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Development of the metabolic syndrome by the level of physical fitness and parent-child associations of the levels of physical activity and obesity among elementary students

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ABSTRACT

Health management in childhood is currently of great importance. Obesity is largely attributed to insufficient sleep, lack of physical activity, unhealthy eating habits, and home environment. High levels of physical fitness are known to be effective in prevention and improvement of diseases. Physical fitness is closely associated with both metabolic diseases and prevention of obesity. Despite the steady increase in the prevalence of obesity in students from Jeju, there is a lack of research on factors associated with reducing the prevalence of obesity in the students. This study aimed to investigate parent-child associations of physical activity levels and obesity by assessing obesity and physical fitness levels, metabolic syndrome risk factors, and physical activity habits in elementary school students from Jeju. In addition, the study aimed to examine the significance of physical fitness by assessing the development of metabolic syndrome according to physical fitness levels in these students. For these purposes, the study was sub-divided into two: Study I comprised the analysis of parent-child associations in levels of physical activity and obesity, and Study II comprised the analysis of the development of metabolic syndrome by level of physical fitness. Results indicated that physical activity levels of boys were positively and significantly associated with those of their fathers. Girls showed a positive correlation with the physical activity levels of their parents. The body mass index of boys was also positively correlated with that of their mothers. The body mass index of girls was positive correlated with that of both parents. Additionally, as a result of analyzing the risk of metabolic syndrome according to physical fitness level while controlling for obesity level, students with low physical fitness levels showed a 5.86 times higher risk of metabolic syndrome than students with high physical fitness levels. In summary, these results suggest that both physical activity and obesity levels of children and their parents are closely related, and that increased physical fitness level is an independent factor associated with the reduction or prevention of risk for developing metabolic syndrome. Family participation in physical activity and the improvement of physical fitness levels are essential for the management of health in childhood.

Key words: elementary students, metabolic syndrome, obesity, physical activity, physical fitness

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1. Introduction

1.1 Background

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 disorders (Censin et al., 2017; Lobstein, Baur, & Uauy, 2004; Reddy, Pickett, & Orcutt, 2006; Schwartz & Chadha, 2008; Stockman, 2009; Weiss, 2011; World Health Organization, 2000). These health problems in children and adolescents are attributed to obesity as well as physical inactivity and poor physical fitness (Hallal, Victora, Azevedo, & Wells, 2006).

According to the Centers for Disease Control and Prevention (CDC), childhood obesity has increased about threefold since 1980, and about 17% of all children aged 2 - 19 years have been classified as obese. The prevalence of obesity in children aged 6 - 11 years was reported to be 17.5% in 2015 in the United States (Ogden, Carroll, Fryar, & Flegal, 2015). In Korea, the prevalence of childhood obesity based on BMI increased from 19.8 % in 2011 to 21.1 % in 2015 (Ministry of Education, 2015, 2016). 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 Jeju was 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 (Ministry of Education, 2015, 2016).

In addition to the increasing prevalence of obesity, the lack of physical activity is a problem that goes hand in hand with decreasing physical fitness in children and adolescents. World Health Organization (2010) stated that over 81% of adolescents aged 11 - 17 years did not meet the recommended 60 minutes of physical activity each day (World Health Oragnization, 2016). Overweight and obese children and adolescents tend to have lower levels of physical activity and physical fitness (DiPietro, 1999; Pietilainen et al., 2008; Wareham, van Sluijs, & Ekelund, 2007). Despite such evidence, physical activity levels remain low; many children engage in considerably less physical activity than is recommended (Reilly et al., 2004; Roger et al., 2012).

The lack of physical activity and physical fitness in children and adolescents, especially among those with obesity, increases the risk for chronic diseases, including heart disease and diabetes (Chan & Woo, 2010; The U.S. Department of Health and Human Services, 2008; Warburton, Nicol, & Bredin, 2006), it also leads to increased morbidity in adulthood, relating to various diseases, in childhood (Booth, Roberts, & Laye, 2012; Durstine, Gordon, Wang, & Luo, 2013). Complications associated with obesity also occur in childhood (Goran, Ball, & Cruz, 2003; Sinha et al., 2002). The risk for metabolic syndrome (MS), which is associated with such risk factors as hypertension, hyperglycemia, and dyslipidemia, is also closely related to childhood obesity (Freedman, Khan, Dietz, Srinivasan, & Berenson, 2001; Park, Boston, Oh, & Jee, 2009). In Korea, the prevalence of MS in adolescents between 12 and 19 years old increased rapidly from 4.0% in 1998 to 7.8% in 2007. In particular, the prevalence of high triglyceride, low high-density lipoprotein cholesterol, and abdominal obesity increased significantly, which suggests that the lack of exercise and unbalanced nutrition in adolescents are the cause of the increased incidence of MS (Lim et al., 2013). The number of children and adolescents with diabetes was estimated to be 57.5 per 100,000 population, and the prevalence among youth (10-17 years old) was about six times higher than that of children (0-9 years old) in 2011 (Korean Diabetes Association, 2012).

Habitual physical activity (PA) and physical fitness (PF) are needed for positive health outcomes in childhood and adulthood, such as maintaining a regular body weight (Strong et al., 2005). PA and PF contribute to reducing not only obesity, but also CVD risk factors, inflammation, and neuronal function as well as cardiovascular morbidity (National Institutes of Health, 1996; Okura, Saghazadeh, Soma, & Tsunoda, 2013). These also improve bone density and body composition (Jakicic, 2009). Therefore, children, regardless of their weight, need to increase their PA and PF.

Despite the steady increase in obesity prevalence among elementary students in Jeju, the causes of the increase remain poorly understood. Also, there are a few studies which demonstrated MS and PF as well as parent-child associations of the levels of PA. Thus, this study aimed to identify the importance of PF by investigating the parent-child associations of the levels of PA and obesity by examining the relationship between levels of obesity, PF, risk factors of MS, and PA, and by investigating the development of MS according to the level of PF among Jeju elementary school students. The results of our study are significant in that they provide basic data for establishing policies for reducing the obesity prevalence of Jeju elementary school students in the future.

1.2 Research purpose

This study aimed to identify the importance of PF by investigating the parent-child associations of levels of PA and obesity, examining between the levels of obesity, PF, the risk factors of MS, and PA habit related to the increase of obesity prevalence, and to investigate the development of the MS by the level of PF among Jeju elementary school students.

Study I: Parent-child associations of the levels of physical activity and obesity among elementary students

This study was to analyze parent-child associations between levels of PA and obesity among elementary students.

Study II: Development of the metabolic syndrome by the level of physical fitness

This study was to analyze the development of MS according to the level of PF among elementary students.

1.3 Research design

This study was conducted as part of the Jeju City Public Health Center's 2015 Jeju Child Obesity Reduction Project. To investigate the factors related to obesity in elementary school students, two studies were conducted as shown in Figure 1.

Study I
Analysis of parent-child associations of the levels of physical activity and obesity among elementary students

Study II
Analysis of development of the metabolic syndrome by the level of physical fitness

Figure 1. Study Design

1.4 Research hypotheses

The following hypotheses were established to clarify the purpose of this study.

1) The parent–children level of obesity and PA habits were correlated.

(1) There was a positive correlation of obesity level between parents and children.

(2) There was a positive correlation of level of PA habits between parents and children.

2) The level of PF was different according to presence of obesity.

(1) The level of PF (muscle strength, muscle endurance, flexibility, cardiovascular fitness, body composition) was high in normal students.

(2) The level of PF (muscle strength, muscle endurance, flexibility, cardiovascular fitness, body composition) was low in obese students.

3) The risk factor and prevalence of MS were different according to presence of obesity.

(1) The risk factor and prevalence of MS were low in normal students.

(2) The risk factor and prevalence of MS were high in obese students.

4) The risk of MS was different according to the levels of obesity and PF.

(1) The risk of MS was low among students with low levels of obesity and high PF.

(2) The risk of MS was high among students with high levels of obesity and low PF.

5) The risk of MS was different according to levels of PF.

(1) Students with high PF levels had a low risk of MS.

(2) Students with a low PF level had a high risk of MS.

1.5 Research limitation

This study has the following limitations.

1) This study selected elementary school students attending some schools in Jeju.

2) The cross-sectional study is limited in determining the causal relationship between obesity, physical activity, physical fitness level and MS risk factors in elementary school students.

3) The degree of growth development, sexual maturity, and exercise performance varied among the participants.

4) We could not control the genetic, psychological, cultural, and environmental factors by the demographic variables of the subjects.

1.6 Definition of terms

1) Obesity

Obesity can be viewed as simply putting on excessive weight, but technically it is characterized by a state in which excess fat tissue accumulates in the body and body fat is elevated above normal.

2) Obese children

Obese children means obesity in school-aged children aged 6 to 12 years.

3) Body mass index

Body mass index (BMI) is a measure of obesity by dividing the body weight (kg) by the height $(m)^2$ according to the formula [BMI = body weight (kg) ÷ height $(m)^2$]. The diagnosis of obesity in children and adolescents was based on the 85-94.9th percentiles as overweight and the 95th percentiles as obesity according to gender and age (Korea Center for Disease Control and Prevention, 2007).

4) Waist Circumference

Waist Circumference (WC) is a measure of abdominal obesity. The method of measuring WC is most commonly used when considering cost and simplicity. Abdominal obesity in children and adolescents was diagnosed to exceed the 90th percentiles according to the International Diabetes Federation (IDF), age, and sex (Zimmet et al., 2007).

5) Percent body fat

Percent body fat (PBF) refers to the ratio of body fat to body weight. In the Physical Activity Promotion System (PAPS), the PBF values and their corresponding weight classification for boys are as follows: 15% to 24.9% overweight; 25% to 32.9% moderate obesity; and over 33% obesity. For girls, the corresponding values are as follows: 27% to 31.9% overweight; 32% to 39.9% moderate obesity; and over 40% obesity (Ministry of Education, 2009).

1.7 Abbreviations

The abbreviations used in this study are as follows.

. BMI : Body Mass Index (kg/m^2)

. DBP : Diastolic Blood Pressure (mmHg)

. FG : Fasting Glucose (mg/dL)

. FI : Fasting Insulin (μU/mL)

. HC : Hip Circumference (cm)

. HDL-C : High Density Lipoprotein Cholesterol (mg/dL)

. HOMA-IR : Homeostasis Model Assessment of Insulin Resistance

. IDF : International Diabetes Federation

. LDL-C : Low Density Lipoprotein Cholesterol (mg/dL)

. MET : Metabolic Equivalent of Task

. MPA : Moderate Physical Activity (min/week)

. MS : Metabolic Syndrome

. PA : Physical Activity

. PACER : Progressive Aerobic Cardiovascular Endurance Run (number)

. PAPS : Physical Activity Promotion System

. PBF : Percent Body Fat (%)

. PF : Physical Fitness

. SBP : Systolic Blood Pressure (mmHg)

. SMM : Skeletal Muscle Mass (kg)

. SR : Sit and Reach (cm)

. SU : sit-up (number/minute)

. TC : Total Cholesterol (mg/dL)

. TG : Triglyceride (mg/dL)

. VPA : Vigorous Physical Activity (min/week)

. WC : Waist Circumference (cm)

. WHR : Waist Hip Ratio (%)

. WHtR : Waist circumference to height ratio (%)

2. Review of Related Literature

2.1 Introduction

This chapter reviews the literature related to this study.

2.2 Physical fitness and metabolic syndrome in childhood

Physical fitness (PF) is defined as the ability to perform daily task without fatigue and the ability to perform PA and/or physical exercise integrating most of the bodily functions, such as skeletomuscular, cardio-respiratory, hematocirculatory, endocrine-metabolic, and psycho-neurological, involved in bodily movement (Caspersen, Powell, & Christenson, 1985; Clarke, 1971; Martínez-Vizcaíno & Sánchez-López, 2008). PF comprises health-related fitness including cardiorespiratory endurance, muscular endurance, muscular strength, body composition, and flexibility and skill-related fitness including agility, balance, coordination, power, reaction time, and speed (Martínez-Vizcaíno & Sánchez-López, 2008; Utesch, Dreiskämper, Strauss, & Naul, 2017). The health-related components of PF are important to childhood health.

The overall risk of death from disease is significantly reduced by PA and PF training, even if overweight or obese (Barlow, Kohl III, Gibbons & Blair, 1995; Welk & Blair, 2000). In 2001, Williams PT of the Lawrence Berkeley National Laboratory in the USA identified both PA and PF levels measured by VO2max as independent risk factors for coronary artery disease (CAD). Williams PT (2001) conducted a meta-analysis that confirmed the relationship between PA/high PF levels and the independent risk factors of CAD and cardiovascular disease (CVD). When both PA and PF increased from the lowest percentile to a higher percentile, especially exceeding 15%, both CAD and CVD showed decreased risk (Williams, 2001). High fitness levels showed a more direct relationship with reduced risk of disease than PA. As these results continue to be controversial among epidemiologists, more research and discussion of this issue will be needed (Blair & Jackson, 2001).

The importance of PF for health is well known and especially, PF in children and adolescents is a major biomarker for health and is related to various diseases. High PF in youth is related to low prevalence of asthma-like symptoms in adulthood (Guldberg–Møller, Hancox, Mikkelsen, Hansen, & Rasmussen, 2015). Melinder et al. (2015) reported that low PF is also associated with the risk of inflammatory bowel disease (IBD). Low PF increased the risk of Crohn's disease (CD) and ulcerative colitis (UC) in adolescence, and an inverse association between PF and IBD risk suggested a protective role of exercise in the risk of IBD (Melinder et al., 2015). Furthermore, cardiorespiratory fitness is associated with obesity and the cardiorespiratory and muscular fitness is related to the risk factors of cardiovascular disease (Boreham & Riddoch, 2001; Ortega, Ruiz, Castillo, & Sjöström, 2008). A relationship between fitness and fatness and cardiovascular disease has been found in children and adolescents. Eisenmann JC et al. reported significant differences between low-fat and high-fat groups within a fitness group and found a linear relationship across groups for the risk of cardiovascular disease in 1,635 youth aged 8-18 years old (Eisenmann, Welk, Ihmels, & Dollman, 2007).

Obesity is a major determinant of various diseases such as MS. Potential mechanisms are often suggested as ways in which PF can reduce the risk of MS in insulin resistance and obesity and the benefits of PF for health have been proven through the results of various studies. Increasing PF can prevent and/or help the risk of MS by promoting enhanced cardiovascular function and muscular endurance (Robinson & Graham, 2004; Spain & Franks, 2001). Furthermore, the authors concluded that MS risk in the high BMI/high fitness group was significantly lower than the high BMI/low fitness group. It was concluded that the relationship between fatness and aerobic fitness was important for decreasing MS risk in Japanese children (Sasayama, Ochi, & Adachi, 2015). In the analysis of PF, obesity, and insulin resistance of childhood and adulthood, low levels of cardiorespiratory fitness in childhood increased odds of adult obesity and insulin resistance, and decreases in PF levels between childhood and adulthood were associated with increased obesity and insulin resistance per unit decrease (Dwyer et al., 2009). Hasselstrøm H et al. reported that the PF level in youth (aged 17 and 25 years) was especially associated with adiposity in adulthood compared to PA level (Hasselstrøm, Hansen, Froberg, & Andersen, 2002). Also, after adjustment for age and sex, PF was associated with reduced odds of MS and especially, compared with PA, PF showed strong effects in controlling risk factors of cardiovascular disease (Sassen et al., 2009). Evidence from these studies suggested that PF is not only a major factor of MS but also an independent component of MS. Hence, the lack of PF can play a pivotal role for the development of cardiovascular disease, type 2 diabetes, and MS in childhood, which can affect the high risk of obesity and MS in adulthood. Consequently, PF is necessary for health and the prevention of various diseases children and adolescents, as well as adults.

2.3 Obesity and physical activity in childhood

Obesity means a state of accumulation of excess body fat in the body according to the number of adipocytes (Bray, 1992). Obesity is diagnosed with measurements for WC, body fat, and central and peripheral fat mass. Obesity is usually expressed as BMI calculated as body weight in kilograms divided by height (kg/m^2). Assessments of obesity classification vary depending on the country. In Korea, obesity is defined as BMI ≥ kg/m^2, whereas in the United States, obesity is BMI ≥ 25 kg/m^2 for overweight and BMI ≥ 30 kg/m^2 for obese using BMI categories.

Childhood obesity means obesity in school-aged children aged 6 to 12 years. Despite the literature on childhood obesity, it is difficult to define childhood obesity accurately. In terms of the BMI of children and adolescents, BMI is determined for specific percentiles of age and sex to account for variability of sex and age. According to the Centers for Disease Control and Prevention (CDC), obesity is defined as a BMI at or above the 95^{th} percentile, and overweight is defined as a BMI at or above the 85^{th} percentile but less than the 95^{th} percentile in the same age and sex (The U.S. Department of Health and Human Services, 2008). According to International Obesity Task Force (IOTF), a standard definition should use age/sex-specific cut-off criteria for study purposes (Cole, Bellizzi, Flegal, & Dietz, 2000).

According to WHO, obesity has increased the incidence of metabolic diseases, such as hypertension, diabetes, and dyslipidemia, which are key causes of increased mortality (World Health Organization, 2016; World Health Organization, 2000). Obesity can occur at any time, especially during childhood and adolescence, when physical and mental changes occur rapidly. Obesity in childhood and young people has been described as a crisis in public health and is increasing the threat to health worldwide. Obesity is a chronic disease worldwide (Lobstein et al., 2004; World Health Organization, 2000).

