

# The Relationship between the Level of Fatness and Fitness during Adolescence and the Risk Factors of Metabolic Disorders in Adulthood

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**Background:** The purpose of the current study was to investigate the association between the level of obesity and physical fitness (PF) during adolescence and the risk factors of metabolic disorders during adulthood.

**Methods:** In the current analysis, 3,993 Korean adults (mean age, 38.70 ± 1.69 years) were recruited. The level of body index (BI) and PF were examined during adolescence through high school record, and their health examination data, including systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting glucose (FG), total cholesterol (TC), and current body mass index (BMI) were obtained from National Health Insurance Corporation Data. Gender-specific analyses were administered to compare health exam data across the level of BI, the level of PF, and a mixed level of BI and PF.

**Results:** Most obese males during high school had statistically higher SBP, DBP, FG, and BMI in adulthood, and most obese females had higher BMI, as compared to most lean males or females. Least fit males during high school had statistically higher BMI in adulthood, and least fit females had statistically higher SBP, DBP, FG, TC, and BMI, as compared to most fit males or females. There was a significant relationship between the mixed level of BI and PF and SBP, DBP, TC and current BMI in both genders.

**Conclusion:** Maintaining a healthy level of body weight and PF during adolescence is recommended to prevent the development of metabolic diseases in adulthood.

**Keywords:** Adolescent; Adulthood; Body index; Body mass index; Metabolic disorder; Physical fitness

## INTRODUCTION

Recently, a worldwide epidemic of obesity in adulthood as well as childhood is progressing at an alarming rate, and consequently, a majority of countries worldwide have made obesity prevention a priority in the area of public health. From the 1960s to 2000s, the number of obese people increased 2.5 times in the US and more than 2 times in Korea. The prevalence of child obesity has also been increasing, similar to adulthood obesity [1-4].

Child or teenage obesity can lead to a development of meta-

bolic disorders, including type 2 diabetes, hyperlipidemia, fatty liver disease, and atherosclerosis. Previous investigations reported that obesity in childhood or adolescence is more likely to have a higher relative risk of metabolic-related disease and cardiovascular disease (CVD), since obese youths show dangerous levels of blood pressure (BP), fasting glucose (FG), triglycerides (TG), total cholesterol (TC), insulin, insulin resistance, inflammatory markers (tumor necrosis factor- $\alpha$ , interleukin-6, high sensitivity C-reactive protein), intima-media thickness, and CVD risk score, as compared to youth with normal body weight [5-9].

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Received: Dec. 28, 2009; Accepted: Mar. 26, 2010

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Furthermore, youth obesity often continues into adult obesity, and can eventually lead to type 2 diabetes, hypertension, CVD, metabolic disorders, and certain cancers [10,11]. Baker et al. [12] determined that the body mass index (BMI) at 7 to 13 years of age was significantly associated with morbidity and mortality of CVD at 25 years of age or older.

Recent studies reported that not only prevention of obesity but also improvement of physical fitness (PF) is important to prevent and treat type 2 diabetes and CVD. Jekal et al. [13] investigated relationship between PF and obesity levels and CVD risk factors using PF test administered at most school in Korea, health exam data, and additional anthropometrics (percent body fat), serum analysis in adolescence. They concluded that there were significant relationships between the level of PF, percent body fat, insulin resistance, TG and metabolic disease risk factors. Longitudinal analysis by Blair et al. [14] reported that decreased level of cardio-respiratory fitness (CRF) yielded increased mortality of CVD as well as all causes.

Latest studies demonstrated that a mixed level of PF and obesity was significantly associated with CVD, type 2 diabetes and metabolic syndrome. Eisenmann et al. [15] examined a mixed effect of cardio-respiratory fitness (CRF) and obesity (CRF X obesity) on risk factors of CVD with 1,615 US adolescents aged 9 to 15 years. Study population was classified into 4 groups by level of CRF and obesity (high fat and low fit; high fat and high fit; low fat and low fit; low fat and high fit), and mean values of CVD risk factors between 4 groups. The result of this study there were significant differences in the values of BP, TG, high density lipoprotein cholesterol (HDL-C) and low density lipoprotein cholesterol (LDL-C) between groups. Jekal et al.

[8] demonstrated that out of obese adolescents, those with higher levels of CRF had decreased CVD risk score compared to counterparts in lower levels of CRF. They also found among normal weight adolescents, those with lower fitness levels had increased CVD risk score compared to those with higher fitness level.

