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Comparison of Metabolic Syndrome Risk Factors across the Level of Fatness and Fitness in Elementary School Students

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Abstract

The objective of this paper was to analyze the risk of metabolic syndrome by level of fatness and fitness in elementary school students.We used that anthropometric measurements were investigated thephysical measurement (height, weight, waist circumference and body composition of the participants), blood pressure, blood test and fitness test (muscle strength, muscle endurance, flexibility and cardiovascular fitness). Statistical Package for the Social Sciences was used for all statistical analysis.First, non-obese boys were significantly higher in all fitness levels compared to obese students. Non-obese girls showed significantly higher scores in all fitness levels in comparison with obese girls, except BS. Second, non-obese boys were significantly lower in SBP, DBP, RHR, glucose, TC, insulin, HOMA-IR, AST, and ALT levels compared with obese students, and significantly higher in HDC-C levels. Non-obese girls showed significantly lower SBP, DBP, RHR, glucose, TC, insulin, HOMA-IR, and ALT levels than their obese counterparts, and had a significantly higher HDL-C level. Third, there was a significant difference in all MS risk factors between the groups except RHR and AST. Fourth, students with high-fatness and low-fitness had a significantly higher risk of MS (51.12 times) than those who had low-fatness and high-fitness. Fifth, low-fitness students had a significantly higher MS risk (5.86 times) by comparison with high-fitness students.Therefore, we suggest that students undergo systematic management to prevent disease and improve fitness.

Keywords: Elementary School Students; Health; Fatness; Fitness; Metabolic Syndrome.

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Introduction

Recently, an increasing number of children and adolescents have been observed to have a poor lifestyle as well as many health problems, including cardiovascular disease (CVD), metabolic, and psychological. These health problems in children and adolescents are contributed to obesity as well as physical inactivity and poorfitness(HallalP C *et al.*, 2006). In accordance with the Centers for Disease Control and Prevention (CDC), obese childhood has increased about threefold since 1980, and about 17% of all children aged 2-19 years have been classified as obese.The obesity prevalence of children aged 6-11 years was reported to be 17.5% in 2015 in the United States(Ogden C L *et al.*, 2015). In Korea, the obese prevalence of childhood based on body mass index (BMI) increased from 19.8 % in 2011 to 21.1 % in 2015. In the last five years, the prevalence of obesity was highest among elementary school students in 17 cities and provinces in Jeju. Results of the survey indicated that the prevalence of obesity in Jejuwas 22.98%, which was 8.45% higher than the national average of 14.53%; Jeju emerged, as the only region exceeding 20% in terms of obesity among elementary school students (Korean Educational Development Institute,2016).

In addition to the increasing obesity prevalence, the lack of physical activity (PA)is a problem that goes hand in hand with decreasing fitness in children and adolescents. Overweight and obese children and adolescents tend to lower levels of PA and fitness. Despite such evidence, PA levels remain low, andthe lack of PAand fitnessalso leads to increased morbidity in adulthood, relating to various diseases, in childhood (Durstine J L *et al.*, 2013).

Habitual PA and fitnessare needed for positive health outcomes in childhood and adulthood, such as maintaining a regular body weight. PA and fitness contribute to reducing not only obesity, but also CVD risk factors, inflammation, and neuronal functionas well as cardiovascular morbidity. According to reports, fitness can decrease the risk of metabolic syndrome (MS) in insulin resistance and obesity, andincreasingfitness can prevent and/or help the risk of MS by promoting enhanced cardiovascular function and muscular endurance (Roberts C K *et al.*, 2013). Also, after adjustment for gender and age, fitness was involved with reduced odds of MS and especially, compared with PA, fitness showed strong effects in controlling risk factors of CVD(Sassen B *et al.*, 2009).Hence, fitnessof childhood can act a pivotal role on the risk of MS, CVD, and diabetes (type 2), which can affect the high risk of obesity and MS in adulthood. Therefore, children, regardless of their weight, need to increase their PA and fitness.