According to results from the 2011-2012 National Health and Nutrition Examination Survey (NHANES), 16.9% of children and adolescents (2-19 years old) in the United States were obese, and 14.9% overweight (Control & Prevention, 2016). In a study of 40,780 children and adolescents (aged 2 to 19 years; 48.8% female) in the United States from 2011-2014, Odgen et al. reported a prevalence of obesity of 17.0% (95% CI, 15.5% - 18.6%) and extreme obesity. Obesity especially increased during the periods of 1988 - 1994 and 2013-2014 in adolescents aged 12-19 years. Extreme obesity also increased in the same periods among children aged 6 to 11 (Ogden et al., 2016). Kim et al. reported that the prevalence of childhood obesity (aged 2 to 19 years) was similar to that of American from the early 2000s, but the prevalence of extreme obesity in boys especially increased from 2001 to 2014 in Korea (Nam, Kim, Rhie, & Lee, 2017). These findings raised concerns that being overweight or obese in childhood continues into adulthood and leads to increased risk for various diseases, including diabetes and MS.

The growing prevalence of childhood obesity has also led to increased incidence of various diseases, such as diabetes and MS (Censin et al., 2017; Schwartz & Chadha, 2008; Weiss, 2011). In overweight and obese children, the body composition, including BMI and body weight, is different compared to children of normal weight. Jun et al. reported that fat mass and fat-free mass were higher in obese than normal weight children and, especially as age increased, the fat mass index (FMI) and fat-free mass index (FFMI) significantly increased (Ma, Feng, Zhang, Pan, & Huang, 2009). As the body composition changed due to being overweight or obese, the level of serum insulin and homeostasis model assessment-insulin resistance (HOMA-IR), a method for diagnosing insulin resistance, was also higher. These values have been reported to be positively correlated with total cholesterol (TC), LDL-C, and TG in overweight and obese children, and are risks associated with type 2 diabetes, cardiovascular disease, and MS, as well as secondary and chronic diseases (Chiarelli & Marcovecchio, 2008; Haque, Khan, Chowdhury, Khaled, & Barua, 2017). MS in childhood and adolescence is carried to adulthood, which increases the risk of cardiovascular disease, diabetes, and MS in adults (Magnussen et al., 2010; Morrison, Friedman, Wang, & Glueck, 2008; Stockman, 2009). Therefore, it is important to diagnose, treat, and prevent obesity in children and adolescents at an early stage.

Physical activity (PA) is “body movement” produced by the contraction of skeletal muscles; it also refers to increased energy expenditure above basal level (The U.S. Department of Health and Human Services, 2008). Regular PA offers various health benefits. Evidence supporting the inverse relationship between physical activity and obesity, cardiovascular disease, hypertension, stroke, osteoporosis, type 2 diabetes, colon cancer, breast cancer, anxiety and depression is constantly being explored. This evidence is observed not only in experimental studies, but also in the results of large-scale specimen observations. The recently revised recommendations of the American College of Sports Medicine (ACSM) and American Heart Association (AHA) on physical activity and health indicated that since the 1955 recommendations were issued, epidemiological observations have registered 10,000 people. Consequently, the positive-reaction relationship between the risk of cardiovascular disease and early mortality and physical activity in various ethnic groups in both men and women has been clearly identified (American College of Sports Medicine, 2013)

Many studies have focused on finding successful interventions for preventing child obesity. Studies have reported that obesity is often prevented by various behavioral interventions, especially physical activity. Trost et al. reported that obese children are significantly lower in moderate physical activity (MPA), vigorous physical activity (VPA), and physical activity self-efficacy compared with non-obese children (Trost, Kerr, Ward, & Pate, 2001). Furthermore, in New Zealand, a country with the third highest prevalence of overweight and obese in children and adults, obese children and adolescents aged 4.8-16.8 years were found to have low levels of PA (Anderson et al., 2017; Siwik et al., 2013). A study that targeted children aged 8 - 11 years (BMI above the 85th percentile) and their parents presented a three-month intervention for reducing BMI z scores in overweight children while increasing levels of PA as well as implementing changes in family behavior and attitudes (Siwik et al., 2013). Intervention studies have indicated the importance of PA for beneficial health and behavioral outcomes in ordinary circumstances; the authors recommended that school-aged youth, aged 6 - 18 years, should participate daily in one or more hours of MPA or VPA (Strong et al., 2005). In other words, PA has the following benefits: 1) prevention or reduction of cardiovascular disease, high blood pressure, injuries, and obesity; and 2) improvement of self-confidence, self-image, and body composition. PA is needed for the prevention and treatment of childhood obesity (Roberts, 2000).

Therefore, increased PA has been recommended as a method for weight reduction and improved health lifestyle in overweight and obese children.

2.4 Metabolic syndrome and physical activity in children

Metabolic syndrome (MS) is called “syndrome X” or “insulin resistance syndrome”. It was initially called “insulin resistance” because MS was observed in various metabolic disorders caused by insulin resistance. MS is generally characterized by the combination of obesity (WC or BMI, and especially, abdominal obesity), dyslipidemia (high TG and low HDL-C), glucose metabolism (glucose intolerance, fasting glucose (FG)), hyperinsulinemia, and hypertension, as well as a risk factor for type 2 diabetes and CVD (Cowey & Hardy, 2006; Earl S Ford, 2005; Grundy, 2006; Grundy et al., 2005; Reaven, 1988, 2005). The definition of MS differs slightly from institution related MS; it is especially difficult to define MS in children because the period of pediatric adolescence is a period in which physiological changes according to sex and age are significant. Overweightness and obese children tend to have hypertension. Overweight and obesity cause insulin resistance, which increases sodium reabsorption. This process activates the sympathetic nervous system and renin-angiotensin system, resulting in hypertension (Hansen, Gunn, & Kaelber, 2007; Kalupahana & Moustaid-Moussa, 2012; Segura & Ruilope, 2007; Yvan-Charvet & Quignard-Boulange, 2011). Furthermore, obesity in children is correlated with increased visceral fat, increased insulin resistance, and cardiovascular risk factors (Bacha, Saad, Gungor, Janosky, & Arslanian, 2003; Kwon et al., 2011). The worldwide prevalence of obesity and diabetes in children and adolescents is rising. In the 1997-2004 National Health and Nutrition Examination Survey (NHANES), the prevalence of MS was 4.5% of adolescents aged 12-17 years. Indeed, as age increased, the prevalence of MS was higher in males than females in the U.S according to IDF definition (E. S. Ford, Li, Zhao, Pearson, & Mokdad, 2008). Grundy et al. reported that the prevalence of MS was one-third of overweight/obese adolescents NHANES (Grundy et al., 2005). An analysis of Medline and Embase databases articles published between August 2007 and January 2009 showed that the prevalence of MS in the general population and community – based sampling was 1.2% to 22.6% with up to 60% of the children and adolescents found to be overweight or obese (Tailor, Peeters, Norat, Vineis, & Romaguera, 2010). The prevalence of MS, according to the National Cholesterol Education Program Adult Treatment Panel III (NCEP), was 4.2%. As defined by

WHO, the prevalence of MS was 8.4% in 1,513 school-aged adolescents. In obese teens, the prevalence of MS rises to 19.5%, defined by NCEP, and 38.9%, defined by WHO (Goodman, Daniels, Morrison, Huang, & Dolan, 2004). In other words, as the prevalence of obesity increased, so did the prevalence of MS (Kirk et al., 2005). Meanwhile, MS in children and adolescents predict a higher prevalence of CVD as well as diabetes and MS-related diseases in adulthood (Burns, Letuchy, Paulos, & Witt, 2009; Franks et al., 2007; Morrison et al., 2008).

MS is associated with PA, which is a key factor related to preventing or reducing MS (Brambilla, Pozzobon, & Pietrobelli, 2011). McMurray et al. reported that MS adolescents had 5.16 times lower PA levels (McMurray, Bangdiwala, Harrell, & Amorim, 2008). In addition, the MS of participants was 14.1%, and this study found that PA was an indicator of the related risk factors of MS, including HDL-C, WC, and TG. Indeed, low physical activity in both males and females aged to 6 - 18 years significantly increased the risk of MS (R. Kelishadi et al., 2007). Kelly et al. demonstrated that participants who exercise had lower MS-related risks compared with participants who do not exercise in overweight and obese children and adolescents (Kelly et al., 2004).

Consequently, PA has been recommended to prevent or reduce MS, including insulin resistance and CVD in obese children and adolescents.

Analysis of Parent-child Associations of the Levels of Physical Activity and Obesity among Elementary Students

3.1 Purpose of the study

This study aimed to analyze parent-child associations of levels of physical activity and obesity among elementary students according to obesity and duration of PA participation.

3.2 Methods

3.2.1 Subjects

This study was conducted with third- to sixth grade students (aged 9–12 years) attending four elementary schools in Jeju. The subjects were selected with the cooperation of the Jeju Special Self-governing Province Education Office and the teachers of each elementary school. The subjects were 567 students (287 boys and 280 girls) who submitted their consent to participate in the research, 1,134 parents (567 fathers and 567 mothers) who submitted their consent to participate in the research. The study protocol was explained to prospective volunteer subjects. Those who provided consent form agreements signed by themselves and their parents were selected to participate. The participant characteristics are shown in <Table 1 and 2>.

Table 1. Participants Characteristics in the Study I

Variables	Boys (n=287)	Girls (n=280)	Total (n=567)
Grade (%)			
3rd	27.2	22.9	25.0
4th	26.8	21.1	24.0
5th	24.7	33.9	29.3
6th	21.3	22.1	21.7
Age (yrs)	10.40±1.10	10.55±1.07	10.48±1.09
Height (kg)	145.57±10.30	146.15±9.32	145.86±9.82
Weight (kg)	41.22±11.07	40.71±9.88	40.96±10.49
Body Mass Index (kg/m^2)	19.22±3.57	18.88±3.34	19.05±3.46
Sexual maturity (%)			
- yes	10 (3.5)	72 (25.9)	82 (14.5)

Mean±Standard Deviation

Table 2. Parents Characteristics in the Study I

Variables	Fathers (n=567)	Mothers (n=567)
Age group (%)		
20s	0.4	0.5
30s	17.3	34.5
40s	72.9	63.0
50s	9.3	2.0
60s	0.2	-
Age (yrs)	43.24±4.47	41.16±7.01
Height (kg)	173.00±5.11	159.88±5.89
Weight (kg)	74.05±10.02	56.96±8.26
Body Mass Index (kg/m^2)	24.71±2.86	22.31±3.33

Mean±Standard Deviation

3.2.2 Study protocol

This study was approved by the Institutional Review Board of Jeju National University (2015-10-003). We distributed 1,746 self-administered questionnaires to the students with the cooperation of their teachers at four elementary schools on October 16, 2015. A total of 1,275 copies were collected by November 13 (73% recovery rate). Questionnaires that were not submitted or were submitted by those who did not agree to participate in the study were excluded, leaving a total of 1,032 copies for analysis. Based on the assumption that all of the parents' questionnaires were submitted (excluding students who did not have a parent questionnaire, or who submitted only one parent questionnaire), 567 copies (567 father's copies and 567 mother's copies) were used as data for the final analysis. The questionnaire investigated the subjects' height, weight, maturity, and physical activity (Figure 2).

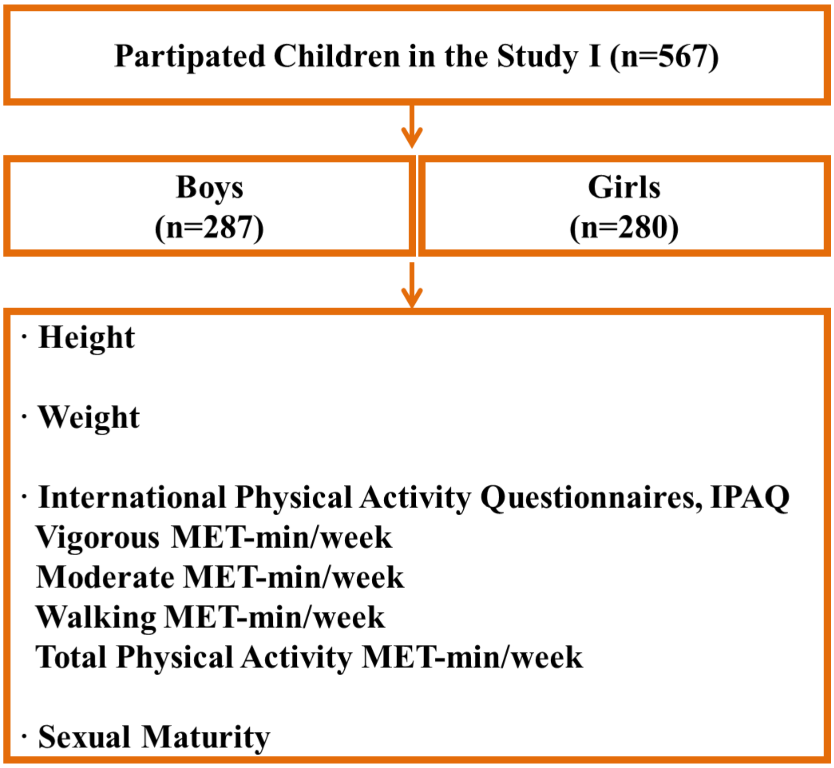

Figure 2. Study Process of Study I

3.2.3 Data sources

1) Student questionnaire

The questionnaire for the students was modified and supplemented with the questionnaire for elementary school students, and the physical activity habit level survey used the International Physical Activity Questionnaire (IPAQ).

(1) Questionnaire on health status

The health status survey was composed of 13 items on subjective health status, sleeping habit, self - esteem, body composition, height, weight, and weight control experience.

(2) Physical activity habit level survey

The physical activity participation time survey was composed of 12 items on sexual maturity, VPA, MPA, walk, sedentary activity, exercise disturbance factor, exercise self-efficacy, etc.

(3) Demographic Survey Questions

The demographic survey consisted of six items on gender, date of birth, residence area, residence duration, living family status,

2) Parent questionnaire

The questionnaires for parents were modified and supplemented by the National Health and Nutrition Survey questionnaire, which was used by the Department of Health and Welfare, Ministry of Health and Welfare, in accordance with the design of the study. The PA survey used the International Physical Activity Questionnaires (IPAQ).

(1) Questionnaire on health status

The health status was composed of eight items, including diagnosis of disease, smoking status, drinking status, alcohol consumption, and body image.

(2) Physical health examination of child

The child physical health survey was composed of six items, including diagnosis of the child's disease, obesity among family members, child's body type, and child's weight-control experience.

(3) Physical activity habit level survey

This tool was composed of seven items on VPA, MPA, walking, and sedentary activity.

(4) Demographic Survey Questions

The demographic survey consisted of three items that gathered information on the respondents' relationship with the student participant, age, education, height, weight, occupation, working style, physical labor intensity, and socioeconomic level.

3) Analysis of physical activity level

The IPAQ is a self-report PA measurement tool. In this study, we used a simplified version. PA level was expressed as a metabolic equivalent of task (MET) (min / week) after measuring the level of VPA, MPA, walking, and sedentary time during the previous seven days. We derived continuous scores and categorical classification scores. The continuous score was calculated as the sum of the walking MET, the MPA MET, and the VPA MET; PA of less than 10 minutes was regarded as having no PA. The procedure for the calculating continuous and categorical scores is as follows (IPAQ Research Committee, 2005).

① Continuous score

· Walking MET = 3.3 (MET level) × walking time (min) × day (day)

· Medium physical activity MET = 4.0 (MET level) × moderate physical activity time (min) × day

· Vigorous physical activity MET = 8.0 (MET level) × vigorous physical activity time (min) × day

② Categorical score

· Inactivity (category 1): This is the lowest level of PA that is included in subjects not included in categories 2 and 3 and is considered insufficient.

· the lowest activity (category 2): active VPA for more than 20 minutes for more than 3 days per week, PA for more than 30 minutes per day for more than 5 days per week, or a combination of walking, MPA, and VPA for more than 5 days per a week at 600 MET (min / week).

· Health promotion PA (category 3): active VPA for more than 3 days per a week at 1500 MET (min / week), or a combination of walking, MPA, and VPA more than 7 days at 3000 MET (min / week).

③ Considerations in the IPAQ Scoring Process

· In calculating MET-min / week, the time is calculated by switching to minutes.

· All intensity PA (walking, MPA, and VPA) can't be more than 16 hours.

· Walking, MPA, and VPA is calculated by entering 240 minutes if reported to be over 4 hour (or 240 minutes).

· Any PA less than 10 minutes shall be considered as not being performed.

4) Sexual maturity

To determine the degree of sexual maturity, boys measured the development of their penis and pubic hair, and girls measured the development of their breasts pubic hair. We also investigated whether boys had experience in ganacratia, girls had experienced their menarche, and if there was a start time, the experience of boys and the presence or absence of their menarche were used as a measure of sexual maturity (Tanner, 1962).

5) Body mass index standards

The criterion for obesity in elementary school students was applied as the 95th percentile for BMI for each age (representative value) presented in the 2007 growth chart (Korea Center for Disease Control and Prevention, 2007). The obesity criteria for parents were applied as 25 kg / m^2 BMI or more (Korean Society of Obesity, 2001).

① The standards of BMI 95th percentile in boys

· 9 years : 23.34

· 10 years : 24.48

· 11 years : 25.50

· 12 years : 26.35

② The standards of BMI 95th percentile in grils

· 9 years : 22.09

· 10 years : 23.08

· 11 years : 23.99

· 12 years : 24.77

3.2.4 Statistical analysis

Statistical Package for the Social Sciences (SPSS version 18.0 for Windows; SPSS Inc., Chicago, IL, USA) was used for all statistical analysis.

1) The categorical variable described the measurement items in term of their frequency, whereas continuous variable were calculated for mean, standard deviation, and median values.
2) All data were divided into boy and girl students, father and mother, obesity (normal, obese) taking into consideration the physical and behavioral characteristics of the subjects. Statistical significance was defined as $p < .05$.
3) Pearson's correlation method was used to analyze the relationship between BMI and the log-transformed value of subjects.

3.3 Results

The results of Study 1 for levels of obesity and PA habit are as follows.

3.3.1 Survey for Obesity Frequency

1) Obesity Frequency by Genders

Results for the obesity frequency by genders are shown in <Table 3>. Of the sample, 12.5% of the boys and 13.6% of the girls were obese.

