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Physical Activity Time is the most Important of Mortality Risk Reduction in over Middle Aged

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ABSTRACT

The study was to investigate the effects of continuation, frequency, and time of physical activity after middle age on all-cause of mortality, and to determine the level of physical activity that should be recommended to Korean adults to reduce total mortality. Data of 3,871 participants in the Korea Longitudinal Study on Aging (KLoSA) who reported exercise habit at 2006 and follow-up until 2018 were analyzed using Cox proportional hazard model and chi-square tests to estimate the annual changes in probability of mortality and independent variables. In the fully adjusted model, the association between physical activity time and all-cause mortality was statically significant. With every 1-minute rise, hazard ratios (HRs) was 0.003 times lower (p = 0.019) for all-cause mortality. However, no significantly association between frequency and duration of physical activity and all-cause mortality. This study found that approximately over 65 min/week of physical activity regardless of the frequency or duration of physical activity reduced all-cause of mortality in Korean community-dwelling adults aged 45 years or more.

1. Introduction

National guidelines for aerobic physical activity recommends aerobic exercise of moderate to vigorous intensity for a minimum of 150 minutes per week or vigorous physical activity for 75 minutes per week. Alternatively, the guidelines recommend an equivalent level of exercise in combination with moderate to vigorous physical activity (Committee, 2018; Kahlmeier et al., 2015; Organization, 2010). Many evidence-based studies have reported a dose-response relationship between physical activity level and mortality. These studies report a decrease in mortality due to any cause when physical activity time increases three times above the recommended level (Arem et al., 2015;

Ekelund et al., 2016). In addition, maintaining a minimum level of physical activity has been found to lower the risks of diabetes, metabolic syndrome, and cardiovascular diseases. Physical activity levels have been shown to have a negative association with all-cause mortality, the risks of cardiovascular diseases and certain cancers, as well as exhibiting beneficial health-related effects (Committee, 2008).

An inadequate level of physical activity leads to public health problems, including serious health care issues and socioeconomic burden (Ding et al., 2016; Lee et al., 2012). An age-related deterioration in health has been reported in Korean adults, possibly the result of declining levels of aerobic physical activity with 45.8% for individuals in their 40s, 37.9% for those in their 50s, and 38.7% and 23.4% for those in their 60s and 70s (KCDC, 2018). Moreover, the percentage of individuals that satisfy the recommended level of physical activity based on the guideline is reported to be only 30% for Korean adults (Korea, 2011-2012) and only 18% for Korean older adults, implying a general lack of physical activity.

Only a few studies have explored the relationship between physical activity level and mortality in Korean adults. One study reported that a significantly reduced mortality based on physical activity is observed in individuals aged > 60 years (Cho et al., 2018). Another study found mortality to be approximately 37% lower in individuals who meet the guidelines of physical activity compared to the who did not meet (Park et al., 2009). Also, the correlation between physical activity level and mortality in adults aged ≥ 45 years is also shown to be confined to non-smokers (Kim, 2017) but smoking habits did not influence the correlation between PA and mortality (Fishman et al., 2016). Thus, studies have reported inconsistent results about the role of physical activity in reducing mortality.

However, most reports on the positive effects of physical activity on mortality have measured the intensity of a single physical activity at only single time points in the investigation, failing to reflect the influence of long-term lifestyle changes in the level of physical activity (Nordstoga et al., 2019). Moreover, although numerous studies have used self-reported physical activity to report reduced mortality based on moderate-to-vigorous physical activity or high-intensity exercise (Arem et al., 2015; Committee, 2008; Hirsch et al., 2010; Nordstoga et al., 2019), the activity level regarding exercise intensity compared with time or frequency among the factors that determine the level of exercise (time × frequency × intensity) may be influenced by health status and personal expectations, therefore highly subjective and overestimated (Cleland et al., 2018). In particular, self-reported physical activity showed low-moderate correlation whit step numbers and weakly correlation with moderate-vigorous activity with data obtained from objective device (Cleland et al., 2018).

