ORIGINAL ARTICLE
Korean J Clin Lab Sci. 2018;50(2):144-154
https://doi.org/10.15324/kjcls.2018.50.2.144
pISSN 1738-3544 eISSN 2288-1662

KJCLS

Relationship of Metabolic Diseases with Physical Activity Depending on Age

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연령별 신체활동에 따른 대사성질환과의 관계

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Metabolic disease is associated with abdominal obesity, high blood pressure, and dyslipidemia. Physical activity has beneficial effects on a variety of diseases. This study examined the relationship between metabolic diseases and physical activity according to age. Among a total of 7,295 subjects, the data from 382 individuals in the normal group and 1,525 persons in the metabolic disease group were analyzed. The data were analyzed statistically by one-way ANOVA, the Pearson's correlation coefficient, and multiple regression analysis. The levels of hemoglobin (HB), hematocrit (HCT), and creatinine (CR), were elevated when a high-intensity physical activity was performed, but they were reduced when a low-intensity physical activity was performed in the normal group aged 10~29 years and the metabolic disease group aged 50~69 years. In the normal group and metabolic disease group aged 30~49 years, the level of high density lipoprotein cholesterol (HDL-C) was elevated when high-intensity physical activity was conducted, whereas it was reduced when low-intensity physical activity was performed. No difference in the level of HDL-C depending on age and exercise intensity was observed in the normal group; the level of HDL-C decreased with age and increased with exercise intensity in the metabolic disease group. Physical activity has different effects in metabolic disease depending on age.

Key words: Age, Metabolic disease, Physical activity

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Received: April 26, 2018
Revised: May 24, 2018
Accepted: May 24, 2018

INTRODUCTION

Metabolic disease, which refers to a constellation of abdominal obesity, high blood pressure, dyslipidemia, and impaired fasting glucose (IFG) occurring in a single person, is known to increase the risk of developing cardiovascular disease and type 2 diabetes [1, 2]. Although the pathogenesis of metabolic diseases has not yet been fully elucidated, it is known to be related to obesity, blood pressure, lipid levels, and body mass index [3, 4]. The prevalence of metabolic syndrome was 23% in a survey of 8,814 persons in urban areas of the United States according

to the NCEP-ATPIII criteria, while it was 16.7% in a survey among the Hong Kong population [5]. Additionally, the 4th Korea National Health and Nutrition Examination Survey found that the prevalence of metabolic syndrome in adults in Korea is 32.4%, which is very high compared with the prevalence rates of other countries throughout the world [6].

Efforts to manage chronic diseases have led to attempts to change behaviors related to personal lifestyle, and the most important health-promoting behavior has been found to be physical activity [7]. Moreover, previous studies have shown that physical activity reduces the risk of metabolic diseases [8-10]. Regular physical activity has beneficial effects that improve cardiopulmonary functions and delays metabolic diseases associated with aging and chronic degenerative diseases [11-14]. There are many types of regular physical activity that adults can participate in. Regular walking is one of the easiest physical activities that can be performed safely anywhere at any time. In addition, several previous studies have reported that regular walking for 30 minutes or more a day reduces the risk of developing metabolic diseases [15, 16]. However, the effects of high-intensity physical activity including regular walking vary greatly. Participation in high-intensity physical activity is known to have more positive effects on physical strength (cardiovascular fitness), body composition and biochemical changes than participation in low-intensity or moderate-intensity physical activity [17, 18]. In particular, if the amount of energy consumed during physical activity is constant, participation in high intensity physical activity can lead to more effective improvement in risk factors associated with cardiovascular diseases than participation in low intensity or moderate intensity physical activity [19]. Rennie et al found that the group participating in high intensity physical activity showed a greater decrease in the risk of developing metabolic disease than the group not participating in physical activity [20]. Moreover, reductions in physical activity have been reported to be closely related to the incidence of metabolic diseases and many adult diseases [21, 22]. Nevertheless, there is a lack of research regarding the age-related association between metabolic diseases and physical activity. Therefore, this study was conducted to investigate the parameters of metabolic diseases in groups participating in high-intensity, moderate-intensity, and low-intensity physical activity according to age.

MATERIALS AND METHODS

1. Ethical approval

The study was reviewed and approved by the Ethics Committee of the Korea Centers for Disease Control and Prevention (Approval Number 2013-12EXP-03-5C).