Despite the steady increase in obesity prevalence among elementary students, the causes of the increase remain poorly understood. Thus, the purpose of this paper was to analyze the risk

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of MS according to level of fatness andfitness in elementary school students.

Materials and Methods

1. Subjects

The subjects of this paper were conducted 378 students (202 male and 176 female) who were in the fourth to fifth grade students (aged 10~11 years) of elementary school. The participants' characteristics are as in [Table 1].This paper was performed under the deliberation of the Medical Research Ethics Review Board of Jeju National University Hospital (JEJUNUH-IRB-2015-10-003). After the end of the study, raw data for academic research were provided from the Jeju Public Health Center (Jeju Public Health Center-53130: 2017.12.07.), a research management institution, and was approved by deliberation exemption of the Jeju National University Institutional Review Board for secondary data analysis.

Table 1: Participants Characteristics

Variables	Boys (n=202)	Girls (n=176)	Total (n=378)
Grade (%)			
4th	101 (50)	90 (51.1)	191 (50.5)
5th	101 (50)	86 (48.9)	187 (49.5)
Age (yrs)	10.61±0.61	10.48±0.51	10.55±0.58
Height (kg)	145.13±6.89	145.45±7.39	145.28±7.12
Weight (kg)	46.24±12.74	43.40±11.45	44.92±12.22
Body Mass Index (kg/m^2)	21.67±4.52	20.27±3.97	21.02±4.32
Sexual maturity (%)			
- yes	3 (1.5)	33 (19.1)	36 (9.52)

Mean±Standard Deviation

2.Study Tools

Anthropometric measurements were investigated thephysical measurement (height, weight, waist circumference and body composition of the participants), blood pressure (BP), blood test and fitness test (muscle strength, muscle endurance, flexibility and cardiovascular fitness).The criteria for MS were based on the Pediatric Adolescent Standards specified the International Diabetes Federation (IDF) in 2007 (Zimmet P *et al.*, 2007).The evaluation criteria of fitness tests were based on the Physical Activity Promotion System (PAPS) implemented by the Ministry of Education (Ministry of Education, 2009). Statistical Package for the Social Sciences (SPSS version 18.0 for Windows SPSS Inc., Chicago, IL, USA) was used for all statistical analysis. The significance level for the hypothesis test was set at $\alpha = .05$. Independent samples

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t-test and Oneway Analysis of Variance (ANOVA) and Logistic regression was used.

Results and Discussion

The purpose of this paper was to analyze the risk of MS according to fitness level and fatness in elementary school students.

As shown in [Table 2], non-obese boys were significantly higher in all fitness levels compared with obese students. Non-obese girls showed significantly higher scores in all fitness levels compared to obese girls, except BS.

Table 2: Comparison of Fitness Level by Body Mass Index in Normal and Obese Students

Variable	Boys		*p*	Girls		*p*
	Normal (n=145)	Obese (n=57)		Normal (n=130)	Obese (n=46)	
LGS (kg)	16.98±4.02	20.81±5.39	**<.001**	16.84±434	18.77±5.33	**.030**
RGS (kg)	18.08±4.09	22.11±5.40	**<.001**	18.18±4.74	21.30±5.56	**<.001**
GS/Wt (%)	00.45±00.10	00.35±00.08	**<.001**	00.48±00.11	00.37±00.09	**<.001**
BS (kg)	45.87±11.75	54.15±11.74	**<.001**	40.96±10.15	41.34±10.74	.833
BS/Wt (%)	1.18±00.34	00.89±00.21	**<.001**	1.09±00.28	00.73±00.21	**<.001**
SR (cm)	6.06±6.46	2.73±6.05	**.001**	9.96±7.23	7.25±9.12	**.043**
SU (num/min)	33.33±11.47	23.02±7.94	**<.001**	24.62±11.28	19.22±9.93	**.005**
PACER (num)	67.70±30.44	35.81±19.50	**<.001**	54.75±23.43	34.57±17.63	**<.001**
TFS (RGS)	00.62±2.38	-1.04±1.95	**<.001**	-00.00±2.28	-00.90±2.28	**.024**
TFS (BS)	00.93±2.42	-00.85±1.84	**<.001**	-00.13±2.33	-1.63±2.17	**<.001**

Mean±Standard Deviation
by BMI standard ≥ 95th percentile
LGS: left grip strength, RGS: right grip strength, GS/Wt: grip strength/weight,BS: back strength, BS/Wt: back strength/weight, SR: sit and reach, SU: sit-up,PACER: progressive aerobic cardiovascular endurance run, TFS: total fitness score.