Furthermore, given that recent studies have reported a correlation between increased physical activity and reduced total mortality and related risks regardless of the exercise intensity or time (Piercy et al., 2018; Singh et al., 2020). Therefore, we hypotheses as follows: to determine the role of physical activity in reducing mortality, it seems essential that changes in physical activity be monitored for an extended period. Also, there will be appropriate amount of time of physical activity in reducing mortality regardless of the intensity and frequency. Thus, the present work reported the findings of a 12-year longitudinal study targeting adults aged ≥ 45 years who responded

that they had performed long-term exercises. The study aimed to investigate the effects of continuation, frequency, and time of physical activity after middle age on all-cause of mortality, and to determine the level of physical activity that should be recommended to Korean adults to reduce total mortality.

2. Methods

2.1 Data source

The data used for the following analyses were derived from the Korean Longitudinal Study of Aging (KLoSA, 2018) from 2006 to 2018. As a type of study that possesses strengths of both cross-sectional data and time series data, KLoSA was constructed by repeatedly surveying the same content for the same respondents every year. Thus, all variables surveyed by KLoSA were repeatedly measured from the 1st wave to the 7th wave to collect observation cases at multiple points in time. This biennial survey involved multistage stratified sampling based on geographical areas and housing types across Korea. Participants were selected randomly using a multistage, stratified probability sampling design to create a nationally representative sample of community-dwelling Koreans aged 45 years and older. Participant selection was performed by the Korea Labor Institute for these rapidly growing populations, including individuals from both urban and rural areas. In case of refusal to participate, another subject was selected from an additional, but similar sample from the same district. In the first baseline survey in 2006, 10,254 individuals from 6,171 households (1.7 per household) were interviewed and follow up until death occurred. Of the 10,254 participants surveyed in the basic survey, 3,932 respondents said they exercised regularly. Among these, we excluded individuals for whom we had incomplete data: 161 individuals who lacked information.

2.2 Independent variables

Physical activity was analyzed using a survey that assesses three domains of Physical activity: the frequency, time and duration in leisure time activity or exercise. The Physical Activity Questionnaire that was developed and used by KLoSA was used in this study.

2.2.1 Physical activity time

Physical activity time was extracted from the response to the question: How many hours and minutes do you usually engaged each session?

2.2.2 Frequency of physical activities a week

Number of physical activities a week was extracted with the following two questions: How many times a week do you exercise? The responses were categorized as “1-2 times/week”, “3-4 times/week”, “5-6 times/week” and “Everyday”.

2.2.3 Exercise duration

Exercise duration was extracted from the response to the question: How long have you been exercising so regularly? The responses were categorized as "< 1 year", "1-2 year", "3-4 year" and "5 year or more".

2.3 Dependent variables

2.3.1 All-Cause Mortality

All-cause mortality during the time interval from year 2006 to the end of follow-up was the main outcome of the study. Death over a maximum follow-up period of 8 years was determined by death certificates.

2.4 Control variables

2.4.1 Socioeconomic and demographic factors

Age groups were divided into three categories: 45-54, 55-64 and ≥ 65 years of age. Education level was categorized into four groups: elementary or lower school, middle school, high school, and college or higher. Gender was categorized as male and female and working restriction was categorized as yes or no. Marital status was divided into three groups: married, separated or divorced, and single. Health insurance was categorized as national health insurance and medical aid.

2.4.2 Health status and behavioral factors

Alcohol consumption was divided into two groups: yes or no and self-rated health was divided into five groups: very good, good, moderate, bad and very bad. Finally, the number of chronic diseases (consisting of hypertension, diabetes, osteoarthritis, rheumatoid arthritis, cancer, chronic pulmonary disease, liver disease, cardiovascular disease, and cerebrovascular disease) and year dummies were included as covariates in our analyses.