2. Subjects

This study was conducted using the second-year survey data of the 6th Korea National Health and Nutrition Examination Survey (KNHANES VI-2) conducted from January to December in 2014. The data used in this study were provided according to the procedures presented in the KNHANES homepage (https://knhanes.cdc.go.kr) [23]. Out of a total of 9,701 respondents aged 19 or older, 2,506 were excluded. Reasons for exclusion included an absence of data regarding physical activity or parameters known to be associated with metabolic diseases, such as blood pressure (BP), waist circumference (WC), body mass index (BMI) and the levels of red blood cells (RBC), hemoglobin (HB), hematocrit (HCT), white blood cells (WBC), platelets (PLT), fasting blood sugars (FBS), triglycerides (TG), high density lipoprotein cholesterol (HDL-C), aspartate aminotransferase (AST), alanine aminotransaminase (ALT), total cholesterol (TC), blood urea nitrogen (BUN), and creatinine (CR). Thus, the data from 7,295 subjects were analyzed. Among these, 382 persons in the normal group and 1,525 persons in the metabolic disease group were analyzed to investigate the relationship between metabolic diseases and physical activity of low-intensity, moderate-intensity and high-intensity according to age using physical, hematological and biochemical parameters.

3. Investigation

The criteria for the diagnosis of metabolic diseases were

defined using the guidelines presented in the National Cholesterol Education Program Adults Treatment Panel III; NCEP ATP III [24]. Briefly, the criteria for diagnosis of metabolic diseases were fasting blood glucose (≥110 mg/dL), Asian waist circumference (male ≥90 cm, female >80 cm), blood pressure (systolic/diastolic blood pressure ≥130/85 mmHg), triglycerides (≥150 mg/dL), and high density lipoprotein cholesterol (male <40 mg/dL, female <50 mg/dL) When three or more of the criteria were met, the patient was diagnosed with metabolic disease.

Physical activity was measured using a Korean-version short-form self-report measure of the International Physical Activity Questionnaire developed for the purpose of comprehensive and objective assessment of daily physical activity in everyday life as well as health-related physical activity [25]. The measurement tool was designed to respond to the vigorous physical activity, moderate physical activity, and walking time of 10 minutes or more during the 7 days before the questionnaire survey. Vigorous physical activity was considered activity that makes you breathe much more heavily than usual, and included carrying heavy objects, running, aerobic exercises, climbing, and cycling at a fast speed. Moderate physical activity was defined as activity that led to slightly heavier breath than usual, such as carrying light items, biking at a normal speed, dancing, etc. Walking included walking during recreational activities, sports, exercise, and leisure time, as well as walking at work, home, and while using transportation. The amount of physical activity was converted into the continuous index and categorical index according to the Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire. The continuous index is for determining the Metabolic Equivalent Task (MET) to compare levels of energy consumption by multiplying the MET level by each activity time. The MET level of each physical activity is 8 for vigorous physical activity, 4 for moderate physical activity, and 3.3 for walking. The categorical index indicates the division of subjects into three levels according to the following criteria. The inactive group, Group 1 (low-intensity), was the group of people who perform the lowest degree of physical activity. This group includes those who do not belong to Group 2 (moderate-intensity) or Group 3 (high- intensity) or do not perform physical activity. Group 2, which was the minimum physical activity group, included people that satisfy any one of the following three criteria: vigorous physical activity for at least 20 minutes per day for at least three days a week; moderate physical activity or walking for at least 30 minutes per day for at least five days a week; physical activity of at least 600 MET-min/week through walking at least 5 days a week or through any combination of moderate or vigorous physical activity. Finally, Group 3, which was the health promoting activity group, included people that satisfied one of the following two criteria: consume at least 1,500 MET-min/week through vigorous activity at least three days per week, or consume at least 3,000 MET-min/week through walking 7 days a week or through any combination of moderate or vigorous physical activity [26]. The amount of physical activity was calculated by measuring the time of vigorous physical activity, moderate physical activity, walking, and sedentary activity in the past 7 days, and then converting them to MET (min/week) values to derive the continuous index and categorical index. The total physical activity score of the continuous score was calculated as the sum of the MET values of walking, moderate-activity, and vigorous activity, while physical activity of less than 10 minutes was considered to be equivalent to no physical activity.

4. Statistical analysis

The data collected in this study were statistically analyzed using the SPSS version 20 program. Descriptive statistics were used to determine the general characteristics of the subjects. ANOVA (analysis of variance) was performed to examine the differences between the normal and metabolic disease groups according to age and the differences depending on physical activity according to age. Correlations between age and metabolic parameters in the normal and metabolic disease groups were confirmed using Pearson's correlation coefficient. An independent sample t-test was conducted to examine the

differences between normal and metabolic disease groups. Multiple regression analysis was conducted to investigate the effects of age and physical activity intensity on parameters of metabolic diseases in the normal and metabolic disease groups.