As shown in [Table 3], non-obese boys were significantly lower in SBP, DBP, RHR, glucose, TC, insulin, HOMA-IR, AST, and ALT levels compared with obese students, and significantly higher in HDC-C levels. Non-obese girls showed significantly lower SBP, DBP, RHR, glucose, TC, insulin, HOMA-IR, and ALT levels than their obese counterparts, and had a significantly higher

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HDL-C level.

Table 3: Comparison of MS Risk Factors by BMI in Normal and Obese Students

Variable	Boys		*p*	Girls		*p*
	Normal (n=145)	Obese (n=57)		Normal (n=130)	Obese (n=46)	
SBP (mmHg)	106.65±15.80	120.48±14.07	**<.001**	105.26±16.12	117.80±13.04	**<.001**
DBP (mmHg)	61.37±9.42	69.64±10.68	**<.001**	62.96±11.08	67.35±10.89	**.022**
RHR (beat/min)	82.72±10.33	87.50±13.91	**.022**	82.73±11.04	87.80±13.48	**.013**
Glucose (mg/dL)	87.02±12.38	101.89±36.59	**.004**	86.51±11.43	92.20±13.64	**.007**
TG (mg/dL)	166.07±21.02	171.43±31.51	.246	163.73±20.75	164.74±26.69	.796
TC (mg/dL)	86.65±61.06	125.09±56.70	**<.001**	72.53±172.77	137.07±71.90	**.015**
HDL-C (mg/dL)	57.67±12.62	46.98±9.56	**<.001**	55.76±10.92	47.22±10.78	**<.001**
LDL_C (mg/dL)	87.75±32.05	95.04±34.24	.151	88.66±18.31	90.11±21.47	.664
Insulin *(μU/mL)*	28.65±31.35	102.56±148.25	**<.001**	26.79±17.58	84.79±91.29	**<.001**
HOMA-IR	5.92±9.41	28.95±52.27	**.002**	5.63±3.88	21.34±26.43	**<.001**
AST (IU/L)	25.11±4.96	28.43±11.94	**.048**	22.78±3.74	25.26±17.75	.352
ALT (IU/L)	17.37±10.62	34.38±26.21	**<.001**	14.33±6.73	30.35±41.12	**.012**

Mean±Standard Deviation
by BMI standard ≥ 95^{th} percentile
SBP: systolic blood pressure, DBP: diastolic blood pressure,RHR: resting heart rate, TG: triglyceride, TC: Total cholesterol, HDL-C: high density lipoprotein cholesterol,LDL-C: low density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance,ALT: alanine aminotransferase, AST: aspartate aminotransferase.

[Table 4] showed significantly difference onall risk factors of MS between the groups exceptRHR and AST.Non-alcoholic fatty liver (NAFL) is typified by higher AST levels than ALT levels in the NAFL prevalence analysis of boy and girl students. MS is also associated to non-alcoholic fatty liver diseases (NAFLD) (Pothiwala P *et al.*, 2009). Kantartzis K et al. noted that fitness was the powerful factor, independently of adipose tissue, as well as exercise

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intensity among the factors predicting change in liver fat in a longitudinal study, and so cardiorespiratory fitness is an important predictor for reducing liver fat in NAFLD (Kantartzis K *et al*., 2009).Thus, fitness, MS risk, cardiovascular risk factors and cancer risk factors are closely related, suggesting that fitnessis very important to prevent MS. Improvement of fitnessin children and adolescents is an especially significant factor to prevent MS in children and adolescents as well as during their transition to adulthood. Many such studies have identified the relationship between various diseases including MS and PA andfitness. However, fitness also plays a significant role in MS, NAFLD, and cancer, and there is a lack of research to determine the relationship between total PA and MS and MS-related diseases.