2.5 Analytical approach and statistics

Chi-square test, and Cox proportional hazards models were used to investigate the association between regularly physical activity and all-cause mortality. To examine the impact of regularly physical activity on mortality, adjusted hazard ratio (HR) was calculated by Cox proportional hazard model which was assessed by proportional hazard assumptions test and there was no violation. The outcome variable was survival time, which was measured from date of enrollment to death or censoring (up to 12 years). Model 1 to model 3 are the results after adjusting physical activity time, Frequency of physical activities a week, and exercise duration in addition to control variables, respectively, and model 4 is a full model, including all physical activity related variables in addition to control variables. For all analyses, the criterion for statistical significance was $p \leq 0.05$, two-tailed. All analyses were conducted using the SAS statistical software package, version 9.4 (SAS Institute Inc., Cary, NC, USA).

3. Results

3.1 Sample characteristics

Baseline characteristics of participants are shown in Table 1. Out of the 3,871 participants gathered at baseline, mean of physical activity time (unit: minutes) in those who death occurred was 56.9 minutes a week and those who didn`t 64.9 minutes a week. Of the total sample population, 19.5% (n = 755) of the participants engaged in physical activity 1-2 times per week, 10.5% (n = 79) of these participants died. 29.8% (n = 1,154) of the participants engaged in physical activity 2-3 times a week, and of these participants 10.6% (n = 122) died. Of the total sample population, 11.8% (n = 455) of the participants had exercised for <1 year, and of these, 12.1% (n = 55 participants) died. 18.6% (n = 721) of the participants exercised for 1-2 years, and of these participants 13.3% (n = 96) died. General characteristics of gender, age, education level, residential region, marital status, working restriction, health insurance, smoking status, alcohol consumption, self-rated health, and number of chronic diseases, are also listed in Table 1.

Table 1. General characteristics of subjects included for analysis at baseline

Mortality							
	Total		No		Yes		P-value
	N	%	mean/N	SD/%	mean/N	SD/%	
Physical activity time (minutes/a session)	3,871	100.0	64.9/3,330	37.0/100.0	56.9/541	34.7/14.0	<.0001
Frequency of physical activities a week							<.0001
1-2 time	755	19.5	676	89.5	79	10.5	
3-4 time	1,154	29.8	1,032	89.4	122	10.6	
5-6 time	839	21.7	711	84.7	128	15.3	
Everyday	1,123	29.0	911	81.1	212	18.9	
Exercise duration (year)							0.120
< 1	455	11.8	400	87.9	55	12.1	
1-2	721	18.6	625	86.7	96	13.3	
3-4	764	19.7	669	87.6	95	12.4	
≥ 5	1,931	49.9	1,636	84.7	295	15.3	
Age							<.0001
≤54	1,434	37.0	1,365	95.2	69	4.8	
55-64	1,148	29.7	1,038	90.4	110	9.6	
65-74	961	24.8	742	77.2	219	22.8	
≥75	328	8.5	185	56.4	143	43.6	
Education level							<.0001
≤ Elementary school	1,225	31.7	953	77.8	272	22.2	
Middle school	691	17.9	612	88.6	79	11.4	
High school	1,300	33.6	1,178	90.6	122	9.4	
≥ College	655	16.9	587	89.6	68	10.4	
Gender							<.0001
Male	1,880	48.6	1,538	81.8	342	18.2	
Female	1,991	51.4	1,792	90.0	199	10.0	