RESULTS

1. Correlation between age and metabolic parameters in the normal and metabolic disease groups

For physical, hematological, and biochemical characteristics according to age in the normal and metabolic disease groups, there were statistically significant differences in

Table 1. General characteristics of the normal and metabolic disease groups according to age

Age	Characteristic		10~29	30~49	50~69	F	*P*
Physical	Normal	N	217	144	21		
		WC	70.37±7.23	72.69±7.01	79.63±9.22	17.478**	0.000
		BMI	20.69±2.52	21.26±2.57	23.14±2.68	9.696**	0.000
		SBP	103.18±6.91	100.76±6.88	103.95±7.97	5.819**	0.003
		DBP	65.57±6.18	67.49±5.44	69.43±6.03	7.299**	0.001
	Metabolic	N	97	486	942		
		WC	76.43±13.21	85.14±9.53	85.03±8.78	38.627**	0.000
		BMI	23.17±5.02	25.34±3.52	24.87±3.11	16.764**	0.000
		SBP	114.29±12.24	118.29±15.43	125.71±16.90	47.338**	0.000
		DBP	71.69±11.29	80.23±11.40	78.31±10.33	25.890**	0.000
Hematological	Normal	N	217	144	21		
		WBC	6.25±1.19	5.75±1.16	5.96±1.10	7.826**	0.000
		RBC	4.62±0.39	4.44±0.34	4.37±0.33	11.329**	0.000
		HB	13.99±1.27	13.57±1.12	14.01±1.11	5.443**	0.005
		HCT	41.46±3.22	40.38±2.79	41.25±2.95	5.574**	0.004
		PLT	263.08±44.39	258.62±50.81	255.33±42.77	0.555	0.575
	Metabolic	N	97	486	942		
		WBC	6.93±1.51	6.87±1.76	6.38±1.78	14.732**	0.000
		RBC	4.97±0.43	4.82±0.43	4.60±0.41	68.580**	0.000
		HB	14.68±1.48	14.80±1.61	14.36±1.42	14.375**	0.000
		HCT	43.25±3.70	43.60±4.11	42.40±3.71	16.079**	0.000
		PLT	288.01±56.95	267.07±55.32	249.5±57.24	30.318**	0.000
Biochemical	Normal	N	217	144	21		
		FBS	86.87±5.42	87.10±6.83	88.71±5.77	0.906	0.405
		TC	157.91±21.73	166.75±20.08	169.05±19.12	8.985**	0.000
		TG	64.26±22.94	66.92±23.23	74.4±19.48	2.156	0.117
		HDL	56.79±9.36	57.69±10.76	53.18±10.17	1.933	0.146
		BUN	11.42±2.92	12.31±3.06	13.95±3.22	9.114**	0.000
		CR	0.73±0.12	0.73±0.12	0.72±0.13	0.162	0.851
		AST	16.71±3.88	16.84±3.26	21.14±3.69	14.347**	0.000
		ALT	12.42±5.51	12.74±4.53	17.14±6.31	7.884**	0.000
	Metabolic	N	97	486	942		
		FBS	106.80±26.06	115.10±34.00	117.12±28.96	5.225**	0.005
		TC	174.58±44.37	207.25±39.76	200.33±40.35	26.627**	0.000
		TG	109.26±71.89	196.15±170.24	167.91±112.10	19.571**	0.000
		HDL	53.67±11.27	49.62±12.02	49.28±11.74	5.833**	0.003
		BUN	12.77±3.81	13.87±4.08	15.77±4.51	43.881**	0.000
		CR	0.77±0.18	0.84±0.17	0.85±0.29	4.454*	0.012
		AST	20.43±11.73	24.02±15.76	25.33±15.66	4.918**	0.007
		ALT	21.89±22.04	28.38±22.83	25.42±18.59	5.712**	0.003

*$P<0.05$, **$P<0.01$.
Abbreviations: N, number; WC, waist circumference; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure; WBC, white blood cell, RBC, red blood cell; HB, hemoglobin; HCT, hematocrit; PLT, platelet; FBS, fasting blood sugars; TC, total cholesterol; TG, triglycerides; HDL, high density lipoprotein; BUN, blood urea nitrogen; CR, creatinine; AST, aspartate aminotransferase; ALT, alanine aminotransaminase.

