailty that may make older adults feel physically challenged, or lack of motivation for engaging in high-intensity PA. As data on these psychosocial factors were not available from KNHANES IV, the relationships between frailty and motivational factors with PA in older adults needs to be examined in future research.

Using GIS in our study helped us understand the pattern of PA by geographic locations in a visually effective way by showing the map. The findings of this study showed that Gangwon-*do* consistently reported lower PA rates than other provinces. Although there is no clear explanation for this phenomenon, the patterns of PA in this area need to be observed closely in order to identify whether this disparity is a random occurrence. Considering that health resources in Korea have historically been allocated based on population size rather than the needs of residents (Kim & Yoo, 2008), determining PA level by geographic region may provide a basis for supporting a better distribution of national resources, as well as helping shape effective health policies for vulnerable populations.

PA levels among older adults appear to be associated with gender, age, income status, living arrangement, and education level. In general, PA participation rates were higher among males, young old, and those who were living with family, as well as those who reported higher income status and education level. Men reported higher PA rate than did women, consistent with the findings of previous studies (Crespo, Smit, Anderson, Carter-Pokras, & Ainsworth, 2000; Hughs et al., 2008; Park, Kim, & Kim, 2002; USDHHS, 2006). This suggests that women may be a suitable target population for future PA intervention

studies. Our analysis produced results that the young old group (age 65–75 years) reported higher levels of PA than older old group (> 75 years), similar to the results of previous studies (Ahmed et al., 2005; Hughes et al.). Older adults with a monthly income greater than 1.2 million KRW reported higher levels of PA than did their lower income counterparts. This positive association between higher income status and PA level has been reported by other studies (Hughes et al.; Park et al., 2002), suggesting that financial status plays an important role in PA participation among older adults.

In this study, individuals living with family reported higher levels of PA than did those living alone. A possible explanation for this finding could be that older adults living with family may experience encouragement and support for regular PA by family members, which ultimately increases their level of PA. While some living arrangements, such as marital status, are positively correlated with PA (Pettee et al., 2006), an excessively large family size appears to have a negative influence on PA rates, which may infer that large households may impose additional family obligations, resulting in reduced engagement in PA (Ahmed et al., 2005).

As a useful tool in data management and communications of geographic information (Choi, Afzal, & Sattler, 2006; Lasker, Humphreys, & Braithwaite, 1995), GIS played a critical role in data analysis in our study by illustrating the geographic variations in PA. If a more narrowed specification of participants' addresses, such as townships or small cities (*"si"*, *"gun"* or *"gu"* in Korean) is available, advanced spatial analyses (e.g., smoothing or spatial regression analyses) would be achieved. However, the KNAHNES IV data only provide regional level of residential addresses, thereby GIS was used to display geographic variations at a province (*"do"*) level. As GIS enables to easily link health issues and geographic information, spatial analysis using GIS technologies assists exploring the association of PA and neighborhood or regional environments that can build a "PA-friendly" community including parks, recreational facilities, and road network (e.g., sidewalks, trails, bike paths). This approach is also applicable

to other public health problems associated with physical activity, such as obesity or chronic illnesses (Brownson, Hoehner, Day, Forsyth, & Sallis, 2009; Matthews, Moudon, & Daniel, 2009).

Because this study used the secondary analysis of KNHANES IV, several limitations originated from the nature of the primary dataset should be recognized. Using the KNHANES data, the responses to the PA-related questions relied solely on subjective memory, which may lead to recall bias. Data were not collected for all types of activities, such as household tasks, thereby making researchers missing some parts of the whole PA picture, especially for women, who were found to be generally less active than men in this study. Although KNHANES as a national dataset is valuable in estimating national prevalence of physical activity and related factors, the cross-sectional design of the survey hinders the identification of the causal relationships between PA and its associated factors. Lastly, there were some regions (e.g., Jeju, Ulsan) that included only small number of participants due to sampling stratification. Moreover, the number of residents meeting the national PA recommendation in these regions was even smaller, which may overemphasize the corresponding percentages on Figure 1. Therefore findings on the map should be interpreted with caution because of their limited generalizability.

CONCLUSIONS

The proportion of Korean older adults who met national guidelines for PA in the year 2007 and 2008 is about 9% in vigorous activity, 10% in moderate activity, and 48% in walking. In particular, the adherence to vigorous and moderate activities is far less than national health objectives. PA rates tended to be lower in women, the older old group, and those who reported lower income and low education levels, as well as in those living alone. Therefore, future intervention studies on PA should focus on these groups to improve their health. This study used GIS to aid in visualization of PA status in older adults by geographic location, which may enhance

public awareness of the regional variations in PA and provide a basis for developing evidence-based health policies for geriatric populations. Future studies should further utilize GIS for linking PA data with neighborhood or regional built environmental resources.

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