Mortality	Total		No		Yes		P-value
	N	%	mean/N	SD/%	mean/N	SD/%	
Marital status							<.0001
Married	3,263	84.3	2,860	87.7	403	12.4	
Separated, divorced	592	15.3	456	77.0	136	23.0	
Single	16	0.4	14	87.5	2	12.5	
Working restriction							<.0001
Yes	1,040	26.9	785	75.5	255	24.5	
No	2,831	73.1	2,545	89.9	286	10.1	
Health insurance							<.0001
National Health Insurance	3,692	95.4	3,196	86.6	496	13.4	
Medical aid	179	4.6	134	74.9	45	25.1	
Alcohol consumption							0.071
Yes	1,626	42.0	1,418	87.2	208	12.8	
No	2,245	58.0	1,912	85.2	333	14.8	
Number of chronic disease*							<.0001
0	2,032	52.5	1,854	91.2	178	8.8	
1	1,100	28.4	911	82.8	189	17.2	
≥2	739	19.1	565	76.5	174	23.6	
Self-rated health							<.0001
Very Good	207	5.4	192	92.8	15	7.3	
Good	1,566	40.5	1,439	91.9	127	8.1	
Moderate	1,196	30.9	1,030	86.1	166	13.9	
Bad	769	19.9	587	76.3	182	23.7	
Very bad	133	3.4	82	61.7	51	38.4	
Total	3,871	100.0	3,330	86.0	541	14.0	

* Hypertension, diabetes, cancer, chronic obstructive pulmonary disease, liver disease, cardiovascular disease, cerebrovascular disease, arthritis

3.2 Relationship between regularly physical activity and all-cause mortality

Table 2 was the result of analyzing the association between physical activity time, frequency of physical activities a week and exercise duration and mortality.

In <Model 1> which included only physical activity times variables, the mortality rate decreased by 0.003 times (p = 0.022) as the exercise minutes increased by 1-munute rise.

<Model 2> was a model that includes only frequency of physical activities a week as a control variable, and there was no association between mortality also, there was no association between mortality rates even in model 3, which included only the annual exercise time variable as the control variable.

In the fully adjusted model (Model 4 in Table 2), the association between physical activity time and all-cause mortality was statistically significant. With every 1-minute rise, hazard ratios (HRs) was 0.003 times lower (p = 0.019) for all-cause mortality. However, no significantly association between the frequency and duration of physical activity and all-cause mortality.

Table 2. Adjusted effect of physical activity and all-cause mortality

	Model 1				Model 2				Model 3				Model 4			
	HR	95% CI		P-value	*HR*	95% CI		P-value	*HR*	95% CI		P-value	*HR*	95% CI		P-value
Physical activity time (minutes)	0.997	0.995	1.000	0.022									0.997	0.994	0.999	0.019
Frequency of physical activities a week																
1-2 time					0.963	0.738	1.256	0.779					0.963	0.737	1.257	0.780
3-4 time					0.896	0.714	1.126	0.346					0.888	0.706	1.118	0.313
5-6 time					1.023	0.820	1.276	0.843					1.022	0.818	1.278	0.846
Everyday					1.000								1.000			
Exercise duration (year)																
< 1									0.947	0.703	1.274	0.718	0.939	0.697	1.267	0.682
1-2									1.015	0.802	1.283	0.903	1.010	0.797	1.279	0.936
3-4									0.993	0.784	1.257	0.951	0.997	0.786	1.264	0.981
≥ 5									1.000				1.000			
Age																
≤54	1.000				1.000				1.000				1.000			
55-64	1.496	1.096	2.042	0.011	1.490	1.091	2.035	0.012	1.495	1.095	2.041	0.011	1.486	1.087	2.030	0.013
65-74	2.984	2.220	4.010	<.0001	2.978	2.210	4.013	<.0001	3.010	2.234	4.055	<.0001	2.925	2.165	3.950	<.0001
≥75	5.585	4.026	7.746	<.0001	5.639	4.053	7.845	<.0001	5.718	4.106	7.964	<.0001	5.445	3.896	7.610	<.0001
Education level																
≤ Elementary school	1.417	1.054	1.904	0.021	1.421	1.057	1.910	0.020	1.425	1.060	1.916	0.019	1.413	1.050	1.900	0.022
Middle school	0.989	0.710	1.378	0.949	0.986	0.707	1.374	0.934	0.985	0.707	1.373	0.930	0.988	0.709	1.377	0.942
High school	0.955	0.708	1.288	0.763	0.955	0.708	1.288	0.763	0.952	0.706	1.284	0.747	0.955	0.708	1.288	0.763
≥ College	1.000				1.000				1.000				1.000			
Gender																
Male	1.000				1.000				1.000				1.000			
Female	0.345	0.277	0.430	<.0001	0.356	0.286	0.443	<.0001	0.355	0.285	0.442	<.0001	0.349	0.279	0.435	<.0001