the levels of various factors (Table 1). In the normal group, SBP (P<0.01), WBC (P<0.01), RBC (P<0.01), HB (P<0.05), and HCT (P<0.01) were found to be negatively correlated with age (Table 2). Additionally, WC (P<0.01), BMI (P<0.01), DBP (P<0.01), TC (P<0.01), BUN (P<0.01), AST (P<0.01) and ALT (P<0.01) were found to be positively correlated with age. In the metabolic disease group, WBC (P<0.01), RBC (P<0.01), HB (P<0.01), HCT (P<0.01), PLT (P<0.01), and HDL-C (P <0.01) were found to be negatively correlated with age. WC (P <0.01), SBP (P<0.01), FBS (P<0.01), BUN (P<0.01), CR (P<0.01), and AST (P<0.05) were found to have a positive correlation with age.

2. The relationship between physical activity and parameters of metabolic diseases by age

The relationship of metabolic diseases with physical activity according to age was examined. Among people aged 10~29 years in the normal group, the levels of significant variables of metabolic diseases (RBC, HB, HCT, CR, and BUN) increased when high-intensity physical activity was performed and decreased when low-intensity physical activity was performed. No significant variables were identified in the metabolic disease group. Among those aged 30~49 years in the normal group and metabolic disease groups, HDL-C, which is a significant variable for metabolic diseases, increased when high-intensity physical activity was performed and decreased when low-intensity physical activity was performed. No significant variables of metabolic diseases were identified in 50~69 year olds of the normal group. In the metabolic disease group, significant variables of metabolic diseases (HB, HCT, CR) were elevated when high-intensity physical activity was performed and reduced when low-intensity physical activity was performed. The relationships between parameters of metabolic diseases and physical activity according to age in the normal group and metabolic disease group are summarized in Tables 3~6.

Table 2. Correlation between age and metabolic parameters in the normal and metabolic disease groups

Parameters	Normal (N=382)		Metabolic (N=1,525)	
	r	*P*	r	*P*
WC	0.279**	0.000	0.159**	0.000
BMI	0.217**	0.000	0.043	0.091
SBP	−0.142**	0.006	0.237**	0.000
DBP	0.204**	0.000	0.005	0.831
WBC	−0.195**	0.000	−0.115**	0.000
RBC	−0.270**	0.000	−0.305**	0.000
HB	−0.117*	0.022	−0.125**	0.000
HCT	−0.135**	0.008	−0.132**	0.000
PLT	−0.083	0.105	−0.198**	0.000
FBS	0.002	0.971	0.096**	0.000
TC	0.250**	0.000	0.034	0.186
TG	0.060	0.239	0.011	0.681
HDL-C	0.039	0.453	−0.097**	0.000
BUN	0.235**	0.000	0.250**	0.000
CR	0.032	0.527	0.088**	0.001
AST	0.139**	0.007	0.064*	0.012
ALT	0.133**	0.009	-0.037	0.145

*P<0.05, **P<0.01.

3. Effects of age and physical activity intensity on HDL-C in the normal and metabolic disease groups

Table 7 shows the effects of age and physical activity intensity on HDL-C in the normal and metabolic disease groups. The results of the analysis showed that there was no statistically significant difference in HDL-C depending on age and exercise intensity in the normal group, and regression equation was not significant. However, in the metabolic disease group, the HDL-C level was found to decrease with age (β= −0.09) and increase with physical activity intensity (β=0.07). In other words, in the metabolic disease group, as more physical activities were performed the HDL-C level was elevated, the regression equation became significant and the explanatory power was 1.3%.

Table 3. The relationship between physical activity and parameters of metabolic diseases by age

Age	Group	Metabolic disease parameters	Physical activity results
10~29 yrs	Normal	RBC, HB, HCT, CR, BUN	High intensity↑, Low intensity↓
	Metabolic	–	–
30~49 yrs	Normal	HDL-C	High intensity↑, Low intensity↓
	Metabolic	HDL-C	High intensity↑, Low intensity↓
50~69 yrs	Normal	–	–
	Metabolic	HB, HCT, CR	High intensity↑, Low intensity↓

Table 4. Physical, hematological, and biochemical characteristics according to physical activity by age (10～29 years)