Numerous studies have been administered to determine the relationship between youth obesity and the incidence rate of adult obesity and the prevalence of chronic disease; however there is little evidence to determine a relationship between a mixed level of PF and obesity in adolescence and the level of obesity and risk factors of metabolic disorders in adulthood, especially in the Korean population. The purpose of the current investigation was to examine the relationship between a mixed level of PF and obesity during adolescence and obesity and risk factors of metabolic disorders in adulthood.

## METHODS

### Study population

In the current study, 15,896 young adults who graduated from 1 of the 10 high schools (5 male schools) located in the city of Seoul or Gyeong-Gi Province were recruited. Out of the total population, only 3,993 young adults who had PF test results and a health exam while in the 11th grade, and participated in the primary national health exam during adulthood were included in the analysis. The current study was approved by the Korean Department of Health and Human Services and National Health Insurance Corporation. The characteristics of study population are presented in (Table 1).

**Table 1.** Participants characteristics

	Total (n = 3,993)	Males (n = 3,357)	Females (n = 636)	P value <sup>a</sup>
Age, yr	38.70 ± 1.69	38.66 ± 1.74	38.93 ± 1.39	< 0.0001
Height, cm	170.24 ± 7.51	172.48 ± 5.57	158.45 ± 4.99	< 0.0001
Weight, kg	70.98 ± 11.74	73.81 ± 10.12	56.10 ± 7.82	< 0.0001
BMI, kg/m <sup>2</sup>	24.40 ± 3.14	24.79 ± 3.01	22.35 ± 2.98	< 0.0001
FG, mg/dL	93.82 ± 22.47	94.58 ± 23.43	89.82 ± 15.96	< 0.0001
SBP, mm Hg	120.97 ± 13.66	122.52 ± 13.30	112.82 ± 12.58	< 0.0001
DBP, mm Hg	76.90 ± 10.01	77.95 ± 9.85	71.32 ± 8.95	< 0.0001
TC, mg/dL	196.78 ± 35.08	199.31 ± 35.19	183.42 ± 31.29	< 0.0001

Data presented as the mean ± standard deviation.

BMI, body mass index; FG, fasting glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol.

<sup>a</sup>Comparison between genders.

### Data collection

Data of PF level and obesity during adolescence were evaluated in current study participants. The body index (BI) was considered as the level of obesity during adolescence, and the equation for the calculation is shown below:

$$\text{BI} = \text{body weight}/(\text{height})^3 \times 10000$$

The value of BI calculated was classified into 5 groups (1st-5th), with the 1st group defined as the most lean body weight and the 5th group defined as the most fat body weight.

The PF test during high school utilized the 100 m sprint for agility, 1,600 m long-distance run for cardio-respiratory endurance, sit-ups, chin-ups and push-ups for muscular endurance, the standing jump for muscular strength, and sit-and-reach for flexibility assessment. Each test result was converted to a score, and the individual PF test score was summed. The total PF score was classified into 1 of 6 groups (0-5 fitness grades), with 0 grade defined as the most fit and 5th grade defined as the least fit.

The National Health Insurance Corporation was asked to provide the 1st health examination data, including FG, systolic blood pressure (SBP), diastolic blood pressure (DBP), TC, and current BMI.

### Statistical analysis

SAS 9.1 version program (SAS Institute Inc., Cary, NC, USA) was employed to perform gender-specific analysis. Using one way-ANOVA, the mean values of BMI and risk factors of metabolic disorder in adulthood were compared by the level of obesity (5 groups) and the level of PF (3 groups) in adolescence. Across the mixed level of obesity and PF (high fat and low fit; high fat and high fit; low fat and low fit; low fat and high fit), the mean values of BMI and risk factors of metabolic disorder in adulthood were compared. Logistic Regression analysis was utilized to determine relative risk (95% confidence interval [CI]) of abnormal values for each risk factor and relative risk of being obese ( $\text{BMI} \geq 25 \text{ kg/m}^2$ ) in adulthood across the levels of obesity (5 groups), PF (3 groups) and a levels of obesity and PF combined (4 groups). Statistical significance was set at  $P < 0.05$ .

## RESULTS

Table 2 shows the distribution of BI and PF, the correlation be-

tween the level of obesity and the level of PF while in high school and the Pearson correlation  $r$  value of 0.088 ( $P < 0.001$ )

Table 3 shows the effects of fatness levels during adolescence on metabolic disease risk factors during adulthood. In males, there were significant differences in the value of FG, SBP, DBP, and BMI in adulthood across the level of BI in adolescence. Males in the most fat group had higher values of FG and BMI than those in the other 4 groups, and males in the most fat group had higher values of SBP and DBP than those in the 1st to 3rd groups.