	Model 1				Model 2				Model 3				Model 4			
	HR	95% CI		P-value	*HR*	95% CI		P-value	*HR*	95% CI		P-value	*HR*	95% CI		P-value
Marital status																
Married	1.000				1.000				1.000				1.000			
Separated, divorced	1.364	1.083	1.718	0.008	1.354	1.076	1.705	0.010	1.358	1.079	1.710	0.009	1.366	1.084	1.721	0.008
Single	1.633	0.403	6.620	0.492	1.449	0.358	5.863	0.603	1.480	0.366	5.986	0.582	1.626	0.401	6.598	0.497
Working restriction																
Yes	1.384	1.111	1.723	0.004	1.378	1.108	1.715	0.004	1.384	1.112	1.722	0.004	1.379	1.107	1.718	0.004
No	1.000				1.000				1.000				1.000			
Health insurance																
National Health Insurance	1.000				1.000				1.000				1.000			
Medical aid	0.955	0.696	1.310	0.775	0.963	0.702	1.321	0.814	0.970	0.706	1.332	0.849	0.959	0.698	1.317	0.794
Alcohol consumption																
Yes	1.000				1.000				1.000				1.000			
No	1.108	0.914	1.343	0.297	1.118	0.922	1.355	0.258	1.117	0.922	1.354	0.258	1.105	0.911	1.340	0.311
Number of chronic disease*																
0	1.000				1.000				1.000				1.000			
1	1.223	0.984	1.521	0.069	1.226	0.986	1.524	0.067	1.230	0.989	1.529	0.063	1.223	0.983	1.521	0.071
≥2	1.136	0.892	1.445	0.301	1.147	0.901	1.460	0.265	1.145	0.900	1.457	0.270	1.139	0.895	1.450	0.290
Self-rated health																
Very Good	1.000				1.000				1.000				1.000			
Good	0.962	0.562	1.645	0.887	0.960	0.561	1.642	0.882	0.958	0.560	1.640	0.876	0.966	0.565	1.654	0.901
Moderate	1.224	0.714	2.100	0.462	1.229	0.716	2.108	0.455	1.229	0.715	2.113	0.455	1.227	0.714	2.109	0.458
Bad	1.519	0.865	2.667	0.146	1.551	0.883	2.722	0.127	1.553	0.882	2.734	0.127	1.523	0.865	2.682	0.145
Very bad	2.725	1.457	5.095	0.002	2.732	1.461	5.109	0.002	2.755	1.472	5.157	0.002	2.706	1.445	5.066	0.002

Model 1: adjusting control variables + physical activity time
Model 2: adjusting control variables + Frequency of physical activities a week
Model 3: adjusting control variables + exercise duration
Model 4: adjusting control variables + physical activity time + Frequency of physical activities a week + exercise duration.

4. Discussion

The present investigation involved a 12-year longitudinal study, where the correlation between mortality and the time, frequency, and duration of exercise was analyzed. The results showed that the association between physical activity time and all-cause mortality, with the cutoff point at 64.9 minutes/week. An increase of one minute was shown to lower the all-cause of mortality by 0.003 times.

Previous studies have shown a minimum increase to 60–75 minutes/week of moderate to vigorous physical activity to be necessary to further reduce mortality (Samitz et al., 2011). Indeed, increased physical activity has been reported to have a preventive effect on reducing premature mortality (Arem et al., 2015; Lee & Skerrett, 2001; Samitz et al., 2011; Warburton et al., 2006). In other studies using meta-analysis, a gradual increase in the level of exercise to 1,000, 2,000, and 3,000 Kcal/week lowers the relative risks of mortality by 11%, 22%, and 31%, respectively (Samitz et al., 2011). And also, The group that continuously performs exercise annually according to intensity had a reduced risk of death of 0.1 per minute for light exercise and 0.27 for moderate or vigorous exercise (Ezra et al., 2017).