Characteristic			Low	Moderate	High	F	*P*
Physical	Normal	N	122	78	17		
		Age	21.46±5.21	19.45±4.80	19.53±4.72	4.205*	0.016
		WC	69.77±7.18	70.8±7.34	72.66±6.83	1.428	0.242
		BMI	20.49±2.45	20.85±2.68	21.39±2.19	1.189	0.307
		SBP	102.79±7.03	103.79±7.06	103.12±5.28	0.505	0.604
		DBP	65.77±6.59	65.50±5.68	64.41±5.49	0.365	0.694
	Metabolic	N	57	28	12		
		Age	17.63±5.97	19.07±5.40	18.25±5.10	0.600	0.551
		WC	75.33±12.37	79.5±13.82	74.5±15.50	1.085	0.342
		BMI	22.72±4.90	24.35±5.13	22.59±5.26	1.095	0.339
		SBP	113.47±12.20	116.14±13.57	113.83±9.23	0.451	0.639
		DBP	70.77±11.82	74.18±11.44	70.25±7.50	0.967	0.384
Hematological	Normal	N	122	78	17		
		WBC	6.13±1.14	6.39±1.27	6.45±1.10	1.362	0.258
		RBC	4.56±0.36	4.67±0.41	4.75±0.46	3.149*	0.045
		HB	13.82±1.20	14.10±1.30	14.66±1.42	3.861*	0.023
		HCT	40.98±3.01	41.91±3.32	42.88±3.67	3.850*	0.023
		PLT	262.56±41.87	264.37±48.27	260.94±45.97	0.061	0.941
	Metabolic	N	57	28	12		
		WBC	7.08±1.54	6.72±1.45	6.76±1.58	0.619	0.541
		RBC	4.99±0.41	4.89±0.46	5.11±0.44	1.150	0.321
		HB	14.64±1.47	14.6±1.63	15.01±1.22	0.343	0.711
		HCT	43.1±3.71	43.1±3.98	44.33±2.99	0.579	0.562
		PLT	287.28±61.86	285.39±50.52	297.58±49.35	0.200	0.819
Biochemical	Normal	N	122	78	17		
		FBS	86.52±5.54	87.15±5.47	88.12±4.21	0.815	0.444
		TC	158.92±21.00	156.27±23.21	158.18±20.63	0.353	0.703
		TG	63.52±22.34	65.17±24.17	65.41±22.48	0.144	0.866
		HDL	56.83±9.30	56.68±9.92	57.04±7.40	0.012	0.988
		BUN	11.25±2.73	11.15±3.01	13.88±2.96	6.927**	0.001
		CR	0.72±0.12	0.74±0.13	0.82±0.14	4.752**	0.010
		AST	16.73±4.01	16.79±3.86	16.18±3.13	0.179	0.836
		ALT	12.61±6.12	11.97±4.64	13.06±4.70	0.443	0.643
	Metabolic	N	57	28	12		
		FBS	108.07±30.59	105.46±21.34	103.92±4.96	0.175	0.840
		TC	169.93±36.85	189.43±53.66	162.00±48.54	2.434	0.093
		TG	113.96±79.51	105.36±62.34	96.00±55.10	0.363	0.697
		HDL	53.47±11.52	52.96±10.02	56.15±13.30	0.348	0.707
		BUN	13.09±4.26	12.68±3.41	11.50±1.88	0.870	0.422
		CR	0.74±0.18	0.79±0.20	0.83±0.13	1.613	0.205
		AST	20.05±8.73	21.46±17.88	19.83±4.86	0.151	0.860
		ALT	20.40±17.84	25.82±31.94	19.75±7.71	0.627	0.537

*$P<0.05$, **$P<0.01$.

DISCUSSION

This study was conducted to investigate the relationship between parameters of metabolic diseases and physical activity according to age in normal adults and those with metabolic disease, as well as to provide basic data for prevention of metabolic diseases depending on physical activity according to age. Overall, about 45% of adults engage in low-intensity physical activity, while 19.7% perform moderate-intensity physical activity, and 35.4% engage in high-intensity physical activity. Participation in high-intensity physical activity has been reported to have a positive effect on various parameters of metabolic diseases [27]. In a study of 612 adult males with no metabolic disease by Laaksonen et al [28], which was controlled for age and BMI, the incidence rate of metabolic

Table 5. Physical, hematological, and biochemical characteristics according to physical activity by age (30~49 years)

