보건학 석사학위논문

The Effect of Physical Activity and Sedentary Behavior on High Density Lipoprotein Cholesterol, Triglyceride and Heart Rate in the Healthy Twin Study

운동과 좌식 생활이 고밀도지질단백질과 중성지질 그리고 심박수에 미치는 영향: 한국 쌍둥이 코호트 연구

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Abstract

Precedent researches show that physical activity has huge effects on energy expenditure and this would be related to level of cholesterol, triglyceride and body fat. Physical activity also exert influence on cardiovascular conditions like heart rate or blood pressure.

In this research, the effect of physical activity and sedentary behavior on metabolic factors like cholesterol, triglyceride, body fat and heart rate are analyzed. Additionally, effect of gender and intensity of physical activity are analyzed. Through twin study, the research shows the effect of gene and environment too.

The amount of physical activity and sedentary time was measured by International Physical Activity Questionnaire (IPAQ), and converted to MET scores (MET-minute/week).

Multiple regression analysis reveals that physical activity might increase the level of HDL (P=0.002) and decrease the level of triglyceride (P=0.016) and

heart rate (P=0.013). Also the sedentary behavior increases triglyceride (P=0.001), fasting blood sugar (P=0.035) and fasting insulin (P=0.002), independent of exercise intensity.

Through the research, Physical activity would increase level of HDL, fasting blood sugar and muscle mass. Furthermore, triglyceride level, heart rate and fat from arms and legs would reduce if people do more exercise. However, other metabolic factors like LDL, insulin and BMI might be affected by other factors like eating habits, smoking and drinking alcohol. Adjusting these factors would increase reliability of the research.

Comparing the male and female group, physical activity has more influence on metabolic factors in males. Direction of evolution might affect these results in male.

Moderate physical activities might reduce the fat from arms and legs, and increase HDL level. However, intense exercise would be needed to improve the cardiovascular system and reduce the circumference of the belly.

The twin study shows HDL level is more affected by physical activity than

gene effects. However, we couldn't tell gene and environmental effect about other metabolic factors through this research. Other methods to adjust environmental factors or direct gene research like GWAS would be needed to improve the research.

keywords : physical activity, sedentary behavior, metabolic factors, HDL, fat, heart rate, the healthy twin study

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Ⅰ. Introduction

Importance of physical activity information is growing nowadays. Courtesy of wearable devices and smart phones, physical activity data could be collected and used more easily. Physical activity can dramatically increase energy expenditure, and exercise can increase energy expenditure 25 fold compared to resting metabolic rate. (1) So the physiology and biochemistry of fuel selection during exercise has been the topic of investigation for several decades. (2) During exercise, muscle increases rates of both fatty acid and glucose oxidation to support higher energy demands, while lipolysis in adipose tissue is enhanced and fatty acid storage is decreased. (3) It is well known that metabolic factors like cholesterol level, heart rate, body mass index have effects on health and disease. High density lipoprotein cholesterol (HDL) have strong inverse association with coronary heart disease (CHD). (4), (5) Also blood sugar, fatty acid, blood pressure and heart rate are cardiovascular risk factors. (6)

However, the common observation that exercise often leads to a less than

expected decrease in body weight, without changes in energy intake, suggests that some compensatory behavioral adaptations occur. (7) Physical activity can be divided into exercise and non-exercise physical activities, like occupation, leisure, sitting, standing, ambulation, talking and fidgeting. (8) In recent research, exercise effects on non-exercise physical activity, this may have the unintended effect of increasing sedentary time. (9) Sedentary time is inversely associated with health risks independent of physical activity, (10) and is particularly concern in older adults, who spend larger portions of the day engaged in sedentary behavior. (11) Sedentary behavior is defined as activities that require minimal movement, resulting in a very low level of energy expenditure such as sitting. (10) In some follow up research, sedentary time did increase in approximately half of the participants in the supervised exercise training. (12)

Researchers are also concerned about intensity of exercise. Some research shows that intensity of the exercise does not have influence on total energy expenditure or reducing body fat. (13) Although the amount of exercise is necessary to change some metabolic factors like HDL, TG or heart rate. (14),

(15)

In twin study, difference between each monozygotic (MZ) twins shows the effect of environment, because MZ twins are genetically identical. On the other hand, difference between each dizygotic (DZ) twins shows the effect of genes, because DZ twins are mostly raised together and their genes are 50% different. (16) Comparison analysis between MZ twins and DZ twins will expose the effect of gene and environment.

In this research, the amount of physical activities in individuals is measured and association between physical activity and metabolic factors like cholesterol, blood sugar, fat, BMI, heart rate and blood pressure is analyzed. Also the effect of sedentary time and sex is measured between physical activity and metabolic factors like other researches. (15) Additionally, effect of physical activity level (intensity of physical activity) is analyzed. Comparison analysis between moderate and vigorous physical activity will show which level of exercise affects each metabolic factors.