Among females, there was a significant difference in adulthood BMI across BI levels during adolescent. However, there was no relationship between the level of obesity while in high school and the value of FG, SBP, DBP, and TC in adulthood.

Table 4 presents the relative risks of the abnormality in BP (SBP  $\geq 130$  mm Hg or DBP  $\geq 85$  mm Hg), FG ( $\geq 100$  mg/dL), TC ( $\geq 200$  mg/dL), and BMI ( $\geq 25$  kg/m<sup>2</sup>) in adulthood. Males in the most fat group were more likely to have an abnormal value in FG (2.3 times), BP (1.9 times), TC (1.4 times), and BMI (19.0 times) in adulthood, as compared to males in the most lean group. Female in the most fat group were 18.7 times more likely to have abnormal values in BMI in adulthood, as compared to females in the most least group; however, there were no significant results in FG, BP, or TC.

Table 5 reports the results of the comparison of the mean values of metabolic disease risk factors and BMI in adolescence across the PF levels in adulthood. Males in the lowest level of PF during high school had higher BMI in adulthood than counter-

**Table 2.** Prevalence of the level of obesity and physical fitness at adolescence

Total (n = 3,993)	
Body index, %	
1st	8.58
2nd	21.27
3rd	50.69
4th	11.15
5th	8.31
Physical fitness, %	
1st	6.66
2nd	20.87
3rd	32.69
4th	26.60
5th	9.84
6th	3.33
Body index and Physical fitness	Pearson $r = 0.088$ $P < 0.001$

**Table 3.** Metabolic parameters in adulthood across the level of body index during adolescence

	1st group	2nd group	3rd group	4th group	5th group	P value
<b>Males</b>						
No.	288	743	1,722	339	245	
FG, mg/dL	94.28 ± 22.04	93.25 ± 16.56	94.25 ± 22.58	94.44 ± 19.82	101.79 ± 44.02 <sup>a,b,c,d</sup>	< <b>0.0001</b>
SBP, mm Hg	121.87 ± 13.46	121.15 ± 12.83	122.25 ± 12.91 <sup>b</sup>	124.88 ± 14.44 <sup>a,b</sup>	126.09 ± 14.86 <sup>a,b,c</sup>	< <b>0.0001</b>
DBP, mm Hg	76.82 ± 9.43	76.75 ± 9.73	78.04 ± 9.67	79.17 ± 9.90 <sup>a,b,c</sup>	80.84 ± 11.19 <sup>a,b,c</sup>	< <b>0.0001</b>
TC, mg/dL	200.30 ± 36.43	197.27 ± 32.11	199.51 ± 35.92	198.96 ± 35.39	202.67 ± 37.20	0.2830
BMI, kg/m <sup>2</sup>	22.74 ± 2.62	23.35 ± 2.55 <sup>a</sup>	24.91 ± 2.62 <sup>a,b</sup>	26.84 ± 2.81 <sup>a,b,c</sup>	27.94 ± 3.14 <sup>a,b,c,d</sup>	< <b>0.0001</b>
<b>Females</b>						
No.	53	102	292	104	85	
FG, mg/dL	89.30 ± 12.57	88.08 ± 11.10	90.26 ± 13.06	87.43 ± 11.01	93.64 ± 30.23	0.0692
SBP, mm Hg	111.49 ± 11.92	114.15 ± 12.95	112.16 ± 11.84	111.83 ± 12.65	115.55 ± 14.55	0.1262
DBP, mm Hg	70.49 ± 7.46	71.85 ± 9.78	70.97 ± 8.31	70.79 ± 8.77	73.01 ± 10.86	0.3243
TC, mg/dL	186.58 ± 28.03	179.16 ± 29.11	184.78 ± 30.82	181.63 ± 31.31	184.06 ± 36.93	0.5001
BMI, kg/m <sup>2</sup>	19.81 ± 2.24	20.82 ± 2.01	22.41 ± 2.78 <sup>a,b</sup>	23.19 ± 2.75 <sup>a,b</sup>	24.53 ± 3.23 <sup>a,b,c,d</sup>	< <b>0.0001</b>

Data presented as the mean ± standard deviation.

1st group, most lean; 5th group, most fat.

FG, fasting glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index.

<sup>a</sup>Significantly different from 1st group, <sup>b</sup>Significantly different from 2nd group, <sup>c</sup>Significantly different from 3rd group, <sup>d</sup>Significantly different from 4th group.