Characteristic			Low	Moderate	High	F	*P*
Physical	Normal	N	88	49	7		
		Age	37.55±5.35	37.08±4.87	38.57±5.53	0.300	0.741
		WC	72.62±7.00	72.77±7.28	73.06±6.06	0.018	0.983
		BMI	21.06±2.32	21.56±3.04	21.66±2.17	0.660	0.519
		SBP	99.99±7.07	102.04±6.49	101.57±6.48	1.462	0.235
		DBP	66.69±5.71	68.76±4.92	68.57±3.95	2.455	0.090
	Metabolic	N	351	111	24		
		Age	41.14±5.57	40.68±5.11	40.21±5.33	0.551	0.577
		WC	85.59±9.73	84.19±9.13	82.86±7.78	1.637	0.196
		BMI	25.38±3.55	25.32±3.56	24.97±2.94	0.156	0.855
		SBP	118.09±14.92	118.61±16.15	119.71±19.62	0.154	0.857
		DBP	80.03±10.75	80.73±13.03	80.67±13.01	0.175	0.840
Hematological	Normal	N	88	49	7		
		WBC	5.89±1.03	5.48±1.26	5.92±1.79	2.000	0.139
		RBC	4.48±0.36	4.42±0.31	4.18±0.16	2.582	0.079
		HB	13.72±1.15	13.40±1.11	12.84±0.26	2.846	0.061
		HCT	40.70±2.81	40.05±2.84	38.53±0.79	2.521	0.084
		PLT	259.61±48.72	259.92±54.74	237.00±50.51	0.664	0.517
	Metabolic	N	351	111	24		
		WBC	6.98±1.72	6.62±1.94	6.54±1.33	2.207	0.111
		RBC	4.84±0.43	4.77±0.42	4.85±0.45	1.067	0.345
		HB	14.87±1.58	14.56±1.67	14.95±1.62	1.642	0.195
		HCT	43.77±4.06	42.98±4.21	44.01±4.21	1.684	0.187
		PLT	265.88±56.58	271.03±51.14	266.29±56.58	0.364	0.695
Biochemical	Normal	N	88	49	7		
		FBS	87.01±6.30	86.78±7.80	90.43±6.00	0.893	0.412
		TC	166.80±20.30	166.49±18.81	168.00±28.32	0.018	0.983
		TG	69.08±24.68	64.86±20.30	54.29±21.20	1.622	0.201
		HDL	56.78±10.167	57.03±9.010	73.86±17.00	9.276**	0.000
		BUN	12.17±3.28	12.47±2.72	13.00±2.52	0.333	0.717
		CR	0.73±0.12	0.73±0.11	0.64±0.12	1.899	0.154
		AST	16.25±2.84	17.80±3.78	17.57±3.10	3.864*	0.023
		ALT	12.39±4.45	13.57±4.80	11.43±2.64	1.398	0.251
	Metabolic	N	351	111	24		
		FBS	114.23±29.08	118.13±43.32	113.92±50.12	0.563	0.570
		TC	206.00±40.41	208.77±37.67	218.50±39.01	1.216	0.297
		TG	199.24±162.29	184.50±167.88	204.29±273.20	0.342	0.711
		HDL	48.90±11.12	50.89±14.31	54.28±11.91	2.976*	0.050
		BUN	13.84±4.09	14.05±4.11	13.58±3.82	0.169	0.844
		CR	0.84±0.17	0.86±0.19	0.85±0.16	0.671	0.512
		AST	23.87±12.93	24.83±23.61	22.50±6.07	0.271	0.763
		ALT	28.79±22.76	28.95±24.86	19.88±8.87	1.761	0.173

*$P<0.05$, **$P<0.01$.

disease decreased to 63% (OR: 0.37, 95% CI: 0.21~0.65) in the group that participated in high-intensity physical activity for 60 minutes or more per week compared to the group that participated for less than 10 minutes per week. The incidence of metabolic disease still decreased to 64% (OR : 0.36, 95% CI : 0.19~0.70) when the study was controlled for the age, body mass index, blood pressure, insulin, fasting glucose level and family history of diabetes.