According to analysis of MZ twins and DZ twins, gene and environmental

effects are tested to reveal which factor affects more on metabolic factors.

Ⅱ. Methods

Research Subjects

The Healthy Twin Study has been started 2005, supported by CDC Korea. This research has successfully collected 3,500 individuals of twins and their families until 2018. (17) First 3320 individuals had been measured epidemiological and clinical data systematically. More than 100 individuals participated in the research until 2018. All subjects are twins or their families. According to IPAQ protocol, subjects who overestimated their amount of physical activity were eliminated (n=16)

Epidemiological data includes basic life style, diet, and physical activity, occupation and socioeconomic status, psychosocial factors, and twin specific questionnaires such as zygosity and development history. (17) Clinical information is collected by blood and urine collection. Also bone density and fat from DEXA (Dual Energy X-Ray Absorptiometry), and muscle mass from

impedance. Individuals physical activity data is collected by IPAQ questionnaires (Korean).

Research Tools

(1) Physical Activity with IPAQ

The amount of physical Activity has been measured by the tool named IPAQ (International Physical Activity Questionnaire).

IPAQ (International Physical Activity Questionnaire) is the self-administered protocol to scoring data about physical activity by telephone or interview. Survey targets of IPAQ are adults from 15-69 years old, and more or less than 15-69 are not recommended to this protocol. IPAQ has short form and long form to measure four types of physical activities. Leisure time physical activities, domestic and gardening activities, work-related physical activities, transport-related physical activities are those. In short form, we can only measure walking, moderate-intensity activities and vigorous-intensity activities. However, in long form we can measure those four types of physical activities. Both short form

and long form are designed to determine duration (in minutes) and frequency (days). Long form could measure scores of specific types of physical activities but short form couldn't. Contents of IPAQ survey can be converted to specific scores called MET scores, and presented to MET-minutes/day or MET-minutes/week. In this research MET-minutes/week is used basically. To calculate kilocalories, MET scores are multiplied by weight in kilograms (MET-min x weight in kilograms/60 kilograms). Measured MET scores can be classified Low, Moderate and High groups. High groups exercise more than an hour per day and have no limits of maximum activities. If walking 5,000 steps in a day is basal activity, walking more than 12,500 steps is high active. (18) More than an hour exercise of moderate-intensity activities or half an hour of vigorous-intensity activities are standards of the High group. Moderate groups are more active than Low groups. They do more than half an hour of moderate-intensity activity. Low groups have people who don't be classified as high or moderate groups.

-Scoring

The flowing methods are used to calculate IPAQ scores in short form. Walking a minute is translated to 3.3 MET, moderate activities a minute is translated to 4.0 MET and vigorous activities to 8.0 MET.

walking MET-minutes/week = 3.3*walking minutes*walking days,

moderate MET-minutes/week = 4.0*moderate-intensity activity minutes*moderate days,

vigorous MET-minutes/week = 8.0*vigorous-intensity activity minutes*vigorous-intensity days

Finally, total physical activities can be measured by sum of walking, moderate and vigorous MET scores.

total physical activity MET-minutes/week = Walking + Moderate + Vigorous MET-minutes/week score

Following rules are standards of low, moderate and high groups by MET

scores. People in Moderate groups do more than 20 minutes of vigorous-intensity activities for 3 days, or 30 minutes of moderate-intensity activities for 5 days, or 600 MET-minutes/week of walking, moderate-intensity, and vigorous intensity activities. People in High groups do more than 3 days of vigorous-intensity activities every week, and more than 1500 MET-minutes/week. If not, people do more than 7 days of walking, moderate-intensity, vigorous-intensity activities and more than 3000 MET-minutes/week. Low groups are composed of people who do not classified as high or moderate groups.

Short form and long form have different scoring systems in specific activities, but they both could calculate walking, moderate and vigorous MET scores. Also, criteria of dividing groups by high, moderate and low are same in short form and long form.

-Cleaning

An accurate data cleaning is important as much as accurate scoring. That IPAQ is the protocol to measure the amount of physical activities by telephone or survey questionnaires, data cleaning is important to get exact data of

physical activities. First, check data about 'hours' and 'minutes'. If 'hours' data has 'minutes' data or 'minutes' data has 'hours' data, they should be changed each other. In some case daily exercise time will be reported as weekly. This data should be divided by 7. If someone answered 'don't know' or refused to answer, these should be eliminated from analysis. There are more rules about revising values of time. The sum of walking, moderate, vigorous activities should not be over 960 minutes (16 hours). This exceed data should be excluded. Minimum values are limited too. If 'minutes' value is less than 10 minutes, it should be corrected to 0.