Table 3. Frequency of Obesity by Genders

Variable	Boys (%)	Girls (%)	Total (%)
Frequency	36 (12.5)	38 (13.6)	206 (13.1)

By the BMI standard of ≥ inclusion in the 95th percentile

BMI: body mass index

2) Obesity Frequency by Parents

Results for the obesity frequency by parent are shown in <Table 4>. A total of 42.5% of fathers were and 16.2% of mothers were obese.

Table 4. Frequency of Obesity by Parents

Variable	Fathers (%)	Mothers (%)	Total (%)
Frequency	241 (42.5)	92 (16.2)	333 (29.4)

By the BMI standard of ≥ inclusion in 25 kg/m^2

BMI: body mass index

3.3.2 Survey for the level of physical activity habit and sedentary time

1) Mean values of physical activity habit and sedentary time by genders

The mean values of PA habit by genders are shown in <Table 5>. Boys had a higher mean value for PA habit than girls.

Table 5. Mean Values of Physical Activity Habit and Sedentary Time by Genders

Variable	Boys (n=287)	Girls (n=280)
VPA (min/week)	278.87±315.94 (150.00)	123.53±200.32 (00.00)
MPA (min/week)	208.55±273.61 (90.00)	119.73±189.51 (00.00)
Walk (min/week)	218.42±267.00 (140.00)	177.19±255.52 (82.50)
Total PA (min/week)	703.33±668.39 (520.00)	420.45±489.87 (255.00)
Total PA METs (min/week)	3837.37±3661.33 (2728.00)	2075.71±2502.95 (1207.50)
Sedentary (min/week)	290.82±183.21 (300.00)	302.73±199.22 (300.00)

Mean±Standard Deviation (median value)

METs: metabolic equivalent of task, MPA: moderate physical activity, Total PA: total physical activity, VPA: vigorous physical activity.

2) Mean values of physical activity habit and sedentary time by parent

The mean values of PA habit and sedentary time by parents are shown in <Table 6>. Fathers had a higher mean value for PA than mothers.

Table 6. Mean Values of Physical Activity Habit and Sedentary Time by Parents

Variable	Fathers (n=567)	Mothers (n=567)
VPA (min/week)	151.11±284.17 (00.00)	92.28±212.47 (00.00)
MPA (min/week)	141.98±273.89 (00.00)	101.32±211.98 (00.00)
Walk (min/week)	183.36±284.88 (00.00)	192.92±271.84 (70.00)
Total PA (min/week)	476.44±671.01 (180.00)	386.20±523.30 (180.00)
Total PA METs (min/week)	2617.99±3652.17 (1031.00)	1833.83±2683.15 (716.63)
Sedentary (min/week)	283.87±160.57 (270.00)	267.27±156.56 (240.00)

Mean±Standard Deviation (median value)

METs: metabolic equivalent of task, MPA: moderate physical activity, Total PA: total physical activity, VPA: vigorous physical activity.

3) Classification by metabolic equivalent of task between genders

<Table 7> lists the classification by METs between genders. A total of 34.2% of the subjects performed HEPA, and 36.7%, MA. Meanwhile, 29.1% were classified as inactive (less than 600 METs).

Table 7. Classification by Metabolic Equivalent of Task among Genders

Variable	Boys (%)		Girls (%)		Total (%) (n=567)
	Normal (n=251)	Obese (n=36)	Normal (n=242)	Obese (n=38)	
HEPA (≥ 3,000)	45.4	38.9	23.6	23.7	34.2
MA (≥ 600)	33.1	33.3	40.5	39.5	36.7
Inactive (< 600)	21.5	27.8	36.0	36.8	29.1

by BMI standard ≥ 95^{th} percentile

by IPAQ standard METs (min/week)

HEPA: health enhancing physical activity, MA: minimally active, METs: metabolic equivalent of task.

4) Classification by metabolic equivalent of task among parents

<Table 8> gives the classification by METs among parents. A total of 23.5% of the subjects performed HEPA, and 28.0%, MA. Meanwhile, 48.5% were classified as inactive (less than 600 METs).

Table 8. Classification by Metabolic Equivalent of Task among Parents

Variable	Fathers (%)		Mothers (%)		Total (%) (n=1,134)
	Normal (n=326)	Obese (n=241)	Normal (n=475)	Obese (n=92)	
HEPA (≥ 3,000)	24.5	30.9	17.1	30.4	23.5
MA (≥ 600)	23.3	24.9	34.4	19.6	28.0
Inactive (< 600)	52.1	44.4	48.0	50.0	48.5

by BMI standard ≥ 25 kg/m^2

by IPAQ standard METs (min/week)

HEPA: health enhancing physical activity, MA: minimally active, METs: metabolic equivalent of task.

3.3.3 Correlation between levels of obesity and physical activity

1) Correlation between levels of physical activity and body mass index among boys and girls

As shown in <Table 9>, both boys and girls had a negative correlation with PA and BMI.

Table 9. Correlation between Levels of Physical Activity and Body Mass Index among Genders

Correlation R *p*	Walk	Total PA	Total PA METs	Sedentary
Boys	-.032 .587	-.114 .054	-.105 .080	-.011 .881
Girls	-.023 .704	-.048 .423	-.067 .268	.063 .441

METs: metabolic equivalent of task, Total PA: total physical activity.

2) Correlation between levels of physical activity and body mass index among parents

Correlations between the level of PA and BMI among parents are shown in <Table 10>. Fathers had a negative correlation between PA and BMI, but total PA METs of mothers were a positively correlated with BMI.

Table 10. Correlation Between Levels of Physical Activity and Body Mass Index among Parents

Correlation R *p*	Walk	Total PA	Total PA METs	Sedentary
Fathers	.070 .095	.073 .082	.054 .226	.012 .848
Mothers	.030 .479	.069 .101	**.089** **.037**	.004 .939

METs: metabolic equivalent of task, Total PA: total physical activity.

3) Correlation of body mass index between parents-children

<Table 11> gives the correlations of BMI between parents and children. Parents' BMI was positively correlated with the boy's BMI, whereas mothers' BMI was positively correlated with boys' and girls' BMI.

Table 11. Correlation of Body Mass Index between Parents-Children

Correlation R *p*	Fathers	Mothers
Boys	.081 .172	**.117** **.048**
Girls	**.188** **.002**	**.241** **<.001**

BMI: body mass index

4) Correlation of physical activity level between parents and boys

<Table 12> lists the findings on the correlation of PA levels between parents and boys. Fathers' walking was positively correlated with boys' walking and total PA. Parents' sedentary time was positively correlated with boys' sedentary time.

Table 12. Correlation of Physical Activity Level between Parents and Boys

Correlation R *p*	Walk	Total PA	Total PA METs	Sedentary
F_Walk	**.135** **.022**	**.129** **.029**	.092 .123	.128 .072
F_Total PA	.090 .129	.110 .062	.072 .227	.120 .090
F_Total PA METs	.036 .562	.047 .458	.028 .660	.110 .140
F_Sedentary	-.031 .728	.049 .582	.054 .541	**.266** **.006**
M_Walk	.114 .055	.061 .305	.035 .557	.094 .188
M_Total PA	.087 .139	.084 .156	.066 .271	.041 .561
M_Total PA METs	.066 .273	.082 .173	.076 .211	.029 .693
M_Sedentary	.124 .118	.123 .123	.114 .152	**.206** **.021**

F: Fathers, M: Mothers, METs: metabolic equivalent of task, Total PA: total physical activity.

5) Correlation of physical activity level between parents and girls

<Table 13> shows the correlation of PA level between parents and girls. Walking, total PA, and total PA METs of fathers was positively correlated with total PA METs of girls. Walking and total PA of mothers was positively correlated with total PA, and total PA METs of girls.

Table 13. Correlation of Physical Activity Level between Girls and Parents

Correlation R *p*	Walk	Total PA	Total PA METs	Sedentary
F_Walk	.040 .509	.110 .066	**.126** **.037**	.020 .807
F_Total PA	-.003 .967	.098 .101	**.119** **.049**	.028 .730
F_Total PA METs	.005 .934	.109 .081	**.128** **.041**	.020 .818
F_Sedentary	-.045 .633	-.113 .229	-.122 .198	.035 .799
M_Walk	.096 .108	.099 .097	.090 .137	.069 .404
M_Total PA	.108 .072	**.121** **.043**	**.122** **.042**	.090 .275
M_Total PA METs	.114 .059	**.130** **.032**	**.135** **.026**	.101 .223
M_Sedentary	-.023 .780	-.021 .794	-.028 .736	.179 .091

F: Fathers, M: Mothers, METs: metabolic equivalent of task, Total PA: total physical activity.

Development of Metabolic Syndrome by the Level of Physical Fitness

4.1 Purpose of the study

This study aimed to analyze the development of MS according to obesity and PF levels by measuring the levels of obesity and PA, PF and MS factors in elementary school students.

4.2 Materials and methods

4.2.1 Subjects

This study was conducted with fourth- and fifth-grade students (10 to 11 years old) in three Jeju elementary schools (two in Jeju-si, one from outside the town). The participants were selected through the cooperation of the Jeju Special Self - Governing Province Education Office and teachers of the elementary schools. The study recruited a total of 390 subjects (212 boys and 178 girls). Excluding two students who did not have a questionnaire and 10 students who did not participate, the study recruited a total of 378 subjects (202 boys and 176 girls) who submitted their consent to participate in the research. The study protocol was explained to the prospective volunteer subjects, and those who provided consent form agreements signed by themselves, and their parents were selected to participate. The participants' characteristics are shown in <Table 14>.

Table 14. Participants Characteristics in the Study II

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

4.2.2 Study protocol

This study was approved by the Research Ethics Review Committee of Cheju National University (IRB JEJUNUH 2015-10-003). The subjects were selected from students who agreed to participate in the study among the students who were found to have moderate abnormal obesity at anthropometry measurements in the first half of 2015. The survey was conducted from October 13, 2015 to October 27, 2015, and all researchers (in the fields of medicine, physical education, and nutrition) visited directly in accordance with the schedule of the school. The investigations conducted anthropometric measurements, physical fitness measurements, blood analysis, one-on-one diet interviews, and a self - administered survey. A total of 421 copies of the questionnaires were distributed and 390 copies were collected (recovery rate 92.6%). Once students who failed to submit questionnaires or who opted out of the survey were excluded, a total of 378 students remained, and these were used for the analysis.

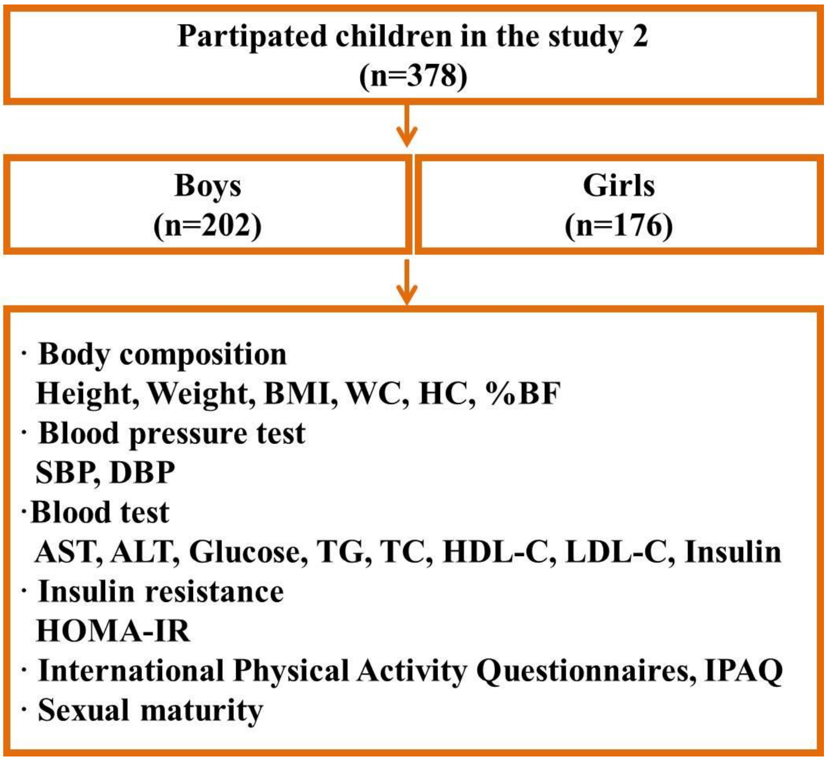

Figure 3. Study Process of Study II

4.2.3 Data sources

1) Anthropometric measurements

The height and weight of the participants, barefoot and in casual clothes, were taken using JENIX auto measuring equipment (DONGSAN JENIX, Seoul, Korea). BMI was calculated as weight (kg) divided by height squared (m^2). WC was measured at the thinnest circumference between the iliac ridge and the twelfth rib in the arm of the participants at a relaxed state. The hip circumference (HC) was measured at participant's hips, from the most protrusive area behind the hips, symphysis pubis, and the thickest point connecting greater trochanter, in a relaxed state. The body composition was measured for skeletal muscle mass (SMM), lean body mass (LBM), body fat mass (BFM), and PBF using Inbody 720 (Biospace Co., Korea), as a precision body composition analyzer using bioelectrical impedance analysis (BIA).

2) Blood pressure

Blood pressure (BP) was measured as systolic blood pressure (SBP) and diastolic blood pressure (DBP) in the left upper arm when the participants had relaxed for at least five minutes. The reading was taken using an automatic blood pressure monitor (OMRON HEM-770A, Japan).

3) Blood collection and analysis

The blood collection process was as follows: 1) All blood samples were collected from the subjects between 08:00 and 09:00 after a 12 h fast. 2) Before blood collection, the participants were stabilized for about 30 minutes; venous blood was then collected from the upper arm vein using a thermionic tube without any anti-coagulant. 3) After blood collection, the blood samples were centrifuged at 3,000 rpm for 15 minutes; blood plasma was isolated and stored at -80 °C. 4) The blood plasma was analyzed for levels of FG, TG, total cholesterol (TC), HDL-C, LDL-C, and fasting insulin (FI). FG was measured using the hexokinase method, and TG, using the glycerol blanked method. TC was measured using the enzyme method. HDL-C was measured using a clinical chemo-immunoassay (Olympus AU5400, Japan) by the direct selective method. LDL-C was calculated using the formula of Friedewald, Levy, and

Fredrickson (1972) (LDL-C = TC - HDL-C - TG ÷ 5). FI was measured using the immunoassay system (Advia Centaur XP, Siemens, USA) by chemiluminescent immunoassay. The blood analysis was performed at Jeju University Hospital.

4) Insulin resistance

Insulin resistance was analyzed according to the HOMA-IR; the calculation formula is as follows (Matthews et al., 1985):

$$\text{HOMA-IR} = \text{FI } (\mu U/mL) \times \text{FG } (mg/dL) / 405$$

5) Metabolic Syndrome (MS)

This study used the Pediatric Adolescent Standards defined by the International Diabetes Federation (IDF) in 2007. The diagnostic criteria are given in <Table 15>. The IDF diagnostic criteria published in 2007 are diagnosed as MS when it certainly includes abdominal obesity and has two or more of the remaining four components. MS is not defined in children under 10 years of age, and different criteria are used for the age group of 10–15 years and over 16 years. Diagnostic criteria for those over 16 years old are the same as those for adults.

Table 15. The International Diabetes Federation Definition of the at Risk Group and Metabolic Syndrome in Children and Adolescents

Metabolic risk factors	Cut-off points of each risk factor
Waist circumference	Obesity ≥90th percentile (or adult cutoff if lower) as assessed by waist circumference
Fasting glucose	≥ 100 mg/dL
Triglycerides	≥ 150 mg/dL
High density lipoprotein cholesterol	≤ 40 mg/dL
Blood pressure	≥130 mm Hg systolic or ≥85 mm Hgdiastolic
Metabolic syndrome definition: Three or more of the following	

by Zimmet et al., 2007

6) Physical fitness measurements

PF was examined in terms of muscle strength, muscle endurance, flexibility, and cardiopulmonary fitness, which are suggested health-related physical strength factors (Gordon & Pescatello, 2009). The evaluation of the PF test is based on the criteria of the Physical Activity Promotion System (PAPS) currently applied to elementary, middle, and high school students (Ministry of Education, 2009).

(1) Muscular strength test

Muscle strength is measured grip strength (GS) and back strength (BS) using a dynamometer (DW-701, Japan) and back strength dynamometer (T.K. K.5102, Japan), respectively.

To measure GS, the subjects were asked to stand in a relaxed posture with their legs wide, naturally straightened, and open at the shoulder width, and with both arms at 15° intervals from body. The display of the dynamometer faced outward, and the width was adjusted to fit the hand (the second joint of the finger was at right angles). The subjects were asked to pull “start” for 2 to 3 secs; the peak value was recorded in 0.1-kg increments. To measure BS, the subjects were asked to stand on the foot of the back strength dynamometer with a 15 cm wide stance. The subjects stretched their knees and arms and bent their upper body forward by 30° to hold the grip of the back strength dynamometer. The subjects adjusted the length of the back tension line to fit their height and then pulled it about 10 cm above the knee. The subjects were then asked to tilt their upper body at the “start” signal and pull the handle for 3 sec. This process was performed twice; the peak value is recorded in 0.1 kg units.

The GS and BS were calculated by dividing the measured value by weight (%) taking into consideration the obesity level of the subject; physical fitness was be evaluated according to the level of obesity. The calculation formula is as follows.

[GS / wt and GS / BS = measured value / weight]

(2) Muscular endurance test

Muscle endurance was measured by sit-up (SU). The subject was laid down in a comfortable position on their back, and the subject's knees were bent and such that the heel and the hip were at an angle of ninety degrees. The soles of the feet were kept flat so that they were spaced apart by a gap of one foot size. With the arms extended straight and the hands along the thighs, the upper body was then lifted up and forward so that the palm of the hand could slide up the thigh and wrap around the knee in response to a beeping sound once every three seconds. Then, when the measurer checked the time, the subject immediately went back to the ready position and repeatedly performed the upper SU. If the SU was not maintained for at least one second of the three-second interval, the SU was not counted, and if two in a row were not counted, then the count was terminated. A signal rhythm file for SU with a 'start' signal was played and the performance times were recorded.