**Table 4.** Relative risk for the high level of blood pressure, glucose, total cholesterol and being obese in adulthood across the level of body index during adolescence

	1st group	2nd group	3rd group	4th group	5th group
<b>Males</b>					
No.	288	743	1,722	339	245
FG (≥ 110)	1.00	1.01 (0.62 to 1.63)	1.04 (0.67 to 1.62)	1.29 (0.76 to 2.17)	<b>2.26 (1.35 to 3.79)</b>
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	0.94 (0.70 to 1.26)	1.14 (0.87 to 1.49)	<b>1.56 (1.28 to 2.15)</b>	<b>1.91 (1.35 to 2.70)</b>
TC (≥ 200)	1.00	<b>1.38 (1.04 to 1.84)</b>	<b>1.39 (1.07 to 1.81)</b>	1.32 (0.96 to 1.82)	<b>1.44 (1.02 to 2.02)</b>
BMI (≥ 25)	1.00	1.16 (0.83 to 1.61)	<b>2.95 (2.19 to 3.99)</b>	<b>8.96 (6.23 to 12.88)</b>	<b>18.96 (12.25 to 29.36)</b>
<b>Females</b>					
No.	53	102	292	104	85
FG (≥ 110)	1.00	0.95 (0.23 to 3.93)	1.26 (0.36 to 4.41)	0.38 (0.06 to 2.34)	1.98 (0.50 to 7.85)
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	0.76 (0.31 to 1.86)	0.71 (0.32 to 1.57)	0.90 (0.36 to 2.24)	1.76 (0.73 to 4.26)
TC (≥ 200)	1.00	0.86 (0.43 to 1.74)	0.80 (0.43 to 1.50)	1.07 (0.52 to 2.20)	1.30 (0.62 to 2.71)
BMI (≥ 25)	1.00	2.22 (0.46 to 10.65)	<b>4.78 (1.12 to 20.31)</b>	<b>12.58 (2.87 to 55.16)</b>	<b>18.65 (4.23 to 82.35)</b>

Data presented as the relative risk (95% confidence interval).

1st group, most lean; 5th group, most fat.

FG, fasting glucose BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index.

parts in the other 2 groups (most fit and moderately fit). In addition, females in the least fit during adolescence had higher FG and TC in adulthood than counterparts in the most fit and moderately fit participants and had higher SBP and BMI in adulthood than the most fit participants.

Table 6 presents the results of the comparison of the relative risks of abnormal values in the adulthood risk factors according to the level PF while in high school. Males in the lowest fit

group during adolescence were 1.3 times more likely to be obese in adulthood, as compared to counterparts in the most fit group; however, there were no significant results for FG, BP, and TC. Females in the least fit level were more likely to have abnormal values in the FG (3.1 times) and BMI (2.4 times) in adulthood, as compared to females in the most fit level group, however, there were no differences in BP and TC.

Table 7 shows comparisons of the value of metabolic disorder

**Table 5.** Metabolic parameters in adulthood across the level of physical fitness during adolescence

	1st group	2nd group	3rd group	P value
<b>Males</b>				
No.	883	1,972	471	
FG, mg/dL	94.04 ± 22.77	95.11 ± 23.80	93.18 ± 22.01	0.2021
SBP, mm Hg	122.34 ± 12.98	122.41 ± 13.13	123.34 ± 14.66	0.3486
DBP, mm Hg	77.84 ± 9.51	77.79 ± 9.88	78.84 ± 10.28	0.1060
TC, mg/dL	199.84 ± 36.11	198.93 ± 34.55	199.33 ± 35.85	0.8140
BMI, kg/m <sup>2</sup>	24.92 ± 2.81	24.60 ± 2.94 <sup>a</sup>	25.36 ± 3.57 <sup>a,b</sup>	< <b>0.0001</b>
<b>Females</b>				
No.	208	377	51	
FG, mg/dL	88.52 ± 11.60	89.38 ± 12.72	98.37 ± 37.12 <sup>a,b</sup>	<b>0.0003</b>
SBP, mm Hg	110.64 ± 11.68	113.66 ± 12.75 <sup>a</sup>	115.49 ± 13.81 <sup>a</sup>	<b>0.0059</b>
DBP, mm Hg	69.85 ± 8.45	71.92 ± 8.93 <sup>a</sup>	72.88 ± 10.35	<b>0.0117</b>
TC, mg/dL	181.32 ± 30.81	182.97 ± 31.03	195.29 ± 33.13 <sup>a,b</sup>	<b>0.0150</b>
BMI, kg/m <sup>2</sup>	21.83 ± 2.91	22.49 ± 2.89 <sup>a</sup>	23.38 ± 3.53 <sup>a</sup>	<b>0.0012</b>

Data presented as the mean ± standard deviation.