In short form, walking, moderate, vigorous time would not be over 180 minutes (3 hours). Exceed values should be changed to 180 minutes. This follows the rule that physical activity time should not be over 21 hours per week (3 hours * 7 days). Long form is little bit more complicated than short form. Walking, moderate, vigorous intensity activities should be calculated separately and exceed values should be changed to 180 minutes (3 hours). This truncation rule will prevent wrong categorization of 'high' group. (19), (20)

(2) Metabolic Factors and other Clinical Factors

The amount of cholesterol, triglyceride, fasting blood sugar and fat had been measured by drawing blood from research subjects. Heart rate had been measured by ECG (electrocardiogram) and blood pressure had been measured by automatic sphygmomanometer. Weight, height, waist measurement and hip measurement had been measured by medical specialists. By using DXA (dual energy x-ray absorptiometry), amount of fat from each arm and leg had been measured. Also by using impedance machine, muscle mass and total body fat had been measured.

Methods of Analysis

(1) Regression analysis between physical activity and metabolic factors

$$Metabolic\ factors = \beta_0 + \beta_1 * Total\ Physical\ activity + \beta_2 * Sedentary\ Time + \beta_3 * age + \beta_4 * sex + \beta_5 * level\ of\ physical\ activity$$

The amount of physical activities has been changed to MET-minute scores by using IPAQ scoring method. By using regression analysis, association between physical activity and cholesterol, blood sugar, insulin, BMI, heart rate, blood

pressure, fat and muscle mass. All regression analysis would be adjusted by sedentary time, level of physical activity, age and sex.

Also by dividing male and female group, effect of sex would be analyzed again.

(2) Regression analysis between metabolic factors and level of physical activity

Physical activities could be divided into moderate and vigorous activities. Regression analysis between metabolic factors and each groups of physical activity, would offer which activity is more effective to health factors. This analysis would be adjusted by age, sex and total physical activity.

(3) Effects of gene and environment

$$\textit{Difference between metabolic factors of each twins} = \beta_0 + \beta_1 * \textit{difference between total physical activity of each twins} + \beta_2 * \textit{age} + \beta_3 * \textit{sex}$$

In twin study, difference between MZ twin (monozygotic twin) would be effect of environment because MZ twins' genes are identically same. On the other hand, difference between DZ twin (dizygotic twin) would be some effect of

genes because their genes are half identical. In this regression analysis, x-axis would be difference between total physical activity of each twins, and y-axis would be difference between metabolic factors of each twins.

Ⅲ. Results

1. Characteristics of physical activity research groups

The total population of this research is 3484, and has 2053 females and 1431 males. Monozygotic twins are 555 pairs and dizygotic twins are 242 pairs in this group. Following the age distribution, 30-49 is the largest group. In physical activity, most people belong to the low group (59.3%), and less in high group (14.6%). There are total 676 pairs of twins in this cohort and 555 pairs are MZ twins and 121 pairs are DZ twins. (Table 1) The number of subjects who measured metabolic factors like cholesterol, blood sugar, heart rate, blood pressure, body fat and muscle are different. (Table 2) Each factors are analyzed respectively in regression analysis.

Subjects who exercise more tend to spend less time in sitting and subjects

who exercise less tend to spend more time in sitting. However, it is not always the case. Some vigorous exercising subjects spend as much time in sitting as low physical activity groups like other researches. (Figure2), (12)

Variables	count	percentage
Gender		
Female	2053	58.9%
Male	1431	41.1%
Age		
17-29	385	11.1%
30-49	1926	55.3%
50-69	1016	29.1%
≥70	157	4.5%
Level of Physical Activity*		
Low (male, female)	2065 (858, 1207)	59.3% (60.0, 58.8)
Moderate (male, female)	911 (371, 540)	26.1% (25.9, 26.3)
High (male, female)	508 (202, 306)	14.6% (14.1, 14.9)
Twin		
Monozygotic Twins	1110 (555 pairs)	
Female	702	63.2%
Male	408	36.8%
Dizygotic Twins	242 (121 pairs)	
Female	134	55.0%
Male	108	45.0%