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(3) Flexibility test

Flexibility is measured by sit and reach (SR) using T. K. K.5103 (Japan). Each subject was asked to sit in the correct posture with both soles fully contacting the vertical plane of the measuring instrument; the subject's two legs were spread open. Then the subject raised both hands, bent forward with the knees fully upright, and then pushed the measuring instrument to the maximum stop as slowly as possible. Then, the subject slowly pushed the instrument to stretch as far forward as possible with two middle fingers; the distance was measured at the point where the fingertip stopped after about two seconds. The subjects performed this method twice and recorded the peak measured values in 0.1 unit.

(4) Cardiorespiratory fitness test

Cardiorespiratory fitness was measured using a Progressive Aerobic Cardiovascular Endurance Run (PACER). A mark cone was set up at both ends of a 15 m distance and the subjects were instructed how to perform the shuttle run. After installing the mark cone at both ends of the 15 m distance, the subjects were instructed how to carry out PACER. The subjects started at a set line, and at the "depart" signal, ran across the 15 m distance before the signal from the audio equipment rang. Before the beep, the subjects were expected to arrive at the appointed position on the opposite side. They would wait until the signal sounded before returning to the starting position. If the subjects did not reach the specified position before the signal, they were allowed to change directions when the signal sounded. If the subjects did not reach the specified position before the second signal, they were eliminated. The total number of runs was logged.

7) The Physical Activity Promotion System standard and total score calculation

(1) Muscle strength test (Grip Strength)

Table 16. Grip Strength Evaluation Standard (kg)

Level \ Grade	Boys		Girls	
	4	5	4	5
Very Low	8.9～11.4	9.9～12.4	8.5～10.4	10.6～11.9
Low	11.5～14.9	12.5～16.9	10.5～13.4	12.0～15.4
Medium	15.0～18.4	17.0～22.9	13.5～17.9	15.5～18.9
High	18.5～30.9	23.0～30.9	18.0～28.9	19.0～28.9
Very High	31.0～36.0	31.0～37.0	29.0～33.6	29.0～35.0

(2) Muscle endurance test (Sit-up)

Table 17. Sit-up Evaluation Standard (num)

Level \ Grade	Boys		Girls	
	4	5	4	5
Very Low	0～6	0～9	0～5	0～6
Low	7～21	10～21	6～17	7～22
Medium	22～39	22～39	18～28	23～35
High	40～79	40～79	29～59	36～59
Very High	80～120	80～120	60～90	60～90

(3) Flexibility test (Sit and reach)

Table 18. Sit-up Reach Evaluation Standard (cm)

Level \ Grade	Boys		Girls	
	4	5	4	5
Very Low	-5.1～-4.1	-5.1～-4.1	-0.1～0.9	-0.1～0.9
Low	-4.0～0.9	-4.0～0.9	1.0～4.9	1.0～4.9
Medium	1.0～4.9	1.0～4.9	5.0～6.9	5.0～6.9
High	5.0～7.9	5.0～7.9	7.0～9.9	7.0～9.9
Very High	8.0～18.0	8.0～18.0	10.0～22.0	10.0～22.0

(4) Cardiorespiratory fitness test (Pacer)

Table 19. Progressive Aerobic Cardiovascular Endurance Run Evaluation Standard (num)

Level \ Grade	Boys		Girls	
	4	5	4	5
Very Low	19～25	22～28	16～20	18～22
Low	26～44	29～49	21～39	23～44
Medium	45～68	50～72	40～56	45～62
High	69～95	73～99	57～76	63～84
Very High	96～103	100～107	77～100	85～104

(5) Obesity test (body mass index)

Table 20. Body Mass Index Evaluation Standard (kg/m^2)

Level \ Grade	Boys		Girls	
	4	5	4	5
Under Weight	14.0 below	14.3 below	14.3 below	14.6 below
Normal Weight	14.1～20.1	14.4～20.9	14.4～21.1	14.7～21.7
Over Weight	20.2～22.3	21.0～23.3	21.2～23.7	21.8～24.4
Mild Obesity	22.4～32.3	23.4～33.3	23.8～33.8	24.5～34.5
Severe Obesity	32.4 above	33.4 above	33.9 above	34.6 above

(6) Total score calculation of the Physical Activity Promotion System

Table 21. Total Score Calculation of Physical Fitness (score)

Classification	Level 1 (80～100)	Level 2 (60～79)	Level 3 (40～59)	Level 4 (20～39)	Level 5 (0～19)
GS	20	20	20	20	20
SU	20	20	20	20	20
SR	20	20	20	20	20
PACER	20	20	20	20	20
BMI	20	20	20	20	20

BMI: body mass index, GS: grip strength, PACER: progressive aerobic cardiovascular endurance run, SR: sit and reach, SU: sit-up

(7) Group classification for the levels obesity and physical fitness (applied PAPS criteria)

- Obesity level: normal group (1 ~ 2 levels), obesity group (3 ~ 5 levels)

- PF level: upper group (1 ~ 2 levels), lower group (3 ~ 5 levels)

8) Physical activity questionnaire

This section was analyzed in the same manner as in Study I.

9) Sexual maturity

This section was analyzed in in the same manner as in Study I.

4.2.4 Statistical analysis

Statistical Package for the Social Sciences (SPSS version 18.0 for Windows; SPSS Inc., Chicago, IL, USA) was used for all statistical analysis.

1) The categorical variable described the measurement items in terms of their frequency, whereas continuous variables were calculated for mean, standard deviation, and median values.

2) In the data analysis, PA results were divided into boy and girl students and obesity level (normal, obese) according to their physical and behavioral characteristics. The comparison of MS risk factors according to the level of obesity and PF (applied PAPS criteria) were analyzed by adjusting for gender and age. The significance level for the hypothesis test was set at $\alpha = .05$.

3) Independent samples t-test and Oneway Analysis of Variance (ANOVA) were used to analyze differences of the independent variable (obesity, PF) and the dependent variable (PF, PA, MS risk factors) for the subjects. Chi-square test method was used to analyze the prevalence of MS in the subjects.

4) Independent samples nonparametric test (Mann-Whitney U test) was used to compare the average level of PA (non-normal distribution) of subjects.

5) Pearson's correlation was used to analyze the correlation of obesity, PA (Log-transformed value), PF level, and MS risk factors in the subjects.

6) Analysis of Covariance (ANCOVA) was used to compare the risk factors of MS according to the level of obesity and PF (applied PAPS standard) by adjusting for sexual maturity, age, and gender of subjects.

7) Analysis of Covariance (ANCOVA) was used to compare the risk factors of MS according to the level of PF (applied PAPS standard) by adjusting for sexual maturity, age, gender, and obesity of subjects.

8) Logistic regression was used for the analysis of MS risk factor diagnostic risk (relative risk and 95% CI) according to the level of obesity and PF (applied PAPS standard) by adjusting for sexual maturity, age, and gender of subjects.

9) Logistic regression was used for the analysis of MS risk factor diagnostic risk (relative risk and 95% CI) according to the PF level (applied PAPS standard) by adjusting for sexual maturity, age, gender, and obesity of subjects.

4.3 Results

The results of the obesity, PA, PF level and MS risk factors among elementary school students in Study II were as follows.

4.3.1 Anthropometric and body composition measurements

1) Mean values of body measurement and body composition by gender

<Table 22> presents the mean values of body measurement and body composition by gender.

Table 22. Mean Values of Body Measurement and Body Composition by Genders

Variable	Boys (n=202)	Girls (n=176)	Total (n=378)
Height (cm)	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
BMI (kg/m^2)	21.67±4.52	20.27±3.97	21.02±4.32
WC (cm)	71.50±12.20	65.86±10.26	68.88±11.67
HC (cm)	83.12±8.89	82.62±8.64	82.89±8.77
WHR (%)	0.86±0.06	0.79±0.06	0.83±0.07
WHtR (%)	0.49±0.07	0.45±0.06	0.47±0.07
BFM (kg)	13.60±8.36	12.54±7.02	13.10±7.77
PBF (%)	27.18±10.51	26.96±8.87	27.08±9.77
LBM (kg)	32.41±5.32	30.83±5.47	31.67±5.44
SMM (kg)	17.16±3.26	16.17±3.22	16.70±3.27

Mean±Standard Deviation
BFM: body fat mass BMI: body mass index, HC: hip circumference, LBM: lean body mass, PBF: percent body fat, SMM: skeletal muscle mass, WC: waist circumference, WHtR: waist circumference to height ratio, WHR: waist-hip ratio

2) Frequency of obesity by genders

<Figure 4> shows the frequency of obesity by gender. The frequency for boys was higher than that for girls. In total, BMI was 27.2%, WC was 24.9%, and PBF was 45%.

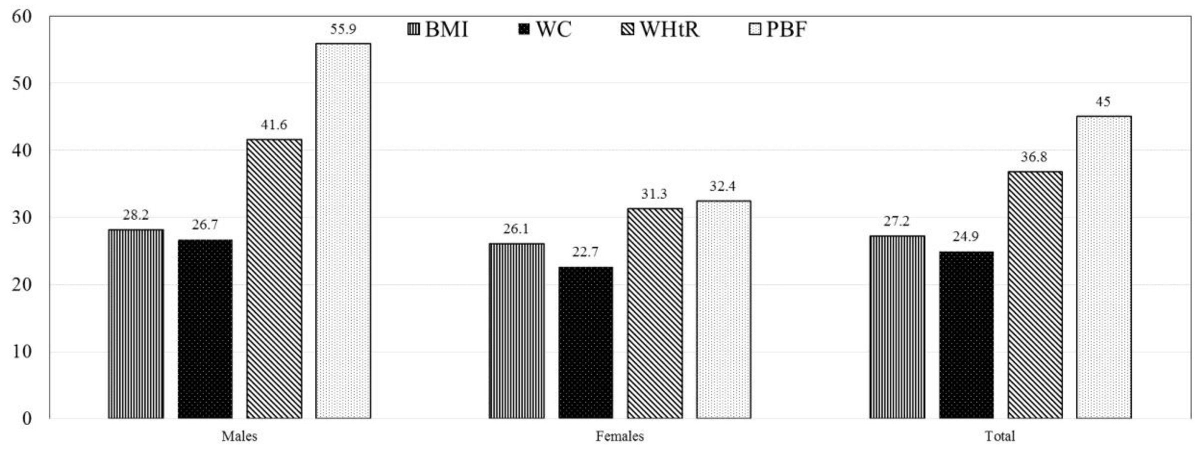

Figure 4. Frequency of Obesity by Genders (%)

4.3.2 Physical activity habit level survey

1) Mean values of physical activity habit by genders

As shown in <Table 23>, boys had higher levels of all PA habit than girls. However, boys also had higher levels of sedentary behavior than girls.

Table 23. Mean Values of Physical Activity Habits by Genders

Variable	Boys (n=202)	Girls (n=176)	Total (n=378)
VPA (min/week)	288.35±326.69 (180.00)	140.69±234.80 (0.00)	220.95±297.32 (60.00)
VPA METs (METs*min/week)	2306.79±2613.52 (1440.00)	1125.48±1878.37 (0.00)	1767.63±2378.55 (480.00)
MPA (min/week)	189.49±271.83 (45.00)	133.85±218.69 (0.00)	164.10±250.22 (4.50)
MPA METs (METs*min/week)	757.96±1087.33 (180.00)	535.42±874.74 (0.00)	656.39±1000.89 (18.00)
Walk (min/week)	247.73±330.57 (82.00)	157.45±244.14 (47.50)	206.53±297.36 (60.00)
Walk METs (METs*min/week)	824.36±1093.80 (287.10)	519.58±805.65 (156.75)	684.54±982.91 (198.00)
Total PA (min/week)	725.57±740.99 (435.00)	431.99±554.13 (250.00)	591.58±677.48 (350.00)
Total PA METs (METs*min/week)	3898.87±3976.86 (2460.75)	2180.48±2918.60 (1095.50)	3110.54±3629.35 (1807.50)
Sedentary (min/week)	217.97±229.47 (160.00)	188.02±222.46 (85.00)	203.16±226.21 (120.00)

Mean±Standard Deviation (median value)

METs: metabolic equivalent of task, MPA: moderate physical activity, VPA: vigorous physical activity, Total PA: total physical activity.

2) Frequency of physical activity habit between normal-weight and obese students

As shown in <Table 24>, obese students showed a lower level of PA habit than normal-weight students (excluding girls' VPA).

Table 24. Frequency of Physical Activity Habit between Normal and Obese Students

Variable	Boys (%)		Girls (%)		Total (%)	
	Normal	Obese	Normal	Obese	Activity	Inactive
VPA Never	54 (37.2)	28 (49.1)	73 (56.2)	23 (50.0)	200 (52.9)	178 (47.1)
MPA Never	65 (44.8)	30 (52.6)	67 (51.5)	25 (54.3)	191 (50.5)	187 (49.5)
Walk Never	53 (36.6)	28 (49.1)	58 (44.6)	22 (47.8)	217 (57.4)	161 (42.6)
Total PA Never	27 (18.6)	18 (31.6)	43 (33.1)	15 (32.6)	275 (72.8)	103 (27.2)

by BMI standard ≥ 95^{th} percentile

MPA: moderate physical activity, VPA: vigorous physical activity, Total PA: total physical activity.

3) Classification by metabolic equivalent of task among normal-weight and obese students

As shown in <Table 25>, normal-weight students showed higher HEPA and MA scores compared with obese students; obese students showed a lower frequency of activity.

Table 25. Classification by Metabolic Equivalent of Task among Normal and Obese Students

Variable	Boys (%)		Girls (%)		Total (%) (n=378)
	Normal	Obese	Normal	Obese	
HEPA (≥ 3,000)	71 (49.0)	21 (36.8)	34 (26.2)	14 (30.4)	140 (37.0)
MA (≥ 600)	39 (26.9)	15 (26.3)	44 (33.8)	12 (26.1)	110 (29.1)
Inactive (< 600)	35 (24.1)	21 (36.8)	52 (40.0)	20 (43.5)	128 (33.9)

by BMI standard ≥ 95th percentile

by IPAQ standard METs (min/week)

HEPA: health enhancing physical activity, MA: minimally active.

4.3.3 Physical fitness measurement

PF was measured by GS, BS, flexibility, and SU. Mean values of PF by genders are shown in <Table 26>. GS / wt and BS / wt were used by dividing GS and BS by weight (wt) according to the obesity level of the subjects.

Table 26. Mean Values of Physical Fitness by Genders

Variable	Boys (n=202)	Girls (n=176)	Total (n=378)
LGS (kg)	18.05±4.76	17.34±4.68	17.72±4.73
RGS (kg)	19.21±4.83	19.00±5.13	19.11±4.97
GS/wt (%)	0.42±0.11	0.43±0.11	0.42±0.11
BS (kg)	48.19±12.30	41.06±10.28	44.85±11.92
BS/wt (%)	1.10±0.34	1.00±0.31	1.05±0.33
SR (cm)	5.13±6.51	9.25±7.83	7.07±7.44
SU (cm)	30.45±11.55	23.20±11.17	27.06±11.92
PACER (num)	59.16±31.31	49.48±23.75	54.60±28.39
TFS (RGS)	0.17±2.39	-0.24±2.31	-0.03±2.36
TFS (BS)	0.44±2.41	-0.53±2.38	-0.02±2.44

Mean±Standard Deviation

BS: back strength, BS/wt: back strength/weight, GS/wt: grip strength/weight, LGS: left grip strength, PACER: progressive aerobic cardiovascular endurance run, RGS: right grip strength, SR: sit and reach, SU: sit-up, TFS: total fitness score.

4.3.4 Metabolic syndrome risk factor measurement

1) Mean values of metabolic syndrome risk factors by genders

<Table 27> presents the mean values by genders of blood pressure, resting heart rate, blood glucose, TG, TC, HDL-C, LDL-C, insulin, insulin resistance, and hepatic index (AST, ALT).

Table 27. Mean Values of Metabolic Syndrome Risk Factors by Genders

Variable	Boys (n=202)	Girls (n=176)	Total (n=378)
SBP (mmHg)	110.52±16.52	108.29±16.08	109.48±16.33
DBP (mmHg)	63.69±10.45	64.11±11.17	63.88±10.78
RHR (beat/min)	84.07±11.62	71.45±116.36	78.18±80.05
Glucose (mg/dL)	91.16±22.87	69.39±142.03	81.03±98.78
TG (mg/dL)	97.22±62.18	89.50±155.27	93.62±115.27
TC (mg/dL)	167.64±24.58	164.01±22.47	165.95±23.66
HDL-C (mg/dL)	54.69±12.76	53.51±11.49	54.14±12.18
LDL_C (mg/dL)	89.71±32.73	44.67±212.93	69.15±147.36
Insulin (*μU/mL)*	49.24±88.63	12.73±182.49	32.25±141.33
HOMA-IR	13.10±30.41	9.93±15.76	11.66±24.86
AST (IU/L)	26.03±7.69	17.59±77.89	22.11±53.52
ALT (IU/L)	22.10±18.13	18.54±22.82	20.45±20.49

Mean±Standard Deviation

ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride.

2) Prevalence of insulin resistance and metabolic syndrome by genders

<Table 28> shows the prevalence of insulin resistance and MS by genders. Insulin resistance used HOMA-IR as a diagnostic standard. For MS, the study used IDF diagnostic criteria for childhood and adolescent MS. The results showed that 45.8% of the students had one or more MS risk factors, and 7.9% of students already had MS. A total of 74.1% of the students had insulin resistance.