Table 4: Comparison of MSRiskFactors across Fatness and Fitness Level

Variable	Low Fat High Fit (n=130)	Low Fat Low Fit (n=84)	High Fat High Fit (n=61)	High Fat Low Fit (n=103)	Total (n=378)	*p*	Post-hoc
SBP (mmHg)	105.62±11.86	103.63±11.54	119.08±11.08	115.29±14.41	110.14±13.80	**<.001**	a,b<c,d
DBP (mmHg)	61.90±9.18	59.59±10.76	67.75±8.80	66.74±10.12	63.74±10.21	**<.001**	a,b<c,d
RHR (beat/min)	83.03±11.08	50.94±.181.61	84.60±13.76	86.72±12.20	77.45±85.50	.074	N/A
Glucose (mg/dL)	84.74±10.54	87.41±14.94	87.60±10.09	94.84±12.28	88.66±12.66	**<.001**	a,b,c>d
TG (mg/dL)	80.22±39.32	89.26±41.33	119.47±76.03	126.66±69.27	101.79±59.86	**<.001**	a,b<c,d
TC (mg/dL)	163.23±18.00	163.06±20.01	174.32±28.50	166.99±28.56	166.07±23.89	**.030**	a<c
HDL-C (mg/dL)	58.56±10.46	56.77±11.48	50.28±10.08	47.73±10.02	53.74±11.46	**<.001**	a,b>c,d
LDL_C (mg/dL)	88.62±15.68	88.43±17.36	100.14±25.57	93.93±25.08	91.97±21.16	**.009**	a,b<c
Insulin (*μ*U/mL)	23.82±22.63	28.63±30.47	43.11±55.82	83.24±89.79	44.94±61.47	**<.001**	a,b,c<d
HOMA-IR	5.20±5.83	6.90±9.91	10.02±15.89	21.11±25.38	10.89±17.30	**<.001**	a,b,c,<d
AST (IU/L)	23.89±3.92	23.79±4.19	26.21±15.44	26.26±10.80	24.92±9.03	.137	N/A
ALT (IU/L)	14.00±4.28	14.16±4.43	26.23±35.31	30.19±25.55	20.64±21.21	**<.001**	a,b<c,d

Mean±Standard Deviation
adjusted by grade, gender, and sexual maturity

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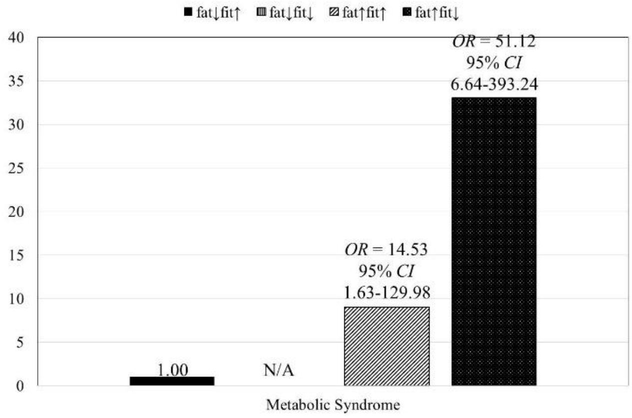

Figure 1. Relative Risk of MS by Fatness and Fitness Level

[Figure 1] presents the relative risk of MS by fatness and fitness level by adjusting grade, gender, and sexual maturity.MS was assessed according to IDF's pediatric diagnostic criteria (Zimmet P *et al.*, 2007).As a result of analyzing the risk of MS according to obesity and fitness level by adjusting the grade, gender, and sexual maturity of the subjects, we found that students with high-fatness and low-fitness had a significantly higher risk of MS (51.12 times) than those who had low-fatness and high-fitness. Those who had high-fatness and high-fitness also had a significantly higher risk of MS (14.53 times). The results of this paper found that students who had high-fatness and low-fitness had a much higher risk of MS than those who had low-fatness and high-fitness. High levels of obesity and low levels of fitness have been involved with increased risk factors for MS, leading to increased risk of CVD, hypertension, and hyperlipidemia (Jurca R *et al.*, 2004).