Table 1. Population and Characteristics

*Divided by amount of physical activity, according to IPAQ protocol

Variables		n	Mean	SD
Physical activity (MET-minute/week)		3484	1248.9	1431.9
Cholesterol	Total (mg/dl)	3482	191.04	36.14
	HDL (mg/dl)	3482	47.12	11.56
	LDL (mg/dl)	3472	108.99	30.22
	Triglyceride (mg/dl)	3462	112.97	71.02
Blood Sugar (mg/dl)		3475	92.83	16.17
Insulin (μIU/ml)		3477	7.725	4.28
Waist Measurement (cm)		3481	80.79	9.35
Hip Measurement (cm)		3478	94.75	5.95
BMI (kg/m^2)		3482	23.66	3.28
Heart Rate (BPM)		3471	66.40	9.49
Blood pressure	SBP (mmHG)	3474	116.32	16.62
	DBP (mmHG)	3474	73.43	10.78
FAT	Left Arm (g)	3440	1009.4	437.7
	Right Arm (g)	3440	962.8	1015.2
	Left Leg (g)	3440	2696.1	428.4
	Right Leg (g)	3440	2678.1	1040.5
Muscle Mass (kg)		2129	42.29	8.69
Body Fat (kg)		2129	17.05	5.84

Table 2. Means of Physical Activity and Metabolic Factors

HDL: High-density Lipoprotein, LDL: Low-density Lipoprotein SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, n: number of subjects, SD: Standard Deviation

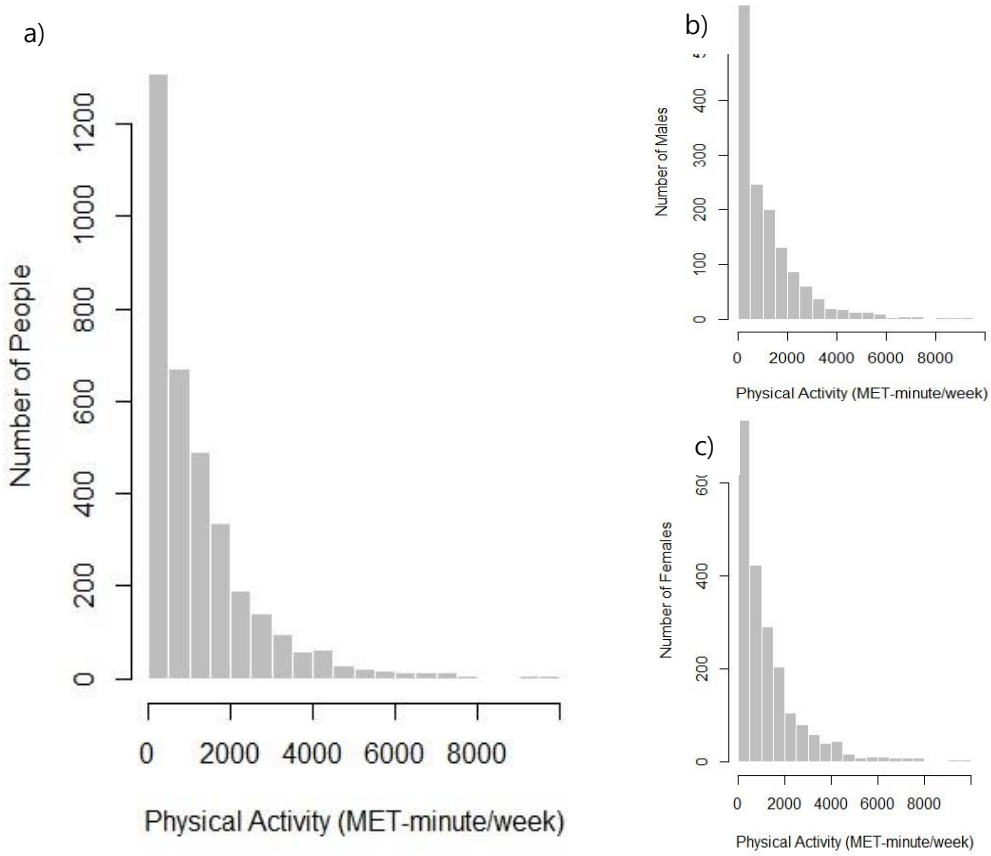

Figure 1. Histogram of Total Physical Activity in Total Population a), male b) and female c)