1st group, most fit; 3rd group, least fit.

FG, fasting glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index.

<sup>a</sup>Significantly different from 1st group, <sup>b</sup>Significantly different from 2nd group.

**Table 6.** Relative risk for the high level of blood pressure, glucose, total cholesterol and being obese in adulthood across the level of physical fitness during adolescence

	1st group	2nd group	3rd group
<b>Males</b>			
No.	883	1,972	471
FG (≥ 110)	1.00	1.02 (0.78 to 1.32)	0.76 (0.51 to 1.12)
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	1.03 (0.87 to 1.21)	1.15 (0.92 to 1.45)
TC (≥ 200)	1.00	0.93 (0.80 to 1.10)	0.91 (0.73 to 1.14)
BMI (≥ 25)	1.00	0.87 (0.74 to 1.02)	<b>1.30 (1.04 to 1.63)</b>
<b>Females</b>			
No.	208	377	51
FG (≥ 110)	1.00	1.69 (0.74 to 3.89)	<b>3.11 (1.00 to 9.65)</b>
BP (SBP ≥ 130 or DBP ≥ 85)	1.00	1.52 (0.89 to 2.58)	2.09 (0.92 to 4.72)
TC (≥ 200)	1.00	1.01 (0.69 to 1.49)	1.46 (0.76 to 2.83)
BMI (≥ 25)	1.00	1.27 (0.79 to 2.05)	<b>2.36 (1.15 to 4.86)</b>

Data presented as the relative risk (95% confidence interval).

1st group, most fit; 3rd group, least fit.

FG, fasting glucose; BP, blood pressure; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index.

der risk factors and BMI in adulthood across the combined levels of obesity and PF (high fat and low fit; high fat and high fit; low fat and low fit; low fat and high fit) in adolescence. Males in the high fat and low fit group had higher values of SBP than males in the low fat and high fit or low fat and low fit group. In addition, males in the high fat and low fit or high fat

and high fit groups had higher DBP values than males in the low fat and high fit or low fat and low fit group. Males in the high fat and low fit group had higher BMI than those in the other 3 groups, and males in the high fat and high fit group had higher BMI than those in the low fat and high fit or low fat and low fit group. However, there were no significant differences in the value of FG and TC in adulthood across the mixed level of obesity and PF in adolescence.

Females in the high fat and low fit or high fat and high fit group during adolescence had higher BMI in adulthood than females in the low fat and high fit or low fat and low fit group; however, there were no significant differences in the values of FG, SBP, DBP, and TC across the mixed level of obesity and PF.

Fig. 1 shows the relative risks of abnormality in adulthood risk factors across a mixed level of obesity and PF in adolescence. Males in the high fat and low fit group while in high school were more likely to have an abnormal value of BP (1.6 times; 95% CI, 1.24 to 1.98) and BMI (4.1 times; 95% CI, 3.18 to 5.18) in adulthood, as compared to those in the low fat and high fit group, and male in the high fat and high fit group were more likely to have an abnormal value of BP (1.3 times; 95% CI, 1.08 to 1.54), TC (1.2 times; 95% CI, 1.02 to 1.44) and BMI (3.8 times; 95% CI, 3.13 to 4.57) in adulthood, as compared to males in the low fat and high fit group.

Females in the high fat and low fit group during adolescence were more likely to have an abnormal value of BP (2.0 times;