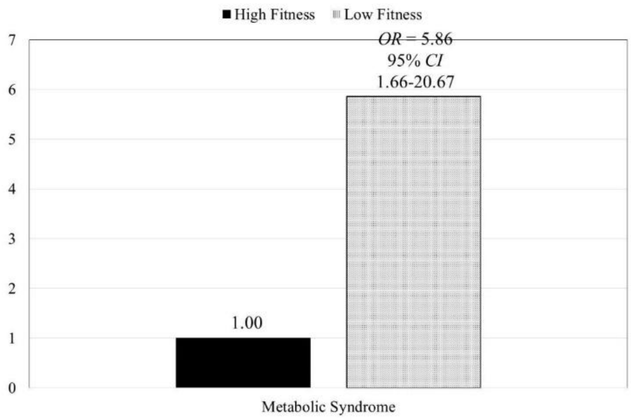

Figure 2. Relative Risk of MS by Fitness Level

[Figure 2] presents the relative risk of MS by fitness level by adjusting obesity, grade, gender, and sexual maturity. Low-fitness students had a significantly higher MS risk (5.86 times) by comparison withhigh-fitness students.These results c indicate that fitness level is an important determinant in the risk ofMS.

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When fitness is low, the risk of premature death, from diseases such as metabolic disorder and CVD, is significantly increased; conversely, when fitness is improved, the mortality rate is decreased (Barlow C E *et al.*, 1995). Furthermore, MS is associated with cancer in which insulin resistance, as a common metabolic abnormality and an independent risk factor on CVD, and the insulin-like growth factor 1 systemact an crucial role in theassociation of MS and cancer particularly adipocytes secreted by visceral fat cells, free fatty acids and aromatase activity(Uzunlulu M *et al.*, 2016).MS can be reduced and influenced by various factors, in particular it is possible to prevent or treat it by exercise and fitness.

Thus, fitness, MS risk, cardiovascular risk factors and cancer risk factors are closely related, suggesting that fitness is very important to prevent MS. Improvement of fitness in children and adolescents is an especially crucial factor to prevent MS in children and adolescents as well as during their transition to adulthood.

The results of this paper showed that the students' abnormalities and frequency of insulin resistance and MS risk factors were very high. At the time of blood sampling, the students' “breakfast” campaign had some limitations that did not encourage the fasting state, which may have had a significant impact on blood analysis. Despite these limitations, the study suggests that special attention should be paid to students with severe metabolic disorders including obesity in managing their condition. However, a limitation of this study is that, at the time of blood sampling, we did not encourage fasting, so as not to counter the students’ breakfast campaign in elementary school, which may have had an adverse impact on the blood analysis. However, students with MS, including obesity, should be managed separately because the results of this study are grave, even if these limitations are reflected.

Conclusion

This paper aimed to investigate the significance of fitness by analyzing the risk of metabolic syndrome according to fitness level and fatness in elementary school students. First, non-obese boys were significantly higher in all fitness levels compared to obese students. Non-obese girls showed significantly higher scores in all fitness levels in comparison with obese girls, except BS. Second, non-obese boys were significantly lower in SBP, DBP, RHR, glucose, TC, insulin, HOMA-IR, AST, and ALT levels compared with obese students, and significantly higher in HDC-C levels. Non-obese girls showed significantly lower SBP, DBP, RHR, glucose, TC, insulin, HOMA-IR, and ALT levels than their obese counterparts, and had a significantly higher HDL-C level. Third, there was a significant difference in all MS risk factors between the groups except RHR and AST.Fourth, high-fatness and the low-fitness were related to a higher risk of

MS. Firth, low fitness levels were association with a higher risk of MS. We suggest that students undergo systematic management to prevent disease and improve fitness.

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