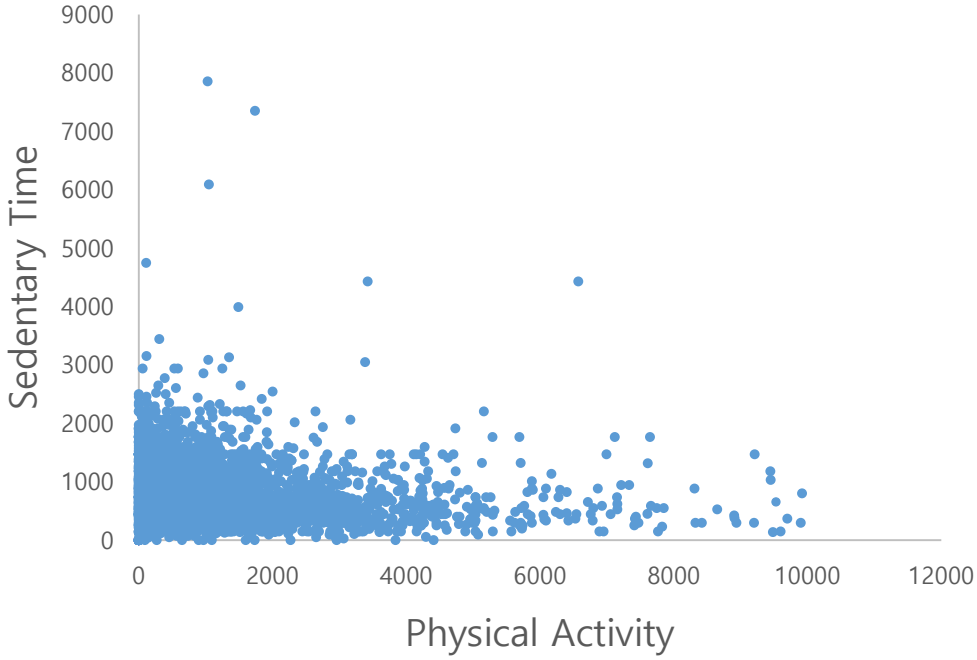

Figure 2. Distribution of Physical Activity and Sedentary Time

2. Total physical activity has effects on some metabolic factors

The total amount of physical activity would increase the level of high-density cholesterol (P = 0.002) and decrease the level of triglyceride (P = 0.016). Also people who exercise more, has less heart rate (P = 0.013). However, sedentary time increases triglyceride (P = 0.001), blood sugar (P = 0.035) and insulin level (P = 0.002) (Table 3).

According to male and female regression analysis, physical activity has more effects on male than female in cholesterol, triglyceride, blood sugar, insulin, body fat level and waist, hip and BMI measurement (Table 4).

Parameter		n	Physical activity (100 MET-minute/week)		Sedentary time (100 MET-minute/week	
			β	P	β	P
Cholesterol	Total (mg/dl)	3482	-0.007	0.794	-0.009	0.809
	HDL (mg/dl)	3482	0.028	0.002**	-0.019	0.117
	LDL (mg/dl)	3472	-0.011	0.640	-0.003	0.903
	Triglyceride (mg/dl)	3462	-0.140	0.016*	0.245	0.001**
Blood Sugar (mg/dl)		3475	0.025	0.053	0.035	0.035*
Insulin (μIU/ml)		3477	-0.004	0.236	0.015	0.002**
Waist Measurement (cm)		3481	-0.003	0.590	0.010	0.252
Hip Measurement (cm)		3478	-0.002	0.593	0.009	0.138
BMI (kg/m^2)		3482	0.0001	0.966	0.001	0.711
Heart Rate (BPM)		3471	-0.020	0.013*	0.016	0.129
Blood pressure	SBP (mmHG)	3474	0.0003	0.975	-0.011	0.479
	DBP (mmHG)	3474	-0.002	0.795	0.004	0.686
FAT	Left Arm (g)	3440	-0.152	0.666	0.339	0.460
	Right Arm (g)	3440	-0.528	0.130	0.576	0.204
	Left Leg (g)	3440	-1.037	0.190	2.021	0.049*
	Right Leg (g)	3440	-1.534	0.060	1.765	0.095
Muscle Mass (kg)		2129	0.002	0.601	-0.010	0.116
Body Fat (kg)		2129	-0.0007	0.898	0.010	0.158

Table 3. Regression Analysis between Physical Activities, Sedentary time and Metabolic Factors

n: number of subjects, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, *P<.05, **P<.005, Adjusted by Age, Sex and level of physical activity