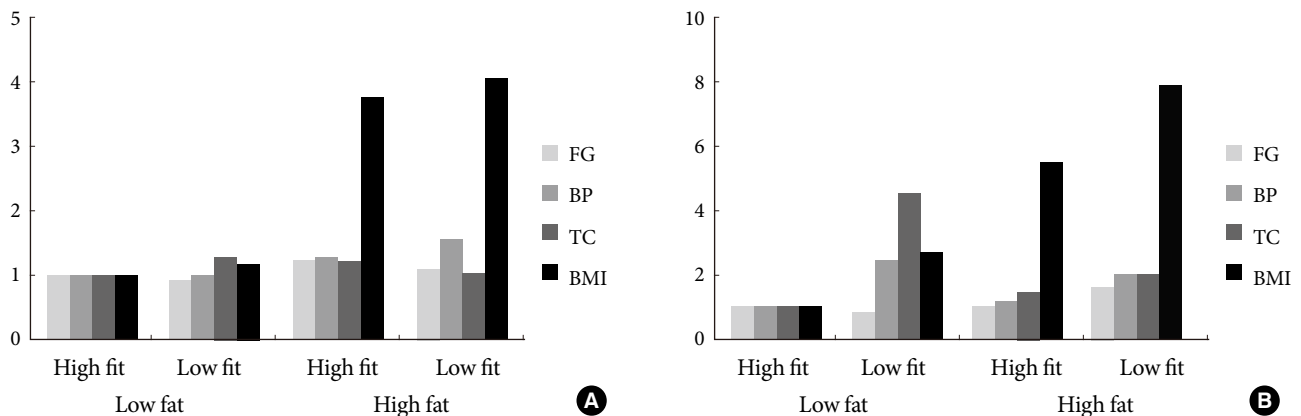
**Table 7.** Metabolic parameters in adulthood across the level of mixed physical fitness and body index during adolescence

	Low fat		High fat		P value
	High fit	Low fit	High fit	Low fit	
<b>Males</b>					
No.	572	453	1,361	935	
FG, mg/dL	94.43 ± 21.41	92.46 ± 13.26	94.81 ± 23.64	95.28 ± 27.36	0.1906
SBP, mm Hg	121.29 ± 13.03	121.38 ± 13.05	122.82 ± 13.09	123.38 ± 13.89 <sup>ab</sup>	<b>0.0052</b>
DBP, mm Hg	76.85 ± 9.73	76.69 ± 9.57	78.39 ± 9.59 <sup>ab</sup>	78.63 ± 10.31 <sup>ab</sup>	<b>&lt; 0.0001</b>
TC, mg/dL	198.66 ± 33.36	197.40 ± 33.61	199.56 ± 34.98	200.01 ± 37.13	0.5818
BMI, kg/m <sup>2</sup>	23.32 ± 2.62	23.00 ± 2.55	25.37 ± 2.74 <sup>ab</sup>	25.72 ± 3.13 <sup>ab,c</sup>	<b>&lt; 0.0001</b>
<b>Females</b>					
No.	113	42	336	145	
FG, mg/dL	87.72 ± 10.43	90.60 ± 14.21	89.40 ± 13.00	92.21 ± 24.05	0.1362
SBP, mm Hg	112.81 ± 12.05	114.38 ± 14.18	112.24 ± 12.53	113.74 ± 12.68	0.5441
DBP, mm Hg	71.52 ± 8.77	71.02 ± 9.88	70.67 ± 8.98	72.74 ± 8.66	0.1373
TC, mg/dL	180.85 ± 29.46	183.98 ± 27.45	182.28 ± 30.67	187.89 ± 34.80	0.2426
BMI, kg/m <sup>2</sup>	20.36 ± 2.18	20.76 ± 2.02	22.80 ± 2.88 <sup>ab</sup>	23.29 ± 3.11 <sup>ab</sup>	<b>&lt; 0.0001</b>

Data presented as the mean ± standard deviation.

FG, fasting glucose; SBP, systolic blood pressure; DBP, diastolic blood pressure; TC, total cholesterol; BMI, body mass index.

<sup>a</sup>Significantly different from low fat and high fit, <sup>b</sup>Significantly different from low fat and low fit, <sup>c</sup>Significantly different from high fat and high fit.



**Fig. 1.** Relative risk for the high level of risk factors of metabolic disorder in adulthood across the level of mixed physical fitness and body index during adolescence. (A) Males, (B) Females. FG ( $\geq 110$  mg/dL), fasting glucose; BP (SBP  $\geq 130$  mm Hg or DBP  $\geq 85$  mm Hg), blood pressure; TC ( $\geq 200$  mg/dL), total cholesterol; BMI ( $\geq 25$ ), body mass index.

95% CI, 1.01 to 4.05), TC (2.0 times; 95% CI, 1.15 to 3.50) and BMI (7.9 times; 95% CI, 3.20 to 19.37), and females in the high fat and high fit group during high school were more likely to be obese (5.5 times; 95% CI, 2.32 to 12.97), and those in the low fat and low fit group were more likely to have an abnormal value of BP (2.5 times; 95% CI, 1.01 to 6.12) and TC (4.6 times; 95% CI, 2.18 to 9.53), as compared to females in the low fat and high fit group in adolescence.