Table 28. Prevalence of Insulin Resistance and Metabolic Syndrome by Genders (%)

Metabolic syndrome risk factors **(Cut-off points)**	**Boys** **(n=202)**	**Girls** **(n=176)**	**Total** **(n=378)**
Abdominal obesity WC ≥ 90^{th} percentile	54 (26.7)	40 (22.7)	94 (24.9)
Elevated blood pressure BP ≥ 90^{th} percentile	22 (10.9)	13 (7.4)	35 (9.3)
High triglycerides TG ≥ 110 mg/dL	32 (15.8)	32 (18.2)	64 (16.9)
Low HDL-C HDL-C ≤ 40 mg/dL	21 (10.4)	18 (10.2)	39 (10.3)
High glucose glucose ≥ 100 mg/dL	35 (17.3)	31 (17.6)	66 (17.5)
Prevalence of Metabolic Syndrome			
MSRF One or more	88 (55.7)	70 (44.3)	158 (41.8)
Metabolic syndrome	19 (9.4)	11 (8.0)	30 (7.9)
Insulin resistance HOMA-IR > 3	148 (75.5)	132 (78.6)	280 (74.1)

by IDF standard

HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, MSRF: metabolic syndrome risk factors.

3) Prevalence of non-alcoholic fatty liver disease by genders

AST and ALT, which measure liver function, are the basic tests for fatty liver diagnosis. As shown in <Table 29>, excessive AST and ALT levels were found in 5.8% and 8.5% of students, respectively. Non-alcoholic fatty liver is characterized by higher AST levels than ALT levels.

Table 29. Prevalence of Non-alcoholic Fatty Liver Disease by Genders (%)

Non-alcoholic fatty liver (Cut-off points)	Boys (n=202)	Girls (n=176)	Total (n=378)
Aspartate aminotransferase AST ≥ 33 IU/L	16 (7.9)	6 (3.4)	22 (5.8)
Alanine aminotransferase ALT ≥ 38 IU/L	20 (9.9)	12 (6.8)	32 (8.5)

ALT: alanine aminotransferase, AST: aspartate aminotransferase

4.3.4 Correlation between the levels of obesity, physical activity, physical fitness, and metabolic syndrome risk factors

1) Correlation between levels of obesity and physical activity

(1) Correlation between levels of obesity and physical activity among boys

As shown in <Table 30>, WC was negatively correlated with the level of total PA, total PA METs, and BPF. It was also negatively correlated with VPA, total PA, total PA METs, and sedentary time.

Table 30. Correlation between Levels of Obesity and Physical Activity among Boys

Correlation R *p*	BMI	WC	WHtR	PBF	LBM	SMM
VPA	-.101 .151	-.118 .094	-.072 .306	**-.148** **.037**	-.023 .749	-.006 .935
MPA	-.112 .113	-.129 .066	-.116 .099	-.102 .149	-.114 .108	-.116 .101
Walk	-.108 .128	-.112 .113	-.111 .116	-.121 .088	-.067 .347	-.057 .424
Total PA	-.134 .057	**-.147** **.037**	-.132 .060	**-.159** **.025**	-.065 .363	-.054 .445
Total PA METs	-.131 .064	**-.146** **.039**	-.123 .083	**-.162** **.023**	-.059 .407	-.047 .513
Sedentary	-.120 .111	-.125 .098	-.118 .120	**-.150** **.047**	-.047 .534	-.048 .526

BMI: body mass index, LBM: lean body mass, METs: metabolic equivalent of task, MPA: moderate physical activity, PBF: percent body fat, SMM: skeletal muscle mass, Total PA: total physical activity, VPA: vigorous physical activity, WC: waist circumference, WHtR: waist circumference to height ratio.

(2) Correlation between levels of obesity and physical activity among girls

As shown in <Table 31>, LBM was positively correlated with VPA, total PA METs, and SMM, as well as with VPA, total PA, and total PA METs.

Table 31. Correlation between Levels of Obesity and Physical Activity among Girls

Correlation R *p*	BMI	WC	WHtR	PBF	LBM	SMM
VPA	.050 .512	.041 .593	-.005 .949	-.075 .324	**.172** **.022**	**.178** **.018**
MPA	-.097 .201	-.089 .241	-.147 .052	-.145 .055	.066 .381	.070 .357
Walk	.013 .869	.007 .922	-.042 .583	-.045 .549	.120 .114	.119 .116
Total PA	.000 .999	-.001 .993	-.064 .398	-.079 .299	.147 .052	**.148** **.049**
Total PA_METs	.013 .866	.010 .894	-.050 .511	-.074 .328	**.157** **.038**	**.159** **.035**
Sedentary	-.135 .074	-.147 .052	-.138 .068	.096 .207	-.145 .055	-.146 .053

BMI: body mass index, LBM: lean body mass, METs: metabolic equivalent of task, MPA: moderate physical activity, PBF: percent body fat, SMM: skeletal muscle mass, Total PA: total physical activity, VPA: vigorous physical activity, WC: waist circumference, WHtR: waist circumference to height ratio.

2) Correlation between levels of obesity and physical fitness

(1) Correlation between levels of obesity and physical fitness among boys

As shown in <Table 32>, BMI, WC, WHtR, and PBF were negatively correlated with GS/wt, BS/wt, SU and PACER.

Table 32. Correlation between Levels of Obesity and Physical Fitness among Boys

Correlation R *p*	BMI	WC	WHtR	PBF	LBM	SMM
LGS	**.359** **<.001**	**.372** **<.001**	**.235** **.001**	**.181** **.011**	**.615** **<.001**	**.602** **<.001**
RGS	**.403** **<.001**	**.409** **<.001**	**.249** **<.001**	**.227** **.001**	**.628** **<.001**	**.617** **<.001**
GS/wt	**-.603** **<.001**	**-.602** **<.001**	**-.546** **<.001**	**-.670** **<.001**	**-.304** **<.001**	**-.286** **<.001**
BS	**.304** **<.001**	**.300** **<.001**	**.245** **<.001**	**.127** **.074**	**.442** **<.001**	**.436** **<.001**
BS/wt	**-.583** **<.001**	**-.593** **<.001**	**-.460** **<.001**	**-.648** **<.001**	**-.421** **<.001**	**-.398** **<.001**
SR	**-.243** **<.001**	**-.324** **<.001**	**-.311** **<.001**	**-.285** **<.001**	**-.205** **.004**	**-.199** **.005**
SU	**-.465** **<.001**	**-.469** **<.001**	**-.489** **<.001**	**-.574** **<.001**	**-.144** **.043**	**-.108** **.128**
PACER	**-.570** **<.001**	**-.560** **<.001**	**-.505** **<.001**	**-.590** **<.001**	**-.309** **<.001**	**-.294** **<.001**
TFS (RGS)	**-.385** **<.001**	**-.411** **<.001**	**-.471** **<.001**	**-.440** **<.001**	-.039 .589	-.019 .789
TFS (BS)	**-.415** **<.001**	**-.447** **<.001**	**-.484** **<.001**	**-.480** **<.001**	-.104 .151	-.082 .259

BMI: body mass index, BS: back strength, BS/wt: back strength/weight, GS/wt: grip strength/weight, LBM: lean body mass, LGS: left grip strength, PACER: progressive aerobic cardiovascular endurance run, PBF: percent body fat, RGS: right grip strength, SMM: skeletal muscle mass, SR: sit and reach, SU: sit-up, TFS: total fitness score, WC: waist circumference, WHtR: waist circumference to height ratio.

(2) Correlation between levels of obesity and physical fitness among girls

As shown in <Table 33>, BMI, WC, and WHtR were negatively correlated with GS/wt, BS/wt, SU, and PACER.

Table 33. Correlation between levels of Obesity and Physical Fitness among Girls

Correlation R *p*	BMI	WC	WHtR	PBF	LBM	SMM
LGS	**.325** **<.001**	**.296** **<.001**	.118 .118	.074 .328	**.652** **<.001**	**.659** **<.001**
RGS	**.362** **<.001**	**.340** **<.001**	**.171** **.023**	.108 .156	**.662** **<.001**	**.667** **<.001**
GS/wt	**-.517** **<.001**	**-.519** **<.001**	**-.562** **<.001**	**-.619** **<.001**	**-.177** **.019**	**-.168** **.026**
BS	.093 .221	.063 .405	-.020 .793	-.044 .562	**.275** **<.001**	**.284** **<.001**
BS/wt	**-.625** **<.001**	**-.646** **<.001**	**-.603** **<.001**	**-.611** **<.001**	**-.462** **<.001**	**-.452** **<.001**
SR	-.033 .660	-.101 .182	-.123 .103	-.133 .079	.055 .469	.059 .436
SU	**-.232** **.002**	**-.236** **.002**	**-.287** **<.001**	**-.360** **<.001**	.022 .769	.032 .670
PACER	**-.439** **<.001**	**-.451** **<.001**	**-.474** **<.001**	**-.484** **<.001**	**-.183** **.015**	**-.178** **.018**
TFS (RGS)	-.107 .160	**-.153** **.044**	**-.266** **<.001**	**-.333** **<.001**	**.258** **.001**	**.268** **<.001**
TFS (BS)	**-.228** **.002**	**-.274** **<.001**	**-.342** **<.001**	**-.388** **<.001**	.068 .368	.079 .297

BMI: body mass index, BS: back strength, BS/wt: back strength/weight, GS/wt: grip strength/weight, LBM: lean body mass, LGS: left grip strength, PACER: progressive aerobic cardiovascular endurance run, PBF: percent body fat, RGS: right grip strength, SMM: skeletal muscle mass, SR: sit and reach, SU: sit-up, TFS: total fitness score, WC: waist circumference, WHtR: waist circumference to height ratio.

3) Correlation between levels of obesity and metabolic syndrome risk factors

(1) Correlation between levels of obesity and metabolic syndrome factors among boys

As shown in <Table 34>, BMI and WC were positively correlated with SBP, DBP, RHR, glucose, TG, insulin, HOMA-IR, AST, and ALT, and negatively correlated with HDL-C. WHtR was positively correlated with SBP, DBP, RHR, glucose, TC, TG, insulin, HOMA-IR, AST, and ALT, and negatively correlated with HDL-C. PBF was positively correlated with SBP, DBP, glucose, TC, TG, insulin, HOMA-IR, AST, and ALT, and negatively correlated with HDL-C.

(2) Correlation between levels of obesity and metabolic syndrome risk factors among girls

As shown in <Table 35>, BMI, WC, WHtR, and PBF were positively correlated with SBP, DBP, RHR, glucose, TG, insulin, HOMA-IR, AST, and ALT, and negatively correlated with HDL-C.

Table 34. Correlation between Levels of Obesity and Metabolic Syndrome Risk Factors among Boys

Correlation R *p*	BMI	WC	WHtR	PBF	LBM	SMM
SBP	**.377**	**.495**	**.471**	**.476**	**.426**	**.404**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
DBP	**.356**	**.447**	**.416**	**.415**	**.355**	**.357**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
RHR	**.185**	**.187**	**.143**	.123	**.204**	**.200**
	.009	**.008**	**.044**	.083	**.004**	**.005**
Glucose	**.292**	**.328**	**.283**	**.264**	**.299**	**.295**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
TG	**.277**	**.382**	**.382**	**.337**	**.238**	**.217**
	<.001	**<.001**	**<.001**	**<.001**	**.001**	**.002**
TC	.099	.100	**.148**	**.145**	-.051	-.041
	.171	.171	**.041**	**.045**	.489	.578
HDL-C	**-.376**	**-.515**	**-.474**	**-.474**	**-.440**	**-.406**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
LDL-C	.099	.044	.087	.107	-.031	-.025
	.151	.534	.216	.133	.659	.729
Insulin	**.375**	**.435**	**.371**	**.338**	**.432**	**.418**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
HOMA-IR	**.342**	**.396**	**.336**	**.305**	**.395**	**.381**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
AST	**.194**	**.166**	**.170**	**.143**	.088	.075
	.006	**.019**	**.016**	**.044**	.218	.291
ALT	**.422**	**.481**	**.468**	**.435**	**.354**	**.346**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**

ALT: alanine aminotransferase, AST: aspartate aminotransferase, BMI: body mass index, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LBM: lean body mass, LDL-C: low density lipoprotein cholesterol, PBF: percent body fat, RHR: resting heart rate, SBP: systolic blood pressure, SMM: skeletal muscle mass, TC: Total cholesterol, TG: triglyceride, WC: waist circumference, WHtR: waist circumference to height ratio.

Table 35. Correlation between Levels of Obesity and Metabolic Syndrome Risk Factors among Girls

Correlation R ***p***	**BMI**	**WC**	**WHtR**	**PBF**	**LBM**	**SMM**
SBP	**.451**	**.389**	**.310**	**.340**	**.454**	**.448**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
DBP	**.265**	**.202**	**.174**	**.177**	**.239**	**.238**
	<.001	**.007**	**.021**	**.019**	**.001**	**.002**
RHR	**.228**	**.207**	**.216**	**.202**	.137	.138
	.002	**.006**	**.004**	**.008**	.071	.069
Glucose	**.208**	**.218**	**.231**	**.245**	.055	.047
	.006	**.004**	**.002**	**.001**	.475	.536
TG	**.204**	**.190**	**.195**	**.200**	.083	.083
	.007	**.012**	**.010**	**.008**	.274	.276
TC	-.013	.010	.067	.051	-.129	-.127
	.863	.899	.388	.512	.098	.102
HDL-C	**-.510**	**-.499**	**-.470**	**-.468**	**-.377**	**-.374**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
LDL-C	.033	.063	.118	.122	-.099	-.100
	.667	.421	.129	.117	.201	.196
Insulin	**.484**	**.504**	**.500**	**.440**	**.286**	**.285**
	<.001	**<.001**	**<.001**	**<.001**	**<.001**	**<.001**
HOMA-IR	**.458**	**.475**	**.474**	**.428**	**.257**	**.256**
	<.001	**<.001**	**<.001**	**<.001**	**.001**	**.001**
AST	.076	.070	.144	.117	-.119	-.113
	.321	.362	.058	.125	.119	.137
ALT	**.316**	**.323**	**.382**	**.329**	.080	.084
	<.001	**<.001**	**<.001**	**<.001**	.295	.267

ALT: alanine aminotransferase, AST: aspartate aminotransferase, BMI: body mass index, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LBM: lean body mass, LDL-C: low density lipoprotein cholesterol, PBF: percent body fat, RHR: resting heart rate, SBP: systolic blood pressure, SMM: skeletal muscle mass, TC: Total cholesterol, TG: triglyceride, WC: waist circumference, WHtR: waist circumference to height ratio.

4) Correlation between levels of physical activity and physical fitness

(1) Correlation between levels of physical activity and physical fitness among boys

As shown in <Table 36>, VPA was positively correlated with BS, flexibility, SU, PACER, and TFS (RGS and BS), whereas MPA was positively correlated with flexibility, SU, and TFS (BS). Walking was positively correlated with GS/wt and flexibility, whereas total PA was positively correlated with GS/wt, BS, flexibility, PACER, TFS (RGS and BS). Sedentary time was positively correlated with flexibility and TFS (BS).

(2) Correlation between levels of physical activity and physical fitness among girls

As shown in <Table 37>, VPA was positively correlated with LGS, RGS, GS/wt, BS, flexibility, TFS (BS), whereas MPA and walking was positively correlated with BS and SU. Total PA was positively correlated with LGS, RGS, BS, SU, and TFS (RGS and BS).

Table 36. Correlation between Levels of Physical Activity and Physical Fitness among Boys

Correlation R *p*	**VPA**	**MPA**	**Walk**	**Total PA**	**Total PA METs**	**Sedentary**
LGS	.019	-.086	.029	-.012	-.001	-.030
	.790	.228	.687	.863	.994	.689
RGS	.062	-.030	.022	.027	.039	.008
	.381	.676	.752	.701	.583	.918
GS/wt	.118	.069	**.145**	.136	**.140**	.141
	.097	.330	**.041**	.055	**.049**	.063
BS	**.174**	.081	.117	**.163**	**.173**	.084
	.014	.253	.098	**.021**	**.015**	.272
BS/wt	.219	.182	.215	.257	.256	.181
	.002	.010	.002	.000	.000	.017
SR	**.219**	**.182**	**.215**	**.257**	**.256**	**.181**
	.002	**.010**	**.002**	**<.001**	**<.001**	**.017**
SU	**.149**	**.144**	.024	.124	.138	.066
	.036	**.044**	.738	.082	.054	.388
PACER	**.243**	.132	.116	**.227**	**.242**	.112
	.001	.062	.101	**.001**	**.001**	.138
TFS (RGS)	**.212**	.103	.082	**.168**	**.189**	.110
	.003	.152	.257	**.019**	**.009**	.152
TFS (BS)	**.257**	**.162**	.139	**.251**	**.270**	**.151**
	<.001	**.024**	.053	**<.001**	**<.001**	**.049**

BS: back strength, BS/wt: back strength/weight, GS/wt: grip strength/weight, LGS: left grip strength, MPA: moderate physical activity, PACER: progressive aerobic cardiovascular endurance run, RGS: right grip strength, SR: sit and reach, SU: sit-up, TFS: total fitness score, Total PA: total physical activity, VPA: vigorous physical activity.