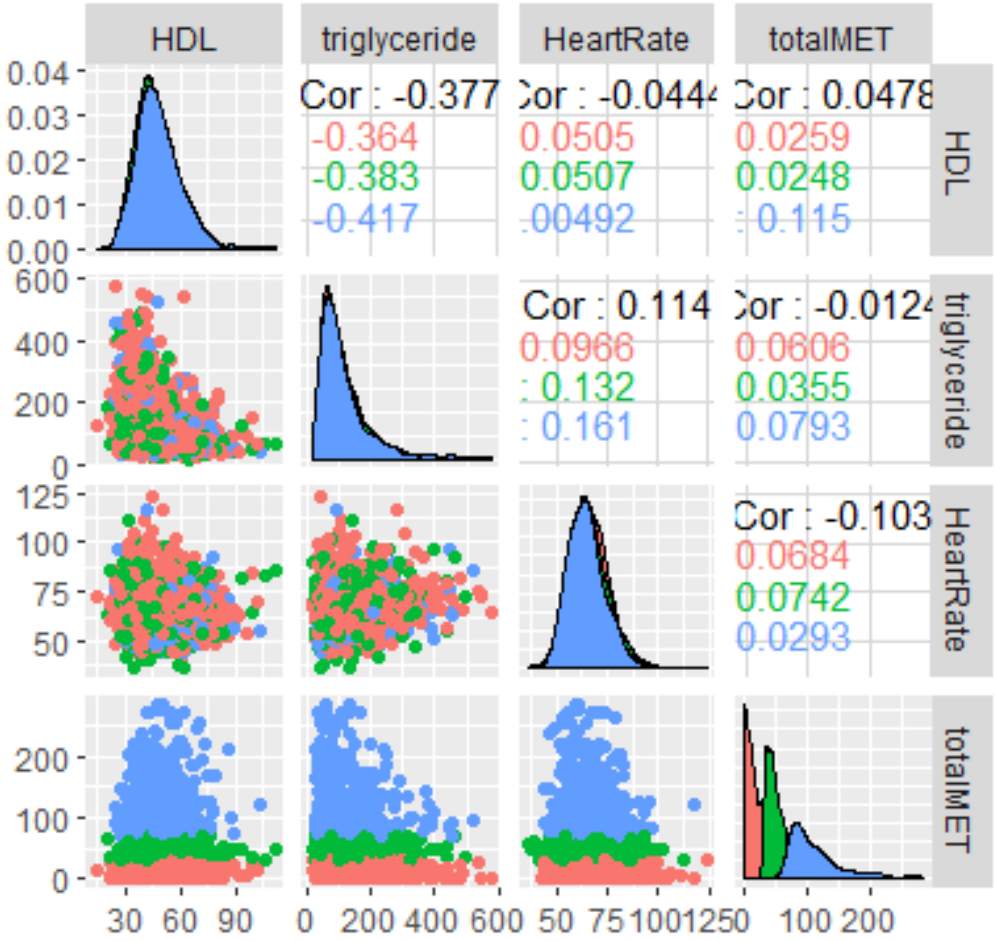

Figure 3. Correlation between physical activity (100 MET minute/week), HDL, TG and Heart Rate

Red for low physical activity group, green for moderate group and blue for vigorous group

Parameter		Physical activity (100 MET-minute/week) of Male			Physical activity (100 MET-minute/week) of Female		
		n	β	P	n	β	P
Cholesterol	Total (mg/dl)	1431	-0.126	0.011*	2051	0.051	0.172
	HDL (mg/dl)	1431	0.042	0.005*	2051	0.022	0.067
	LDL (mg/dl)	1426	-0.104	0.014*	2046	0.033	0.287
	Triglyceri -de (mg/dl)	1419	-0.275	0.016*	2043	-0.076	0.194
Blood Sugar (mg/dl)		1428	0.057	0.020*	2047	0.006	0.648
Insulin (μIU/ml)		1430	-0.013	0.026*	2047	0.0002	0.963
Waist Measurement (cm)		1430	-0.030	0.006*	2051	0.008	0.360
Hip Measurement (cm)		1428	-0.020	0.013*	2050	0.004	0.444
BMI (kg/m^2)		1431	-0.008	0.050*	2051	0.003	0.322
Heart Rate (BPM)		1427	-0.026	0.056	2044	-0.016	0.098
Blood pressure	SBP (mmHG)	1429	-0.016	0.418	2045	0.006	0.671
	DBP (mmHG)	1429	-0.008	0.563	2045	-0.001	0.876
FAT	Left Arm (g)	1412	-0.795	0.140	2028	0.046	0.919
	Right Arm (g)	1412	-1.301	0.018*	2028	-0.221	0.616
	Left Leg (g)	1412	-2.643	0.043*	2028	-0.235	0.811
	Right Leg (g)	1412	-3.506	0.011*	2028	-0.464	0.642
Muscle Mass (kg)		824	0.016	0.117	1305	0.003	0.544
Body Fat (kg)		824	-0.022	0.027*	1305	0.008	0.236

Table 4. Regression Analysis between Physical Activities and Metabolic Factors in Male and Female

n: number of subjects, SBP: Systolic Blood Pressure, DBP: Diastolic Blood Pressure, *P<.05

Adjusted by Age, level of physical activity and sedentary time

3. Moderate and Vigorous Physical Activities have different effects on metabolic factors.

Types of physical activity have different effects on each health factors. The level of HDL is more influenced by moderate than vigorous physical activity. However, waist measurement and heart rate are affected by vigorous physical activity than moderate ones. Both moderate and vigorous activity are associated with fat in arms and legs (Table 5).