It has been reported that physical activity contributes to decreased levels of TC and TG, which are related to various cardiovascular and metabolic diseases, including arteriosclerosis, as well as to an increase in HDL-C, which helps prevent diseases [29]. In this study, high-intensity physical activity was found to induce statistically significant differences in HDL-C in both the normal group ($P<0.01$) and the metabolic disease group ($P<0.05$) of 30~49 year

Table 6. Physical, hematological, and biochemical characteristics according to physical activity by age (50~69 years)

Characteristic			Low	Moderate	High	F	*P*
Physical	Normal	N	16	5	-		
		Age	57.31±5.81	52.60±3.72	-	2.867	0.107
		WC	77.59±7.03	86.16±13.05	-	3.741	0.068
		BMI	22.64±2.52	24.72±2.81	-	2.466	0.133
		SBP	104.13±9.10	103.40±2.51	-	0.030	0.864
		DBP	69.44±6.66	69.40±3.91	-	0.000	0.991
	Metabolic	N	723	177	42		
		Age	59.59±5.56	59.15±5.43	59.79±5.61	0.492	0.612
		WC	85.16±8.93	84.60±8.22	84.54±8.60	0.356	0.701
		BMI	24.92±3.20	24.81±2.73	24.21±2.97	1.087	0.338
		SBP	126.21±17.29	123.11±15.32	128.02±15.66	2.825	0.060
		DBP	78.18±10.39	78.36±10.00	80.24±10.55	0.790	0.454
Hematological	Normal	N	16	5	-		
		WBC	6.16±1.05	5.32±1.11	-	2.369	0.140
		RBC	4.35±0.28	4.47±0.49	-	0.528	0.476
		HB	13.91±0.96	14.36±1.58	-	0.626	0.439
		HCT	41.02±2.69	41.98±3.96	-	0.391	0.539
		PLT	250.88±41.46	269.60±48.65	-	0.720	0.407
	Metabolic	N	723	177	42		
		WBC	6.42±1.75	6.19±1.83	6.50±2.12	1.351	0.259
		RBC	4.59±0.41	4.60±0.41	4.74±0.42	2.597	0.075
		HB	14.31±1.45	14.46±1.28	14.93±1.30	4.440*	0.012
		HCT	42.27±3.74	42.55±3.59	44.01±3.40	4.559*	0.011
		PLT	251.00±57.40	244.97±54.19	243.45±66.32	1.037	0.355
Biochemical	Normal	N	16	5			
		FBS	88.63±5.95	89.00±5.79	-	0.015	0.903
		TC	167.69±21.20	173.40±10.55	-	0.329	0.573
		TG	74.81±21.26	73.20±14.18	-	0.025	0.876
		HDL	53.75±10.70	51.36±9.07	-	0.203	0.658
		BUN	14.25±3.40	13.00±2.65	-	0.563	0.462
		CR	0.70±0.13	0.77±0.12	-	1.069	0.314
		AST	20.63±3.52	22.80±4.15	-	1.345	0.260
		ALT	17.06±6.81	17.40±5.03	-	0.010	0.920
	Metabolic	N	723	177	42		
		FBS	117.50±30.10	116.25±26.41	114.17±17.10	0.359	0.698
		TC	200.93±40.99	200.08±38.15	191.02±38.03	1.201	0.301
		TG	171.88±117.50	155.44±89.54	152.26±98.78	1.962	0.141
		HDL	48.98±11.87	49.92±10.33	51.78±14.80	1.424	0.241
		BUN	15.79±4.58	15.61±3.90	16.02±5.57	0.185	0.831
		CR	0.84±0.25	0.84±0.19	1.04±0.80	9.472**	0.000
		AST	25.44±16.63	24.66±11.62	26.43±13.20	0.281	0.755
		ALT	25.81±19.86	24.27±13.48	23.52±14.18	0.712	0.491

*$P<0.05$, **$P<0.01$.

olds. These results are consistent with those reported [30-32]. Overall, these findings show that high-intensity physical activity increases HDL-C and is effective at preventing coronary artery diseases and metabolic diseases among 30~49 year olds. In addition, several previous studies have reported that high-intensity physical activity affects the composition and function of erythrocytes that constitute blood [33]. In the present study, we also found an increase in erythrocyte-related parameters in the normal group of 10~29 year olds and the metabolic disease group of 50~69 year olds when high-intensity physical activity was performed. The effects of regular physical activity vary depending on the intensity of physical activity. Participation in high-intensity physical activity has a greater effect on reducing the risk of developing high cholesterol, diabetes, and

Table 7. Effects of age and physical activity intensity on HDL-C in the normal and metabolic disease groups

Group	Independent variable	Non-standardization factor		Standardization factor	t	Collinearity statistic		F
		B	Se	β		tolerance	VIF	
Normal	Constant	53.42	1.98		27.015**			1.888
	Age	0.05	0.04	0.05	1.010	0.978	1.022	
	Activity	1.51	0.84	0.09	1.791	0.978	1.022	
		R^2= 0.010, adjusted R^2=0.005, DW=1.936						
Metabolic	Constant	51.76	1.48		35.077**			
	Age	−0.08	0.02	−0.09	−3.462**	.990	1.011	11.010**
	Activity	1.53	0.55	0.07	2.798*	.990	1.011	
		R^2= 0.015, adjusted R^2=0.013, DW=1.905						