Table 37. Correlation between Levels of Physical Activity and Physical Fitness among Girls

Correlation R *p*	VPA	MPA	Walk	Total PA	Total PA METs	Sedentary
LGS	**.234**	.109	.136	**.154**	**.172**	-.135
	.002	.149	.072	**.041**	**.023**	.073
RGS	**.221**	.074	.138	.140	**.158**	-.111
	.003	.331	.069	.064	**.037**	.144
GS/wt	**.154**	.131	.122	.132	.137	.040
	.042	.085	.107	.082	.070	.603
BS	**.151**	**.148**	**.176**	**.192**	**.184**	-.071
	.045	**.050**	**.019**	**.011**	**.015**	.352
BS/wt	.070	.143	.116	.128	.117	.076
	.357	.059	.126	.090	.123	.316
SR	.125	-.022	-.004	.039	.060	-.010
	.098	.771	.954	.607	.432	.895
SU	**.194**	**.210**	**.173**	**.206**	**.202**	-.056
	.010	**.005**	**.022**	**.006**	**.007**	.458
PACER	.040	.072	.053	.073	.062	-.073
	.601	.340	.486	.334	.416	.333
TFS (RGS)	**.228**	.107	.123	**.167**	**.180**	-.140
	.002	.157	.105	**.027**	**.017**	.065
TFS (BS)	**.195**	.138	.139	**.184**	**.185**	-.090
	.010	.067	.066	**.015**	**.014**	.237

BS: back strength, BS/wt: back strength/weight, GS/wt: grip strength/weight, LGS: left grip strength, MPA: moderate physical activity, PACER: progressive aerobic cardiovascular endurance run, RGS: right grip strength, SR: sit and reach, SU: sit-up, TFS: total fitness score, Total PA: total physical activity, VPA: vigorous physical activity.

5) Correlation between levels of physical activity and metabolic syndrome risk factors

(1) Correlation between levels of physical activity and metabolic syndrome risk factors among boys

As shown in <Table 38>, VPA was negatively correlated with SBP, insulin, and HOMA-IR, whereas MPA was positively correlated with TC and AST. Walking was positively correlated with TC and AST. Total PA was positively correlated with HDL-C, LDL-C, and AST, and negatively correlated with insulin and HOMA-IR.

(2) Correlation between levels of physical activity and metabolic syndrome risk factors among girls

As shown in <Table 39>, MPA was negatively correlated with glucose and TG, and total PA METs were negatively correlated with glucose. Sedentary time was negatively correlated with SBP and DBP, as well as AST.

Table 38. Correlation between Levels of Physical Activity and Metabolic Syndrome Risk Factors among Boys

Correlation R *p*	VPA	MPA	Walk	Total PA	Totla PA METs	Sedentary
SBP	**-.142**	-.103	-.012	-.116	-.134	-.017
	.046	.147	.868	.102	.059	.824
DBP	.061	-.074	.018	.012	.012	-.071
	.394	.295	.800	.870	.872	.352
RHR	.039	-.041	.004	.003	.002	-.005
	.581	.563	.955	.968	.977	.949
Glucose	-.094	-.120	-.065	-.111	-.118	-.053
	.183	.091	.365	.116	.097	.483
TG	-.095	-.046	-.028	-.095	-.102	-.031
	.181	.514	.695	.180	.154	.683
TC	.077	.057	**.155**	.128	.112	.061
	.288	.430	**.031**	.078	.125	.435
HDL-C	.124	.138	.123	**.155**	.150	.116
	.080	.052	.083	**.028**	.035	.126
LDL-C	.074	.054	.114	**.137**	.123	-.015
	.284	.435	.097	**.047**	.075	.842
Insulin	**-.188**	-.058	-.044	-.147	**-.169**	-.048
	.007	.413	.536	.037	**.017**	.525
HOMA-IR	**-.151**	-.063	-.062	-.126	**-.139**	-.091
	.028	.363	.372	.067	**.045**	.219
AST	.118	**.205**	**.167**	**.195**	**.170**	.153
	.096	**.004**	**.017**	**.006**	**.016**	.043
ALT	-.061	.008	-.069	-.049	-.061	-.052
	.389	.909	.331	.487	.394	.493

ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol , HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, METs: metabolic equivalent of task, MPA: moderate physical activity, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride, Total PA: total physical activity, VPA: vigorous physical activity.

Table 39. Correlation between Levels of Physical Activity and Metabolic Syndrome Risk Factors among Girls

Correlation R ***p***	**VPA**	**MPA**	**Walk**	**Total PA**	**Totla PA METs**	**Sedentary**
SBP	-.025 .746	-.042 .587	.013 .870	-.010 .895	-.019 .802	**-.192** **.012**
DBP	-.072 .345	-.095 .210	0.14 .858	-.061 .421	-.072 .343	**-.190** **.011**
RHR	-.005 .952	.072 .347	-.084 .271	-.047 .539	-.043 .571	-.045 .556
Glucose	-.057 .454	**-.226** **.003**	-.096 .212	-.164 .031	**-.153** **.046**	-.110 .152
TG	-.056 .458	**-.156** **.039**	-.104 .169	-.144 .057	-.133 .079	-.053 .488
TC	.025 .747	.037 .633	.053 .498	.045 .567	.037 .636	.048 .540
HDL-C	.026 .735	.104 .169	.053 .489	.065 .391	.051 .506	.133 .079
LDL-C	.032 .676	.094 .226	.082 .289	.082 .289	.071 .363	.050 .523
Insulin	.077 .319	-.064 .406	-.014 .859	-.033 .668	-.018 .811	-.102 .187
HOMA-IR	.051 .511	-.095 .220	-.050 .521	-.070 .364	-.054 .488	-.121 .118
AST	.037 .624	.019 .808	-.056 .467	.003 .973	.015 .841	**.178** **.018**
ALT	.020 .792	-.067 .378	-.079 .298	-.038 .622	-.016 .829	-.006 .935

ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, METs: metabolic equivalent of task, MPA: moderate physical activity, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride, Total PA: total physical activity, VPA: vigorous physical activity.

6) Correlation between levels of physical activity and metabolic syndrome risk factors

(1) Correlation between levels of physical activity and metabolic syndrome risk factors among boys

As shown in <Table 40>, LGS and RGS was positively correlated with SBP, DBP, glucose, insulin, and HOMA-IR, but negatively correlated with HDL-C. GS/wt negatively correlated with SBP, DBP, TC, TG, insulin, HOMA-IR, AST, and ALT, and positively correlated with HDL-C. BS was positively correlated with SBP, DBP, glucose, insulin, HOMA-IR, and ALT, but negatively correlated with HDL-C. BS/wt was negatively correlated with SBP, DBP, glucose, TG, insulin, HOMA-IR, and ALT, and positively correlated with HDL-C.

(2) Correlation between levels of physical activity and metabolic syndrome risk factors among girls

As shown in <Table 41>, GS/wt was negatively correlated with RHR, insulin, and ALT, and positively correlated with HDL-C. BS/Wt was negatively correlated with SBP, glucose, insulin, HOMA-IR, and positively correlated with HDL-C.

Table 40. Correlation between Levels of Physical Fitness and Metabolic Syndrome Risk Factors among Boys

Correlation R *p*	LGS	RGS	GS/wt	BS	BS/wt	SR	SU	PACER	TFS (RGS)	TFS (BS)
SBP	**.248**	**.248**	**-.288**	**.182**	**-.324**	-.064	**-.180**	-.111	-.038	-.058
	<.001	**<.001**	**<.001**	**.010**	**<.001**	.520	**.011**	.119	.597	.424
DBP	**.220**	**.242**	**-.235**	**.178**	**-.264**	-.072	**-.155**	-.128	-.062	-.084
	.002	**.001**	**.001**	**.012**	**<.001**	.318	**.029**	.073	.390	.244
RHR	.083	.089	-.118	.075	-.086	-.118	-.018	**-.236**	-.125	-.128
	.247	.214	.097	.295	.231	.102	.799	**.001**	.083	.077
Glucose	**.212**	**.238**	-.134	**.174**	**-.162**	-.051	-.093	**-.365**	**-.207**	**-.246**
	.003	**.001**	.059	**.014**	**.022**	.477	.189	**<.001**	**.004**	**.001**
TG	.012	.013	**-.323**	**.146**	**-.176**	-.083	**-.340**	**-.340**	**-.342**	**-.280**
	.865	.856	**<.001**	**.040**	**.013**	.249	**<.001**	**<.001**	**<.001**	**<.001**
TC	-.136	-.097	**-.161**	-.033	-.058	.021	-.142	-.006	-.111	-.085
	.062	.185	**.027**	.652	.427	.773	.051	.932	.131	.252
HDL-C	**-.227**	**-.223**	**.330**	**-.233**	**.278**	**.228**	**.335**	**.383**	**.313**	**.302**
	.001	**.002**	**<.001**	**.001**	**<.001**	**.001**	**<.001**	**<.001**	**<.001**	**<.001**
LDL-C	-.087	-.070	-.113	-.010	-.032	-.049	-.058	-.025	-.093	-.069
	.222	.323	.112	.885	.654	.498	.413	.723	.196	.341
Insulin	**.169**	**.223**	**-.242**	**.175**	**-.228**	**-.207**	**-.192**	**-.278**	**-.194**	**-.209**
	.017	**.002**	**.001**	**.013**	**.001**	**.004**	**.007**	**<.001**	**.007**	**.004**
HOMA-IR	**.157**	**.217**	**-.215**	**.168**	**-.202**	**-.182**	**-.152**	**-.243**	**-.174**	**-.191**
	.026	**.002**	**.002**	**.018**	**.004**	**.010**	**.031**	**.001**	**.015**	**.008**
AST	-.030	-.050	**-.157**	.073	-.062	-.013	-.077	-.097	-.118	-.062
	.670	.485	**.027**	..308	.386	.856	.282	.176	.102	.393
ALT	.120	.109	**-.337**	**.175**	**-.254**	-.120	**-.215**	**-.315**	**-.254**	**-.220**
	.092	.124	**<.001**	**.013**	**<.001**	.093	**.002**	**<.001**	**<.001**	**.002**

ALT: alanine aminotransferase, AST: aspartate aminotransferase, BS: back strength, BS/wt: back strength/weight, DBP: diastolic blood pressure, GS/wtt: grip strength/weight, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, LGS: left grip strength, PACER: progressive aerobic cardiovascular endurance run, RGS: right grip strength, RHR: resting heart rate, SBP: systolic blood pressure, SR: sit and reach, SU: sit-up, TC: Total cholesterol, TG: triglyceride, TFS: total fitness score.

Table 41. Correlation between Levels of Physical Fitness and Metabolic Syndrome Risk Factors among Girls

Correlation R *p*	LGS	RGS	GS/wt	BS	BS/wt	SR	SU	PACER	TFS (RGS)	TFS (BS)
SBP	**.273**	**.305**	-.116	**.184**	**-.183**	.029	-.065	.031	.130	.064
	<.001	**<.001**	.135	**.017**	**.017**	.712	.398	.690	.094	.409
DBP	**.175**	**.195**	-.021	.134	-.059	**.151**	-.114	.120	**.154**	.113
	.020	**.010**	.787	.076	.440	**.046**	.131	.114	**.041**	.137
RHR	-.016	-.039	**-.218**	.001	-.132	.108	-.075	**-.149**	-.053	-.034
	.835	.606	**.004**	.985	.083	.158	.323	**.050**	.487	.655
Glucose	.009	.017	-.127	-.088	**-.196**	.023	**-.224**	**-.220**	-.149	**-.187**
	.910	.830	.098	.253	**.010**	.762	**.003**	**.004**	.051	**.014**
TG	.055	.041	-.095	.036	-.082	-.012	.021	-.038	.008	.003
	.470	.589	.214	.639	.279	.879	.787	.613	.912	.974
TC	-.119	-.130	-.048	-.003	.074	**.155**	.072	.044	.067	.114
	.128	.095	.538	.974	.343	**.046**	.355	.572	.395	.143
HDL-C	**-.151**	**-.149**	**.319**	-.044	**.357**	.032	**.264**	**.324**	**.174**	**.216**
	.046	**.050**	**<.001**	.566	**<.001**	.673	**<.001**	**<.001**	**.021**	**.004**
LDL-C	-.129	-.129	-.096	-.032	.003	.145	-.003	-.010	.008	.049
	.097	.097	.218	.683	.971	.061	.969	.897	.917	.531
Insulin	.108	.106	-.286	-.069	**-.353**	-.111	**-.202**	**-.260**	**-.177**	**-.245**
	.160	.169	**<.001**	.371	**<.001**	.149	**.008**	**.001**	**.021**	**.001**
HOMA-IR	.134	**.168**	-.111	-.027	**-.262**	-.014	-.087	-.170	-.028	-.109
	.083	**.030**	.153	.731	**.001**	.858	.265	**.028**	.718	.159
AST	-.046	-.064	-.041	.100	.085	-.021	-.011	-.031	-.054	.012
	.546	.402	.594	.189	.265	.782	.882	.683	.484	.878
ALT	.036	.030	**-.173**	.095	-.106	-.045	-.116	**-.165**	-.113	-.089
	.633	.695	**.023**	.210	.161	.552	.126	**.030**	.168	.240

ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol , HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride.

4.3.5 Comparison between levels of physical activity, physical fitness and metabolic syndrome risk factors

1) Comparison of physical activity level by body mass index in normal-weight and obese students

<Table 42> shows the results of comparison of PA level according to BMI (95^{th} percentile) in boy and girl students. As shown in <Table 42>, non-obese boys were significantly higher in walking and total PA compared with obese students. No significant difference was observed in girls.

Table 42. Comparison of Physical Activity 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)	
VPA (min/week)	311.00±337.52 (210.00)	226.75±289.08 (80.00)	.105	125.84±216.88 (0.00)	183.28±278.23 (7.50)	.309
MPA (min/week)	207.79±283.18 (60.00)	139.74±233.34 (0.00)	.165	133.83±206.29 (0.00)	133.91±253.43 (0.00)	.627
Walk (min/week)	273.74±339.53 (105.00)	177.00±296.22 (40.00)	**.039**	159.24±247.41 (50.00)	152.30±237.07 (21.00)	.879
Total PA (min/week)	792.53±766.72 (540.00)	543.49±637.21 (350.00)	**.028**	418.92±517.82 (260.00)	469.50±652.12 (232.50)	.949
Total PA METs (METs*min/week)	4249.73±4115.71 (2790.00)	2957.08±3436.37 (1626.00)	**.035**	2067.56±2680.09 (1095.50)	2504.52±3528.47 (1071.00)	.787
Sedentary (min/week)	238.22±237.99 (205.00)	164.52±197.63 (85.00)	.117	198.46±227.33 (115.00)	158.04±207.29 (0.00)	.227

Mean±Standard Deviation (median value)

Non-parametric comparison (median value compared)

by BMI standard ≥ 95^{th} percentile

METs: metabolic equivalent of task, MPA: moderate physical activity, VPA: vigorous physical activity, Total PA: total physical activity.

2) Correlation of physical fitness level by body mass index in normal-weight and obese students

As shown in <Table 43>, non-obese boys were significantly higher in all PF levels compared with obese students. Non-obese girls showed significantly higher scores in all PF levels compared with obese girls, except BS.

Table 43. Comparison of Physical 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 ≥ 95^{th} percentile

BS: back strength, BS/wt: back strength/weight, GS/wt: grip strength/weight, LGS: left grip strength, PACER: progressive aerobic cardiovascular endurance run, RGS: right grip strength, SR: sit and reach, SU: sit-up, TFS: total fitness score.

3) Correlation of the metabolic syndrome risk factors level by body mass index in normal-weight and obese students

As shown in <Table 44>, 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 HDC-C level.

Table 44. Comparison of Metabolic Syndrome Risk Factors 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)	
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

ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride.

4.3.6 Comparison of metabolic syndrome risk factors between levels of obesity and physical fitness

1) Comparison of metabolic syndrome factors across fatness and combined fitness level

As shown in <Table 45>, there was a significant difference in all MS risk factors between the groups except RHR and AST.

Table 45. Comparison of Metabolic Syndrome Factors across Fatness and Combined 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=105)	Total (n=380)	*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 a,b<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 a,b<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 a,b<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 a,b>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 a,b<d

Mean±Standard Deviation
adjusted by grade, gender, and sexual maturity
ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, N/A: not applicable, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride.

Table 46. Prevalence of Metabolic Syndrome Factors across Fatness and Combined 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)
MSRF One or more	20	18	37	83	158
Metabolic syndrome	0	0	5	25	30

MSRF: metabolic syndrome risk factors.

2) The risk of one or more metabolic syndrome factors across fatness and combined fitness level

<Figure 5> illustrates the risk of one or more MS factors across fatness and combined fitness level by adjusting for grade, gender, and sexual maturity. MS was assessed according to IDF's pediatric diagnostic criteria (Zimmet et al., 2007). As a result, the students who scored high in fatness and low in fitness had a significantly higher the risk of one or more MS factors (33.04 times) compared with students who scored low in fatness and high in fitness. High fatness and high fitness students had a significantly higher risk of one or more MS factors (9.03 times).

Table 47. Relative Risk of Metabolic Syndrome by Fatness and Combined Fitness Level

Variable	B	S.E	Wals	df	Sig.	EXP(B)	95% C.I.for EXP(B)	
							Lower	Upper
Gender	.603	.305	3.918	1	.048	1.827	1.006	3.320
Grade	.036	.271	.017	1	.896	1.036	.609	1.762
Sexual maturity(1)	-.044	.479	.009	1	.926	.957	.374	2.447
Fat+Fit_Group			95.608	3	.000			
Fat+Fit_Group(1)	.390	.366	1.136	1	.286	1.477	.721	3.027
Fat+Fit_Group(2)	2.201	.381	33.306	1	.000	9.031	4.277	19.070
Fat+Fit_Group(3)	3.498	.389	80.839	1	.000	33.039	15.413	70.821
Constant	-2.838	1.826	2.416	1	.120	.059		

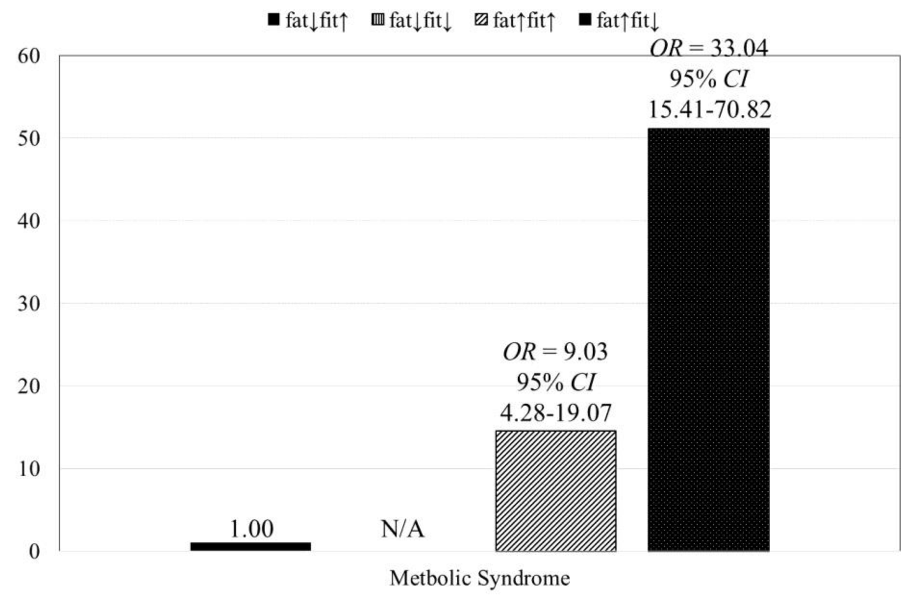

Figure 5. The Risk of One or More Metabolic Syndrome Factors across Fatness and Combined Fitness Level

3) Relative risk of metabolic syndrome by fatness and combined fitness level

<Figure 6> presents the relative risk of MS by fatness and combined fitness level by adjusting grade, gender, and sexual maturity. MS was assessed according to IDF's pediatric diagnostic criteria (Zimmet et al., 2007). High-fatness and low-fitness students had a significantly higher MS risk (51.12 times) compared with low-fatness and high-fitness students. High fatness and high fitness students had a significantly higher the risk of MS (14.53 times).