4. HDL level is more influenced by environment than gene

The difference level of HDL and TG are associated with difference of total physical activity in monozygotic twins in male (P = 0.002, P = 0.011), and not in dizygotic twins. Also the fat difference of arms is associated with difference of total physical activity in monozygotic twins in male (P = 0.010, P = 0.003), and not in dizygotic twins (Table 6).

Parameter		Physical activity (100 MET-minute/week)			
		Moderate		Vigorous	
		β	P	β	P
Cholesterol	Total	-0.004	0.892	-0.0146	0.685
	HDL	0.022	0.031*	0.0134	0.240
	LDL	0.010	0.707	0.005	0.854
	Triglyceride	0.072	0.248	-0.082	0.234
Waist Measurement		-0.013	0.070	-0.016	0.043*
Hip Measurement		0.007	0.198	0.004	0.415
Heart Rate		-0.010	0.224	-0.019	0.040*
FAT	Left Arm	-0.971	0.011*	-1.532	0.003**
	Right Arm	-0.893	0.017*	-1.127	0.006*
	Left Leg	-1.827	0.032*	-2.208	0.019*
	Right Leg	-1.752	0.046*	-1.896	0.051

Table 5. Regression Analysis between Metabolic Factors and each region of physical Activity (Moderate and Vigorous)

*P<.05, **P<.005. This regression analysis is adjusted by Age, Sex and total physical activity

Parameter		Physical activity difference (100 MET-minute/week) in MZ twins				Physical activity difference (100 MET-minute/week) in DZ twins			
		Male (n=408)		Female (n=702)		Male (n=108)		Female (n=134)	
		β	P	β	P	β	P	β	P
Cholesterol difference	Total	-0.037	0.3538	-0.025	0.553	-0.002	0.975	-0.122	0.324
	HDL	0.036	0.002**	0.012	0.332	0.044	0.135	0.035	0.254
	LDL	-0.024	0.397	-0.036	0.292	-0.071	0.355	0.067	0.510
	Triglyceride	-0.258	0.011*	0.063	0.339	-0.064	0.764	-0.182	0.344
Blood sugar difference		0.005	0.766	0.038	0.024*	0.017	0.603	-0.016	0.730
BMI difference		-0.005	0.068	0.003	0.414	-0.002	0.779	0.001	0.889
FAT difference	Left Arm	-1.191	0.010*	-0.0002	0.999	-2.286	0.209	0.023	0.989
	Right Arm	-3.329	0.003**	0.213	0.821	-3.497	0.456	-1.769	0.583
	Left Leg	-0.450	0.342	-0.175	0.690	-1.748	0.379	-0.397	0.816
	Right Leg	-1.637	0.161	-1.123	0.237	-4.665	0.332	-0.795	0.810

Table 6. Regression Analysis between Physical Activities and Metabolic Factors in Monozygotic twins and Dizygotic twins

MZ twin: Monozygotic twin, DZ twin: Dizygotic twin, *P<.05, **P<.005

Regression analysis between 'difference of MET scores' and 'difference of metabolic data' from each MZ and DZ twins.

IV. Discussions

Through the research, physical activity would increase level of HDL and decrease triglyceride level and heart rate as other research shows (4), (6). This association between physical activity and metabolic factors are clearly revealed in analysis divided by sex. In male group, most metabolic factors are related with physical activity except blood pressure or muscle mass. Other researches revealed that female shows less change in cholesterol level or body fat, and they need larger volume of exercise than male (15), (21). This might have effect on the result of this study. The strict case-control study of low and vigorous physical activity groups might improve the result in female.

Sedentary behavior might have association with some metabolic factors, independent of physical activity. Triglyceride, fasting blood sugar and insulin level might rise when sedentary time increases. To control these factors, spending time in sitting should be reduced, regardless of exercise intensity.

Level of physical activity shows similar results of precedent researches. (13) Moderate and vigorous physical activities both might be relevant to reducing body fat, in comparative analysis between moderate and vigorous group.

However, vigorous exercise should be done to decrease heart rate.

In twin study, effect of gene and environment are analyzed. Change of HDL, triglyceride level and fat from arms might be more influenced by environmental factors then genes. Though, number of subjects are divided because of stratification analysis and population of MZ twins and DZ twins are quite different. These factors might have effects on the result of twin study. For advanced research, long term follow-up study might be required, or strict case control study like controlling the amount of exercise, meal and other physical activity should be needed.

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국문 초록

이 연구는 개인이 얼마나 신체활동(physical activity)을 하는지, 그리고 좌식생활을 얼마나 하는지에 따라 콜레스테롤과 중성지방, 심박수 그리고 체지방량이 어떻게 변하는지를 알아보기 위한 연구이다.