## DISCUSSION

Over the last decades, the obese population in the world has been increasing dramatically. The US obese population had increased more than 2.5 times from 12.8% in the early 1960s to 32.2% in the early 2000s [1,2]. Interestingly, in 2003-2004, the prevalence of overweight or obese (BMI  $\geq 25$  kg/m<sup>2</sup>) among African American female adults was 81.6% [1,2]. As in the US, the prevalence of Korean obesity has dramatically increased,

and the National Health and Nutrition Survey reported that the number of obese people had increased more than 2 times from 13.9% in 1995 to 30.6% in 2001 [3].

Furthermore, the child and adolescent obesity has also progressively increased. In the US, the prevalence of children and adolescents at risk of being overweight or obese increased from 13.9% in 1999-2000 to 17.1% in 2003-2004, and in Korea, the prevalence of adolescents at risk of being overweight or obese increased from 12.0% in 1997 to 19.0% in 2005 [1,4].

The current study identified the relationship between the level of obesity and fitness during adolescence and the risk factors of metabolic disorders and the level of BMI in 40s adulthood. This study suggests a strong relationship between the level of obesity while in high school and the level of obesity in adulthood. In both genders, a higher level of BI in adolescence was associated with a higher level of BMI in adulthood. In males, BMI among study participants in the 2nd or 3rd levels of BI (the leaner level group) while in high school was 23 to 25 kg/m<sup>2</sup>, but BMI among those in the 4th or 5th levels (the higher fat levels) of BI while in high school was 25 kg/m<sup>2</sup> or higher. The prevalence in females was similar to males, and females in the 4th or 5th level were overweight or obese in adulthood. The results of previous studies were in agreement with the current finding in the association between the level of youth obesity and the level of adult obesity. Freedman et al. [16] determined the correlation coefficient between the obesity level in childhood or adolescence and the obesity level in adulthood was 0.64 in males, and 0.58 in females.

In a previous study comparing the obesity level during childhood, the level while in high school (similar to current participants) was significantly correlated with the level at adulthood. The study examined the association between the obesity level at 7, 11, and 16 years of age, and the obesity level at 33 years or age, (young adulthood) [17]. The study identified that 79.6% of males and 70.5% of females among people who were overweight (upper 95th percentile) at 7 years of age remained overweight or obese at 33 years of age, while 93.1% of males and 89.2% of females among people who were overweight or obese at 16 years of age became overweight or obese at 33 years old. Furthermore, Guo et al. [18] demonstrated that people who were overweight or obese while in elementary school were 4.6 to 7.9 times more likely to become overweight or obese in adulthood, whereas people who were overweight or obese while in high school were 57.8 times more likely to become overweight or obese in adulthood.

There were significant associations between the level of adolescent obesity and the level of FG, BP, and TC. Freedman et al. [16] showed that, compared to people who were normal or lean in childhood, people who were overweight or obese were more likely to have higher values of TC, TG, LDL-C, SBP and DBP, and a lower value of HDL-C. Wright et al. [19] also found that the level of obesity at 9 years of age was significantly associated with the level of fat or glucose metabolism in adulthood.

The associations between the level of youth obesity and the level of adulthood risk factors of metabolic disease were observed as different according to gender; a significant association existed in males but not in females. In the present study and other studies, since the probability of being obese from adolescence to adulthood was relatively higher in males compared to females, the probability of abnormal values in adulthood risk factors of metabolic disease was increased in males [17,18]. In addition, at 40 years of age, the prevalence of obesity was relatively higher in males and; therefore, adulthood obesity independently and directly influences the abnormality of metabolic disorder risk factors. In conclusion, due to the significant probability of obesity in childhood continuing into adulthood, the higher prevalence of adulthood obesity in males, and the prevalence of obesity and the mean values of FG, BP, and TC being significantly higher in males, as shown in (Table 1), maintaining a healthy body weight in childhood, as well as in adolescence, is important, especially among males.