4) Comparison of metabolic syndrome factors across combined fitness level

<Table 49> presents the comparison of MS factors across combined fitness level. The high-fatness group had a significantly lower glucose, insulin, and HOMA-IR compared with low-fatness group.

Table 48. Relative Risk of Metabolic Syndrome by Fatness and Combined Fitness Level

Variable	B	S.E	Wals	df	Sig.	EXP(B)	95% C.I.for EXP(B)	
							Lower	Upper
Gender	.732	.453	2.613	1	.106	2.080	.856	5.054
Grade	.223	.423	.279	1	.598	1.250	.546	2.864
Sexual maturity(1)	-.853	.742	1.322	1	.250	.426	.100	1.823
Fat+Fit_Group			18.342	3	.000			
Fat+Fit_Group(1)	-16.408	4482.447	.000	1	.997	.000	.000	
Fat+Fit_Group(2)	2.676	1.118	5.732	1	0.17	14.533	1.625	129.981
Fat+Fit_Group(3)	3.934	1.041	14.282	1	.000	51.116	6.644	393.236
Constant	-8.635	3.046	8.038	1	.005	.000		

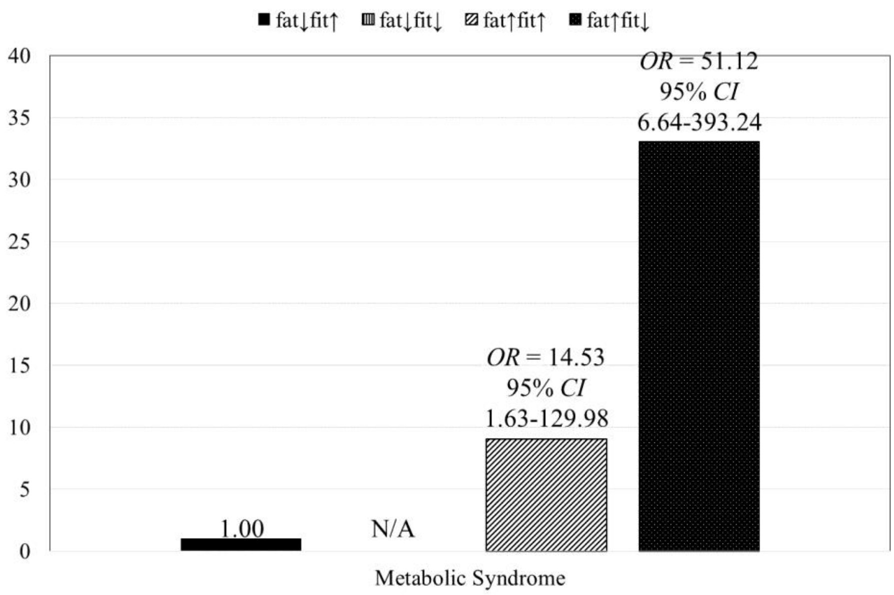

Figure 6. Relative Risk of Metabolic Syndrome by Fatness and Combined Fitness Level

Table 49. Comparison of Metabolic Syndrome Factors across Combined Fitness Level

Variable	High-Fitness (n=191)	Low-Fitness (n=189)	*p*
SBP (mmHg)	109.99±13.19	110.28±14.43	.052
DBP (mmHg)	63.80±9.44	63.67±10.96	.098
RHR (beat/min)	83.54±12.00	71.36±120.20	.105
Glucose (mg/dL)	85.67±10.45	91.65±13.94	**.001**
TG (mg/dL)	92.98±56.89	110.60±61.62	.326
TC (mg/dL)	166.83±22.49	165.30±25.25	.211
HDL-C (mg/dL)	55.87±11.01	51.61±11.54	.098
LDL_C (mg/dL)	92.37±20.11	91.57±22.20	.269
Insulin (μU/mL)	30.09±37.77	59.79±75.56	**.003**
HOMA-IR	6.77±10.44	15.01±21.39	**.002**
AST (IU/L)	24.64±9.38	25.20±8.67	.992
ALT (IU/L)	17.98±21.11	23.31±21.04	.450

Mean±Standard Deviation
adjusted by grade, obesity, gender, and sexual maturity
ALT: alanine aminotransferase, AST: aspartate aminotransferase, DBP: diastolic blood pressure, HDL-C: high density lipoprotein cholesterol, HOMA-IR: homeostasis model assessment of insulin resistance, LDL-C: low density lipoprotein cholesterol, RHR: resting heart rate, SBP: systolic blood pressure, TC: Total cholesterol, TG: triglyceride.

Table 50. Prevalence of Metabolic Syndrome Factors across Combined Fitness Level

Variable	High Fit (n=191)	Low Fit (n=187)	Total (n=378)
MSRF One or more	57	101	158
Metabolic syndrome	3	27	30

MSRF: metabolic syndrome risk factors.

5) The risk of one or more metabolic syndrome factors across combined fitness level

<Figure 7> illustrates the risk of one or more MS factors across combined fitness level by adjusting for obesity, grade, gender, and sexual maturity. MS was assessed according to IDF's pediatric diagnostic criteria (Zimmet et al., 2007). As a result, the low-fitness students had a significantly higher risk of one or more MS factors (2.27 times) compared with students who scored high-fitness students.

Table 51. The Risk of One or More Metabolic Syndrome Factors across Combined Fitness Level

Variable	B	S.E	Wals	df	Sig.	EXP(B)	95% C.I.for EXP(B)	
							Lower	Upper
Gender	.591	.303	3.801	1	.051	1.807	.997	3.274
Grade	.070	.269	.067	1	.796	1.072	.633	1.817
Sexual maturity(1)	-.056	.478	.014	1	.907	.946	.370	2.413
BMI_Group(1)	2.645	.288	84.219	1	.000	14.082	8.005	24.774
Fitness_Group(1)	.818	.256	9.510	1	.002	2.267	1.347	3.813
Constant	-.3.088	1.334	5.359	1	.021	.046		

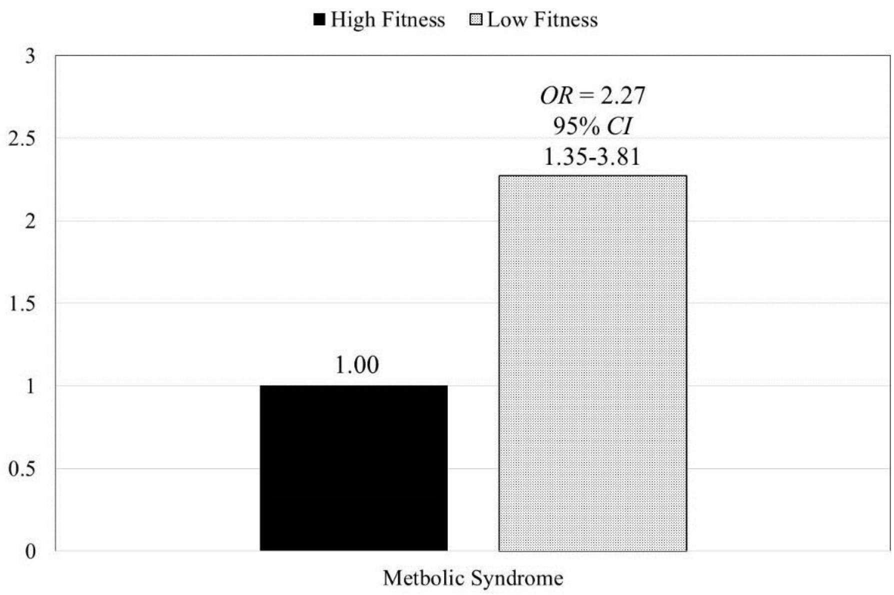

Figure 7. The Risk of One or More Metablic Syndrome Factors across Combined Fitness Level

6) Relative risk of metabolic syndrome by combined fitness level

<Figure 8> presents the relative risk of MS by combined fitness level by adjusting obesity, grade, gender, and sexual maturity. MS was assessed according to IDF's pediatric diagnostic criteria (Zimmet et al., 2007). Low-fitness students had a significantly higher MS risk (5.86 times) compared with high-fitness students.

Table 52. Relative Risk of Metabolic Syndrome by Combined Fitness Level

Variable	B	S.E	Wals	df	Sig.	EXP(B)	95% C.I.for EXP(B)	
							Lower	Upper
Gender	.588	.488	1.447	1	.229	1.800	.691	4.688
Grade	.514	.463	1.232	1	.267	1.671	.675	4.140
Sexual maturity(1)	-1.230	.870	1.999	1	.157	.292	.053	1.609
BMI_Group(1)	19.442	2692.037	.000	1	.994	2.777E8		
Fitness_Group(1)	1.768	.643	7.559	1	.006	5.860	1.661	20.670
Constant	-25.356	2692.038	.000	1	.992	.000		

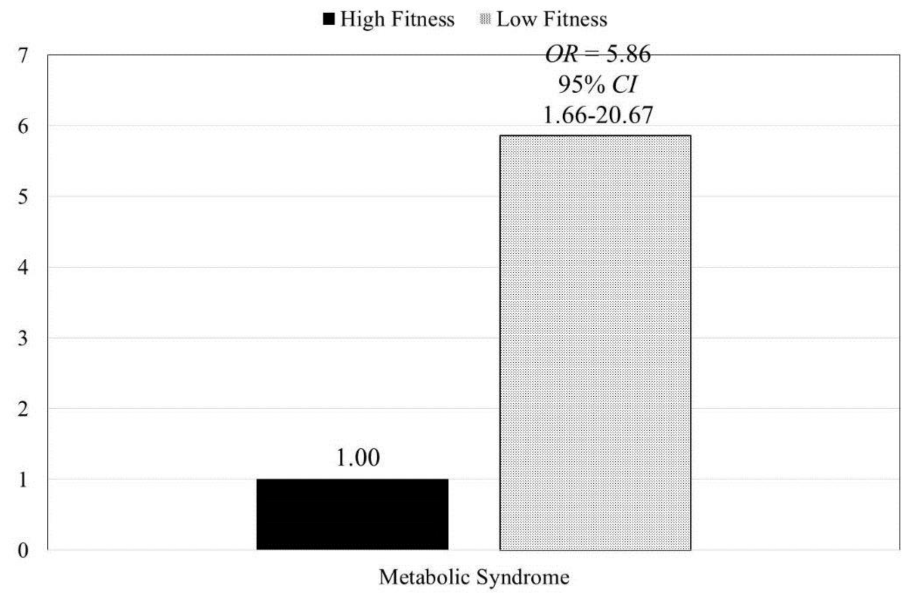

Figure 8. Relative Risk of Metabolic Syndrome by Combined Fitness Level

5. Discussion

This study aimed to investigate the relationship between obesity-related factors and the correlations of obesity-related factors in Jeju elementary school students by analyzing the students' home environment and personal health-related factors (PA, PF level, MS risk factor). The results of this study are as follows.

5.1 Correlation of the obesity level between parent and children

The current study showed that the BMI of boys was positively correlated with the BMI of their mothers, whereas the BMI of girls was positively correlated with the BMI of both parents.

The parental associations with obesity are already well known (S. E. Barlow, Bobra, Elliott, Brownson, & Haire-Joshu, 2007; Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). If one parent is obese, a child is more likely to become obese. Bahreynian et al. reported that the odds ratio (OR) of obesity was 2.79 with boys of obese-/overweight parents [OR = 2.79; 95% CI = 2.44-3.20] and 3.46 with girls of obese-/overweight parents [OR = 3.46; 95% CI = 3.03-3.94] compared with normal weight parents (Bahreynian et al., 2017). Liu et al. showed the parent–child relationship and correlates in weight status in the United States; children were 2.1 (95% CI: 1.6, 2.8) times more likely to be obese when only their fathers were obese, and 1.9 (95% CI: 1.5, 2.4) times more likely when only the mothers were obese. This OR was 3.2 (95% CI: 2.5, 4.2) when both parents were obese. The obesity of a parent is associated with the obesity of their children (Liu, Chen, Liang, & Wang, 2013). Furthermore, parental BMI was associated with elevated offspring BMI, WC, TG, and cardiorespiratory fitness, and the weight of parents was significantly associated with risk of CVD of children (McCarthy, Ye, Yuan, & He, 2015). Regular PA is the most important factor in preventing body fat accumulation over a long period of time, including considerations for heredity and environment (Faith, Tepper, Hoffman, & Pietrobelli, 2002). Thus, the parents' environment is an important multi-factorial contributor to obesity in childhood; regular physical activity is needed for preventing obesity of childhood (Bahreynian et al., 2017).

5.2 Correlation of the PA level between parent and children

We focused on the relationship between children and parents based on previous research results, and decided that it was necessary to understand the relationship between the lifestyle and health behavior (physical activity, etc.) in children and parents.

In this study, we found that walking in fathers was positively correlated with walking and total PA in boys, and that sedentary time for parents was positively correlated with sedentary time for boys. In the analysis of the correlation between PA level of parents and girls, the level of walking, total PA, and total PA METs in fathers was positively correlated with total PA METs in girls, and walking and total PA in mothers was positively correlated with total PA and total PA METs in girls. There is a positive correlation between parent- and child MPA, and it was shown that continuously improving the PA of parents was effective in increasing the level of PA of children (Fuemmeler, Anderson, & Masse, 2011). Fogelholm et al. reported stronger correlations with obesity and sedentary activity (inactivity) than with parent- and children PA, suggesting that attention should be paid to lifestyle to emphasize the role of parents (Liu et al., 2013). Thus, based on the results of our previous study, the PA level of children was closely related to that of the parents.

In this study, the PA of the subject was measured using the IPAQ. The questionnaire is used as a very valuable research tool in large-scale epidemiological studies. It consists of questions about the type, duration, and frequency of PA. This method has limitations in that accurate information cannot be obtained by monitoring the subjects. Although self-report questionnaires are commonly used, it is difficult to prepare a questionnaire depending on the age and condition of the subject. Self-report questionnaires are appropriate for children aged 10 years or more, and require a teacher or parent to help when used with children under 10 years of age. When using questionnaires with children, there may also be the concern whether the child or parent can correctly remember information about their activities. According to study, children were able to remember only about 50% of the body of work done in the last week (Baranowski, 1988). Furthermore, information bias can arise because the situation can be underestimated (height, weight, PA, eating habits, etc.) depending on educational factors and social needs. In order to supplement the limitations of this study, we distributed the questionnaire with the help of the teacher and the parents to explain to children how to complete the questionnaire. However, self-report questionnaires have many limitations in themselves, because respondents do not know the information accurately. On the other hand, classifying and analyzing the approximate level of PA of the subject, the questionnaire is very useful and an appropriate research tool. This study is meaningful because it was a basic study to observe the cross-sectional study.

5.3 Analysis of the levels of obesity, physical activity, physical fitness, and metabolic syndrome risk factors

We investigated the relationship and conducted a comparative analysis according to each factor by measuring obesity, PF, and MS risk factors in elementary students, as well as the parent-child correlations for the PA and obesity presented in Study I.

In the fourth grade of elementary school, there is a period of biological development and growing self-identity and interest in the body (Oh, 2011). Korea stipulated in the “School Health Law” that a school health checkup be conducted for fourth-grade elementary school students, in accordance with the 'Basic Act on Health Examination' (Korea Ministry of Government Legislation, 2012). Thus, it is meaningful to focus on the health status of the school-aged children above the fourth grade.

In this study, we found that normal-weight student boys had a significantly higher level of walking and total PA compared with obese student boys. No statistically significant difference was observed in normal-weight student girls. In addition, we found that all the PF levels were higher in normal-weight students; the health indicators of the normal-weight students were found to be significantly different from those of obese students.

Lifestyle is a crucial period that is largely determined in childhood and adolescence. In addition, obesity and decreased PA during this period can increase the risk of chronic diseases in adulthood. These results have been reported in a number of previous studies, and the current findings confirm that participation in regular PA has many health benefits. Many studies have reported the associations with PA, such as an inverse relationship with psychological and cognitive functions, early mortality, cardiovascular / coronary artery disease, hypertension, stroke, osteoporosis, type 2 diabetes, obesity, colon cancer, breast cancer, and depression (Min, Lee, Spence, & Jeon, 2017; The U.S. Department of Health and Human Services, 2008).