기존연구에서 잘 알려지다시피 운동을 포함한 신체활동은 몸의 에너지 소비량에 큰 영향을 미치고 이는 곧 체지방량이나 콜레스테롤, 혈당 등의 대사물질들과 심박수나 혈압 같은 신진대사들과 연관이 있다. 또한 신체활동 중에서도 어떤 신체활동이 신진대사와 관련이 있는지도 각각 다르다는 것이 알려져 있으며, 성별에 따른 차이도 나는 것으로 알려져 있다.

따라서 이 연구에서는 신체활동과 좌식생활이 신진대사에 전반적으로 어떤 영향을 미치는지 알아보고, 성별에 따른 차이와 운동 강도에 따른 차이를 알아볼 것이다. 또한 쌍둥이 연구를 병행하여 유전자와 환경 중 어떤 영향이 운동과 신진대사간의 연관성에 영향을 더 크게 주는지도 알아 볼 것이다.

운동량과 좌식생활 시간은 International Physical Activity Questionnaire (IPAQ) 설문지를 사용하여 수치화 되었으며 이는 MET-minute/week의 단위로

사용된다.

각각의 다중회귀분석에 따른 결과 신체활동은 고밀도 콜레스테롤의 양을 늘리고 (P=0.002) 중성지질과 (P=0.016) 심박수를 (P=0.013) 낮추는데 영향을 주는 것으로 나타났다. 또한 좌식생활 정도는 운동량과 독립되어 중성지질의 양을 늘리고 (P=0.001) 공복 혈당과 (P=0.035) 인슐린의 양을 (P=0.002) 늘리는 것으로 나타났다.

성별에 따른 차이도 매우 다르게 나타났는데, 남자의 경우 혈압과 근육량을 제외하고는 거의 모든 신진대사 요소들에서 운동량에 따른 차이를 보였다.

쌍둥이 분석의 경우 각각 쌍둥이 간의 운동량 차이를 x축으로 놓고, 신진대사 요소들간의 차이를 y축으로 두고 회귀분석을 진행하였을 때, 일란성 쌍둥이에서는 고밀도 콜레스테롤, 중성지질, 그리고 팔에서의 지방량 차이가 운동량 차이와 연관이 있다고 나왔지만, 이란성 쌍둥이들간의 분석에서는 유의미한 연관성을 찾을 수 없었다.

위 연구결과를 보았을 때, 다른 연구에서와 마찬가지로 운동을 많이 할수록 고밀도 콜레스테롤이 증가하고 중성지방량과 심박수가 감소한다는

것을 알 수 있다. 이런 운동과 신진대사의 관계는 남녀를 나누어 보면 더 극명하게 드러나는데, 남성의 경우 혈압이나 근육량을 제외한 대부분의 신진대사에서 운동과의 연관성을 보였다. 다른 연구에서 콜레스테롤 양이나 체지방량이 여성에서 변화가 더 적으며, 변화를 위해서 남성보다 더 많은 양의 운동을 필요로 한다고 말하는 것으로 보아 이러한 영향이 위의 연구에서도 드러난 것으로 추측된다.

좌식생활도 다른 연구에서와 마찬가지로 운동량과 독립적으로 신진대사에 영향을 주는 것으로 나타났는데, 특히 중성지질, 혈당, 인슐린 양에서 큰 영향을 주는 것으로 예상된다. 위의 요소들을 호전시키기 위해서는 운동 강도뿐만 아니라 앉아있는 시간을 줄일 필요가 있는 것으로 예상된다.

운동 강도에 따른 차이도 다른 연구결과들과 유사한 경향을 보였다. 적당한 운동을 하는 그룹과 활발하게 운동을 하는 그룹을 비교해 보았을 때, 체지방량을 줄이는 데에는 적당한 운동이나 격렬한 운동이 모두 효과적이지만, 심박수를 감소시키기 위해서는 격렬한 운동이 필요한 것으로 보인다.

쌍둥이 연구를 통한 유전자와 환경의 영향을 비교 분석한 결과에서는 고밀도

콜레스테롤, 중성지질, 팔의 지방량은 유전자 보다는 운동과 같은 환경의 영향이 더 큰 것으로 보인다. 하지만 이는 남녀를 나누어 분석하면서 대상의 수가 적어진 대다가 일란성과 이란성 쌍둥이간의 인구수 차이가 결과에 영향을 주었을 가능성이 있다. 따라서 더 명확한 결과를 위해서는 오랜 기간 주적 연구를 진행하거나, 운동이나 식사량, 기타 신체활동을 제한 할 수 있는 환경에서 쌍둥이간의 연구를 진행 할 수 있든 사례조절 연구가 뒷받침 되어야 할 것으로 예상된다.

주요어 : 신체활동, 좌식생활, 신진대사, 고밀도지단백질, 지방, 심박수, 쌍둥이 코호트 사업