In our study, however, where the analysis was preceded by corrections for sociodemographic factors, health status, and behavioral factors, the duration of exercise required to lower the mortality of adults aged ≥ 45 years was shown to be 64.9 minutes, with an increase of one-minute leading to a further fall in mortality risks. The results indicated a level of time that does not satisfy the recommended level of physical activity suggested by previous studies.

In 2008, physical activity guidelines for Americans' optimal health suggested a goal of 150–300 minutes/week of moderate to vigorous physical activity (500–1,000 MET) for optimal health among adults, and this has continuously been emphasized. Nonetheless, the goal is not met by many individuals. The 2018 physical activity guidelines for Americans suggested that even light-intensity physical activity could reduce the all-cause of mortality as long as the level ensures a beneficial impact on overall health (Singh et al., 2020). The cutoff of 64.9 minutes for reduced mortality as presented in our study showed something similar result that suggests that mortality can be reduced by the continuation of approximately 65 minutes/week of physical activity, despite the activity level being not as high as the recommended level.

Lewis et al. (Lewis et al., 2018). investigated the correlation between physical activity and all-causes of mortality in older Mexican-Americans for a seven-year period. They reported that increased physical activity could be the most favorable all-cause of mortality rates. Lewis et al. (Lewis et al., 2018) moreover, found that the risks of mortality tend to be lower in the group of the same or reduced physical activity in seven years, suggesting that maintaining any level of physical activity is the crucial point. Mok et al. (Mok et al., 2019) also measured the physical activity energy expenditure (PAEE) using self-reported physical activity. They reported that the PAEE increases by 1 kJ/kg/day each year. In contrast, the cases exhibiting a continuous increase to 5–10 kJ/kg/day after 5–10 years show a fall in total mortality by 24%. Although many studies have reported that increasing or maintaining physical activity is effective in reducing mortality (Blair et al., 1995; Gregg et al., 2003; Petersen et al., 2012), their results (Lewis et al., 2018; Mok et al., 2019) indicated a positive

effect on increasing the relative life expectancy with increased physical activity during the period of investigation regardless of the initial level of physical activity. In addition, studies reporting a fall in total mortality by reduced sedentary time in individuals with a low level of physical activity lend further support to our findings. In our study, the frequency or duration of exercise showed no correlation to reduced risk of mortality. As reported in previous studies, the lack of correlation is presumed to be because the analysis targeted only individuals who responded that they performed regular exercise. In other words, as long as one continues to exercise, the mortality risk decreases irrespective of the frequency or duration of exercise.

The physical activity guidelines in 2008 also suggested that, regarding the duration of exercise, any type of physical activity should be performed for a minimum of ten minutes. However, in a study by Ostman et al. (Ostman et al., 2017), which compared continuous exercise and accumulative exercise through the meta-analysis of 19 studies, the biomarkers, including cardiopulmonary function and blood pressure, show no differences, suggesting that it is necessary to prevent sedentary habits rather than regulate the minimum time of exercise. In addition, as it takes a long time (five to ten years) to reach the recommended or an adequately high level of physical activity (Byberg et al., 2009), many individuals find it challenging to achieve such levels.

5. Conclusion

The findings in our study are significant as they suggest a standard time of exercise of ten minutes a day for people struggling to find the time to exercise, based on the longitudinal study of individuals who exercise regularly. A fall in all-cause of mortality was observed in those who did approximately over 65 minutes/week of exercise regardless of the frequency or duration of exercise. Therefore, what is crucial, as shown in this study, is to maintain physical activity irrespective of its intensity, duration, or frequency.

Disclosure Statement

The authors declare that they have no conflicts of interest.

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