The current study identified that PF promotion also plays a significant role in preventing obesity and abnormality in risk factors of metabolic disorders in adulthood, as well. The increased level of PF while in high school was associated with the decreased level of BMI in adulthood in both genders. In particular, people in the 4th or 5th group of PF level had a mean BMI value of 25 or higher (obese) in males and 23 or higher (overweight) in females in adulthood. There was no statistically significant association in males, but the decreased level of PF in adolescence was significantly associated with abnormal values of FG, BP, and TC. Kvaavik et al. [20] in the Oslo Youth Study, found that the level of PF at 13 years of age was negatively related to the level of obesity in the 40s, and Carnethon et al. [21] in the longitudinal investigation with PF and chronic disease, determined that those in the low range of PF were more likely to be diagnosed with hypertension (2.2 times), type 2 diabetes (1.8 times) and metabolic syndrome (1.9 times), as compared to people in the high level of PF. The

findings established that not only maintaining healthy body weight but also increasing PF levels while in school is recommended to prevent obesity and metabolic disorders in adulthood. For females, high school is often the last opportunity to participate in physical activity and promote PF, while most males are able to go into the mandatory military service and have another opportunity to increase PF levels. The current finding reported that a more significant association between the level of high school PF and the level of obesity and risk factors in adulthood existed among females, as compared to males, and this finding supports our recommendation to increase PF levels during childhood and adolescence, especially for females.

Additional investigation demonstrated an association between the level of PF while in high school and height in adulthood. The mean value of adulthood height in males was 173.2 cm and 159.4 cm in females for people in the 1st level of PF, 172.4 cm in males and 158.1 cm in females for people in the 2nd to 3rd level of PF, and 171.7 cm in males and 157.1 cm in females for people in the 4th to 5th level of PF. The increased level of PF in adolescence was significantly related to the increased value of adulthood height (respectively,  $P < 0.001$ ,  $P = 0.001$ ). Currently, many Koreans are interested in physical development programs or growth exercise programs to increase height in adulthood, and the findings from the present study suggest a positive correlation for healthy physical growth and development by increasing PF level.

In analysis of the mixed effect of obesity and PF in adolescence on the level of obesity in adulthood, the level of adolescence obesity is a significant predictor of adulthood obesity other than PF level in adolescence. People in both genders in the high fat group while in high school were more likely to be obese (males 4.1 times; females 7.9 times), irrespective of the PF level while in high school, as compared to those in the lean group. Other analysis in the current study demonstrated that the level of obesity, as well as the level of PF while in high school, was independently associated with the level of obesity in adulthood. However, the comparison between the 2 predictors identified that the obesity level is a more important predictor of the adulthood obesity level, independent of the fitness level. The current finding is not similar to a previous study by Lee et al. [22]. In Lee's study, people in the low fat and low fit group were more likely to increase mortality rate by CVD or all-causes, as compared to those in the high fat and high fit group. Lee's and the current study examined the long-term as-

sociation between the mixed level of obesity and PF and mortality or risk factors related to metabolic disease. However, Lee analyzed only CRF as the PF, and the current analysis examined total fitness score, including cardio-respiratory, muscular strength, endurance and flexibility. Additionally, Lee utilized percent body fat, and the current study used the BI from 1980 to 1990 in Korea. Similar to the current finding, Jekal et al. [8] in the cross-sectional study investigating the association of the obesity level and PF into the CVD risk score calculated with BP, insulin resistance, HDL-C, waist circumference and TG among high school students, identified that independent of the level of PF, an increased BMI was significantly associated with an increased CVD risk score.

There were gender-differences in the findings, and in females, there was a greater association between the PF level in adolescence and risk factors in adulthood. In both genders there was no significant association with FG, however, there were significant associations between BP and TC in adulthood, and the obesity level while in high school for males and significant associations between BP and TC and the PF level while in high school for females. The different gender findings were due to the long-term opportunity while in their early 20s for males only to improve their PF through military service.

Due to the low participation rate of the national health examination, only 25% (almost 4,000 people) among the total population (almost 16,000 people) data were included in the final analysis. The limitation of the current study was using total PF scores kept for high school graduates other than individual values of the PF test such as 100 m sprint, sit-ups or 1,600 m long-distance run, and BI kept for high school graduates other than BMI. Other limitations of the current study were the absence of health behavior data, such as smoking, drinking and socio-economic status data in adulthood, which could be a mediator of adulthood health status [23]. In addition, the current study was not an actual longitudinal investigation.

However, the current study was the first investigation examining the association between the level of obesity and PF in adolescence and the obesity level and risk factors in adulthood (40-year age group) in the Korean population. The current investigation suggests that maintaining a healthy body weight, as well as increasing PF levels during school, play significant roles in preventing obesity or abnormalities in metabolic disease risk factors in adulthood in Korea.



## ACKNOWLEDGEMENT

This study was supported by the National Research Foundation of Korea Postdoctoral fellowship Grant funded by the Korean Government (NRF-2009-351-G00138), Korea Science and Engineering Foundation (KOSEF) grant funded by the Korean government (MOST) (No. 2009-0073910), and the Seoul City R & BD program (grant no. 10526).

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