*P<0.05, **P<0.01.
Abbreviation: VIF, Variance inflation factor.

hypertension, which are associated with metabolic diseases, than low-intensity or moderate-intensity physical activity. In a study of 49,005 adults, Williams and Thompson showed that the group participating in running, which is a high-intensity physical activity, had a lower risk of developing various diseases than the group participating in walking, which is a moderate-intensity physical activity [34]. Specifically, the risk of developing hypertension was 38% (Hazard Ratios (HR): 0.62, 95% CI: 0.55~0.70) and the risk of developing diabetes was 71% (HR: 0.29, 95% CI: 0.21~0.40). Regular physical activity has been shown to improve health, prevent chronic illnesses and have positive effects on mental health. As a result, the World Health Organization (WHO) and many countries, including the United States, Canada, Australia and Japan, have announced physical activity recommendations. It should be noted that the present study has the following limitations. The physical activity intensity of walking varies according to the speed of walking. For example, it can be 2.5 METs when you walk at 3.2 kph and 8.0 METs when you walk at 8 kph. Moreover, it is affected by diverse factors, including weight of the load, carrying a baby, and geographical factors such as slope [35]. Therefore, it is not desirable to calculate the physical activity intensity of walking on the basis of METs of a single person. To enable more accurate measurement of the total physical activity, the validity of the method of calculating intensity of moderate-intensity physical activity, that is, the validity of calculating physical activity intensity in terms of average METs, needs to be discussed in the future research. Deriving the MET-min or kcal by calculating the intensity in terms of the average METs does not reflect the fact that a level of physical activity intensity may actually refer to a range of considerably different levels of intensity. While there was no difference in the levels of HDL-C observed according to age and physical activity intensity in the normal group, the level of HDL-C decreased with increasing age and increased with exercise intensity in the metabolic disease group. Physical activity has a different effect depending on age in the metabolic disease.

요 약

본 연구의 목적은 2014년 조사되어진 제 6기 2차 국민건강영양조사 자료를 바탕으로 연령별 신체활동에 따른 대사성질환과의 관계를 파악하여 연령별 신체활동에 따른 대사성질환과의 관련성을 규명하여 예방적 기초자료를 제공하기 위한 연구이다. 본 연구는 제 6기 2차(2014) 국민건강영양조사의 자료를 이용하여 수행되었다. 정상군의 382명과 대사질환군의 1,525명을 총 9,701명의 설문 응답자 중 관련 자료가 없는 2,506명을 제외하고 총 7,295명을 분석했다. 본 연구에서 신체활동은 국제신체활동 설문지 (IPAQ)를 기반으로 재분류 되었다. 대사증후군의 정의는 2004년 개정 된 NCEP-ATP III에 근거하여 다음과 같은 결론을 얻었다. 연령에 따른 대사성질환과 신체활동과의 관계에서 10~29세 정상군과 50~69세의 대사질환군에서 혈색소, 적혈구용적, 크리아티닌의 수치는 고강도 신체활동이 수행되었을 때 증가했고 저강도 신체활동을 수행되었을 때 감소했다. 30~49세의 정상군과 대사질환군에서 고밀도 지단백 콜

레스테롤 수치는 고강도 신체활동이 수행되었을 때 증가했지만, 저강도 신체활동이 수행되었을 때 감소하였다. 따라서 연령과 운동강도가 고밀도 지단백 콜레스테롤 수치에 미치는 영향을 조사하였다. 결과는 정상군에서 연령과 운동강도에 따라 고밀도 지단백 콜레스테롤 수치에 차이는 없었지만 대사질환군에서는 연령에 따라 고밀도 지단백 콜레스테롤 수치가 감소하였고 운동강도에 따라 증가하였다. 종합하면, 본 연구의 결과는 대사질환군에서 고밀도 지단백 콜레스테롤 수치는 고강도 신체활동에서 긍정적인 효과를 나타내고 연령은 부정적인 효과를 나타냈다. 이러한 결과는 우리가 신체활동과 연령에 따라 대사성 질환을 더 잘 이해하는데 도움이 될 수 있다.

Acknowledgements: None
Conflict of interest: None

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