As a result of analyzing the risk of MS according to obesity and PF level by adjusting the grade, gender, and sexual maturity of the subjects, we found that students who had 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 the present study 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. Jekal et al. (2009), in a study of 12-week exercise interventions, reported lower cardiovascular risk for those with low obesity and high PF (Jekal et al., 2009). Furthermore, high levels of obesity and low levels of PF (muscle strength, endurance, and cardiopulmonary fitness) have been associated with increased risk factors for MS, leading to increased risk of CVD, hypertension, and hyperlipidemia (Bertoli et al., 2003; Jurca et al., 2004; Ouyang et al., 2004; Wessel et al., 2004).

In this study, we analyzed the risk of MS according to PF level by adjusting for obesity, grade, gender, and sexual maturity of the subjects in order to investigate the relationship between PF level and MS, as well as obesity level. Students with low-fitness showed a 5.86 times higher risk of developing MS than the students with high-fitness. These results c indicate that PF level is an important determinant in the development of MS.

When PF is low, the risk of premature death, from diseases such as metabolic disorder and CVD, is significantly increased; conversely, when PF is improved, the mortality rate is decreased (C. E. Barlow, Kohl III, Gibbons, & Blair, 1995; Eisenmann et al., 2007; The U.S. Department of Health and Human Services, 2008; Welk & Blair, 2000). Furthermore, MS is associated with cancer in which insulin resistance , as a common metabolic abnormality and an independent risk factor for CVD, and the insulin-like growth factor 1 system play an important role in the association of MS and cancer particularly adipocytes secreted by visceral fat cells, free fatty acids and aromatase activity (Pothiwala, Jain, & Yaturu, 2009; Uzunlulu, Caklili, & Oguz, 2016). MS is also involved in increased risk of cancer due to MS risk factors including obesity, dyslipidemia and Type 2 Diabetes Mellitus (T2DM).

Inflammation and hypoxia and MS is associated with various cancer including colorectal cancer, breast cancer, and endometrial cancer (Alokail et al., 2013; Bhandari, Kelley, Hartley, & Rockett, 2014; Braun, Bitton-Worms, & LeRoith, 2011; Esposito et al., 2013; Rosato et al., 2010; Veniou et al., 2016; Wu, Dong, Duan, Zhu, & Deng, 2017). MS can be reduced and influenced by various factors, in particular it is possible to prevent or treat it by exercise and PF. Vainshelboim B et al. reported that higher cardiorespiratory fitness was associated with lower total cancer incidence among 4,920 men aged 59.2±11.4 years in a study following health outcomes for 12.7±7.5 years (Vainshelboim et al., 2017). Inanother comparison study of an aerobic exercise intervention compared to usual care in 65 participants, the exercise intervention group (at least 120 mins/week of exercise) showed a significant decrease in MS z score in breast cancer survivors (Thomas, Alvarez-Reeves, Lu, Yu, & Irwin, 2013).

AST was found to be over 5.8%, and ALT was found to be over 8.5%. Non-alcoholic fatty liver is characterized by higher AST levels than ALT levels in analysis of the prevalence of non-alcoholic fatty liver in boy and girl students. MS is also associated with non-alcoholic fatty liver diseases (NAFLD) (Pothiwala et al., 2009). NAFLD also plays an important role in PA and PF (Roya Kelishadi, Cook, Amra, & Adibi, 2009; Rector & Thyfault, 2011). Furthermore, NAFLD is a major cause of liver disease in children (Schwimmer et al., 2006). Kelishadi R et al. reported that cardiorespiratory fitness had the highest inverse correlation with HOMA-IR and ALT, and that PA also had an inverse correlation with HOMA-IR and ALT in 95 youths (Roya Kelishadi, Cook, Amra, & Adibi, 2009). Kantartzis K et al. noted that fitness was the strongest factor, independently of adipose tissue (including total- and visceral adipose tissue), as well as exercise 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 et al., 2009).

Thus, PF, MS risk, cardiovascular risk factors and cancer risk factors are closely related, suggesting that PF is very important to prevent MS. Improvement of PF in children and adolescents is an especially important 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 and PF. However, PF also plays an important role in MS, NAFLD, and cancer (Estévez-López, Martinez-Tellez, & Ruiz, 2017; Earl S Ford & Li, 2006; Hashida et al., 2017), and there is a lack of research to determine the relationship between total PA and MS and MS-related diseases.

The MS criteria used the IDF Pediatric Adolescent MS Criterion in this study, whereas most previous studies used the modified NCEP Ⅲ diagnostic criteria. Many previous studies have not considered abdominal obesity as a necessary factor for the diagnosis of metabolic syndrome. However, the IDF diagnostic standard defines abdominal obesity as an essential factor for the diagnosis of MS. Considering that the MS is a collection of various symptoms caused by a common pathophysiology (Zimmet et al., 2007), it may be more appropriate to accept abdominal obesity as an essential factor in the diagnosis of MS.

The results of this study 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.

The results of this study showed that the participants had very high levels and frequency of insulin resistance and MS risk factors. 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.

6. Conclusions and Recommendations

This study aimed to investigate parent-child associations of PA levels and obesity, and to identify the significance of PF by analyzing development of MS according to PF levels in Jeju elementary students. The following conclusions were drawn.

First, the BMI of boys was positively correlated with those of their mothers. The BMI of girls was positively correlated with the BMI of both parents.

Second, the PA of boys was positively correlated with the PA level of their fathers. Girls showed a positive correlation with the PA level of their parents.

Third, there was a significant, positive difference between the level of PF and MS risk factors in normal-weight students compared to obese students.

Fourth, high-fatness and the low-fitness were associated with a higher risk of MS.

Fifth, low fitness levels were associated with a higher risk of MS.

Improving and developing health and well-being is possible by practicing the proper health behavior. School age is a time when health-related habits are formed. Promoting a child's healthy behavior is the basis for a healthy adulthood.

The study highlighted the fact that obese students not only have visible problems but are also at risk of serious health conditions. This work emphasizes the role of parents. The incidence and prevalence of obesity and low PA and PF in children and adolescents in Korea is becoming a social problem. Systematic and long-term research on childhood obesity has not been conducted owing to such conditions as lack of budget, insufficient workforce, and lack of networks such as the support of local professional manpower and facilities. We suggest that students undergo systematic management to prevent disease and improve PF.

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ABSTRACT (KOREAN)

국문초록

아동기의 건강관리는 그 어느 때보다 중요한 의미를 갖는다. 비만은 주로 충분하지 못한 수면시간과 신체활동, 건강하지 못한 식습관, 가정환경 등이 주요 기여 요인으로 알려져 있고, 높은 체력수준은 비만 예방뿐만 아니라 대사질환과 밀접한 관련이 있어 질환 예방 및 개선에 효과적인 것으로 알려져 있다. 그러나 제주지역 학생들의 비만율이 지속적으로 증가하고 있음에도 불구하고, 비만율 감소를 위한 관련 요인 조사나 연구는 부족한 실정이다. 이에 본 연구의 목적은 제주지역 초등학생을 대상으로 비만도, 체력수준, 대사증후군 위험요인 및 신체활동 참여습관을 조사하여 부모-자녀 간 신체활동과 비만 수준에 대한 관계 분석 및 체력수준에 따른 대사증후군 발생 위험을 분석하여 체력의 중요성을 규명하고자 하였다. 이를 위해 다음과 같이 총 2 가지의 연구로 나누어 진행하였다.

연구 1) 부모-자녀 간 신체활동과 비만 수준에 대한 관계 분석,

연구 2) 체력수준에 따른 대사증후군 발생 위험 분석

첫 번째, 부모와 자녀의 신체활동 참여습관 및 비만 수준에 대한 관계를 확인한 연구에서는 남학생 신체활동은 아버지의 신체활동량과 양의 상관관계가 나타났고, 여학생 신체활동은 부모 모두의 신체활동과 양의 상관관계가 나타났다. 비만 수준에서는

남학생의 체질량지수는 어머니의 체질량지수와 양의 상관관계, 여학생은 부모 모두의 체질량지수와 양의 상관관계가 나타났다.

두 번째, 체력수준에 따른 대사증후군 발생 위험을 분석한 연구에서는 대상자의 성별, 학년, 성 성숙도, 비만 수준을 통제한 후 체력수준에 따른 대사증후군 발생 위험도를 분석한 결과 체력수준이 낮은 학생이 체력수준이 높은 학생에 비해 대사증후군 발생 위험이 5.86 배 유의하게 높은 것으로 나타났다.

이러한 결과를 요약해보면 부모와 자녀의 신체활동 및 비만 수준은 밀접한 관계가 있으며, 높은 체력수준은 대사증후군 발생 위험을 감소하거나 예방할 수 있는 독립적인 요인임을 입증하였다. 아동기의 건강관리를 위해서는 가족단위의 신체활동 참여와 체력수준 향상이 필수적이다.

주요어: 초등학생, 비만, 신체활동, 체력, 대사증후군

APPENDIX

<조사 참여 동의서>

조사참여자용 설명서 및 동의서

조 사 제 목 : 「제주시 아동 비만 증가요인 설문조사」
연구책임자 : ０００ 교수 (제주대학교 의학전문대학원)

1. 조사 배경 및 목적

최근 5년간 시행한 전국 초·중·고등학교 학교건강검사 표본조사 통계에서 체질량 지수를 기준으로, **제주특별자치도의 비만 유병률이 전국 평균보다 높고 점점 심각**해지고 있습니다
(2014년 기준 **전국 평균 12.9%, 제주특별자치도 16.7%**).

본 조사는 제주시 소재 **초등학교 학생을 대상으로 건강상태 및 신체활동, 식생활을 측정**하여 제주 아동의 비만 요인을 분석함으로써 **제주시 아동의 비만율을 줄이고 건강증진을 위한 종합대책을 마련하는데 객관적 근거 제시**를 목적으로 합니다.

2. 실시기관 : 제주대학교병원

3. 조사과정

본 조사에서 개발된 자기기입식 설문지를 활용하여 조사가 진행되며, 조사 대상은 조사 참여에 동의한 초등학생 3~6학년과 학부모입니다.

설문조사는 2종류(△학생용, △학부모용)로, 설문지는 학생을 통해 전달될 예정이며 조사 참여에 동의하시는 학생 및 학부모님께서는 동의서와 함께 2종류의 설문지를 작성하시어 동봉된 봉투에 넣어 밀폐 후 전달하여 주시면 됩니다.

4. 조사 참여에 다른 위험성 및 불편사항

본 조사 참여에 따른 위험성은 없습니다만, 설문조사 참여에 따라 일정한 시간이 소요되며 설문지 배포 및 수거과정에서 개인정보의 유출 가능성을 최소화하기 위하여 설문지는 학급 내 번호와는 달리 별도의 코드로 표시될 예정이며 작성된 설문지는 동봉된 봉투에 넣어 밀폐 후 조사자에게 전달될 예정입니다.

5. 조사 참여에 따른 혜택

본 조사 참여로 귀하에게 직접적인 혜택은 없습니다. 그러나 본 조사 결과는 제주시 아동 비만율을 줄이고 건강증진을 위한 종합대책을 마련하는데 객관적 근거를 제시하는 자료로 활용될 것임을 알려드리는 바입니다.

6. 자유의사에 의한 조사 참여 동의 및 철회

본 동의서에 기술된 목적을 위하여 조사에 참여하는 것은 귀하의 자발적 의사에 의한 것이며 귀하께서는 본 조사에 참여하기를 거부하실 수 있으며 참여에 동의하셨더라도 중단하길 원하시면 언제든지 참여를 중단하실 수 있습니다. 본 조사에 참여하시려면 본 동의서 내용을 확인하신 후 서명란에 서명하시면 됩니다.

7. 신분의 비밀 보장

기록된 귀하의 기본정보 및 건강상태·신체활동·식생활은 다른 설문조사 참여자의 내용과 함께 종합한 결과로만 활용될 예정이며 귀하의 개인정보는 다른 곳에 이용되지 않을 것입니다.

8. 조사 참여자로서의 권익에 관한 정보 제공

구 분	소 속	성 명	연 락 처	이메일
책임연구원	제주대 의학전문대학원	0 0 0		
공동연구원	제주대 식품영양학과	0 0 0		
공동연구원	제주대 체육학과	0 0 0		
연구실무자	제주대병원 공공보건의료사업실	0 0 0		

제주대학교병원 의학연구윤리심의위원회 담당자	0 0 0		

※ 만일 본 조사에 문의사항이 있거나 문제가 발생할 경우, 상기 원구원에게 연락하여 주시기 바랍니다.

"제주시 아동 비만 증가 요인 설문조사"

조 사 참 여 동 의 서

본인은 본 동의서의 내용에 대해 설명을 들었고 동의서 내용을 읽고 이해하였으며 본인이 궁금해 하는 질문에 대한 답변을 들었습니다.

본인은 자발적으로 본 조사에 참여하는 것에 동의하므로 동의서에 서명합니다.

작 성 일 년 월 일

참 여 자	(서 명)	
책 임 연 구 자	(서 명)	
법 정 대 리 인 (미성년자의 경우)	(서 명)	
	참여자와의 관계	

<학생 설문지>

설문번호						
조 사 일	2015년 □□월 □□일					

제주 아동 비만 요인에 관한 학생 설문조사

안녕하십니까?

최근 5년간 시행한 초등학교 학교건강검사 표본조사 통계에서 비만도를 기준으로 한 제주특별자치도의 **비만 유병률이 전국에서 가장 높은 것**으로 보고되고 있습니다.

이에 본 연구는 **제주 아동의 비만 요인을 파악**함으로써 우리 아이들의 **비만율을 낮추고 건강증진을 위한 종합대책 마련의 기초자료로 활용**하고자 수행하고 있습니다.

번거우시더라도 제주 아이들의 비만문제를 해결하고 건강하게 자라날 수 있도록 **동참하시어 가능한 사실에 가깝게** 답하여 주시기 바랍니다.

본 조사 결과는 **개인적 자료로 분석되는 것이 아니라 조사된 모든 학생들의 평균자료로 분석되며 연구 목적 외에는 다른 어떤 목적에도 쓰이지 않도록 엄중하게 관리**될 것입니다.

학생들의 참여에 감사드리며 내내 건강과 행복 누리길 바랍니다.

감사합니다.

2015년 10월

제주시 보건소 / 제주대학교병원 / 제주대학교

아동비만 증가요인 조사연구팀

I 다음은 학생의 건강상태에 관한 조사입니다

1. 평소 **자신의 건강상태**가 어떻다고 생각합니까?
   ① 매우 건강한 편이다. ② 건강한 편이다. ③ 보통이다.
   ④ 건강하지 못한 편이다. ⑤ 매우 건강하지 못한 편이다.

2. 학생은 평균적으로 **하루 몇 시간 정도 잠**을 잡니까? (　　　　　) 시간

3. 다음은 여러분이 **스스로를 어떻게 생각하는지**를 물어보는 질문입니다. 각 문항을 읽고 자신의 생각에 해당되는 응답을 하나만 골라 ○표 하세요.

문 항	전혀 그렇지 않다	그렇지 않은 편이다	그런 편이다	매우 그렇다
1) 나는 내가 다른 사람들처럼 가치있는 사람이라고 생각한다	①	②	③	④
2) 나는 내가 좋은 성품을 가졌다고 생각한다	①	②	③	④
3) 나는 대부분의 다른 사람들처럼 일을 잘 할 수 있다	①	②	③	④
4) 나는 내 자신에 대하여 긍정적인 태도를 지니고 있다	①	②	③	④
5) 나는 내 자신에 대하여 대체로 만족한다	①	②	③	④
6) 나는 가끔 내 자신이 쓸모없는 사람이라는 느낌이 든다	①	②	③	④
7) 나는 대체로 내가 실패한 사람이라는 느낌이 든다	①	②	③	④
8) 나는 자랑스러워할 만한 것이 별로 없다	①	②	③	④
9) 나는 때때로 내가 좋지 않은 사람이라고 생각한다	①	②	③	④
10) 나는 내가 내 자신을 좀 더 존경할 수 있게 되었으면 좋겠다	①	②	③	④

4. 다음은 여러분의 **신체에 대한 생각**을 묻는 질문입니다. 각 문항을 하나씩 읽고 그 문항에 대해 자신이 어디에 해당되는지 하나를 골라 ○표 하세요.

문 항	전혀 그렇지 않다	그렇지 않은 편이다	그런 편이다	매우 그렇다
1) 나는 언제나 남들 앞에 나가기 전에 내 모습이 괜찮은지 확인한다	①	②	③	④
2) 나의신체는 섹시한 매력이 있다	①	②	③	④
3) 나는 언제나 살찐 것에 대해 또는 살이 찔까봐 걱정한다	①	②	③	④
4) 나는 내 모습그대로가 좋다	①	②	③	④
5) 나는 수시로 거울에 비친 내 모습을 살펴본다	①	②	③	④
6) 나는 외출 전 준비하는 시간이 오래 걸린다	①	②	③	④
7) 나는 몸무게가 조금만 변해도 신경이 쓰인다	①	②	③	④
8) 대부분의 사람들은 나를 예쁘다고 여길 것이다.	①	②	③	④
9) 내가 항상 멋있게 보이는 것은 중요하다	①	②	③	④
10) 나는 사람들이 내 외모에 대해 어떻게 생각하는지에 관심이 없다	①	②	③	④

문 항	전혀 그렇지 않다	그렇지 않은 편이다	그런 편이다	매우 그렇다
11) 나는 신체적인 매력이 없다	①	②	③	④
12) 나는 내 외모에 대해 관심이 없다	①	②	③	④
13) 나는 항상 내 외모를 향상시키려고 노력한다.	①	②	③	④

5. 현재 **자신의 체형**이 어떻다고 생각합니까?
① 매우 마른 편이다 ② 약간 마른 편이다 ③ 보통이다
④ 약간 살이 찐 편이다 ⑤ 매우 살이 찐 편이다

6. 학생은 **자신의 체형에 얼마나 만족**하고 있습니까?
① 전혀 만족하지 못한다 ② 만족하지 못하는 편이다 ③ 보통이다
④ 만족하는 편이다 ⑤ 매우 만족한다

7. **현재의 키와 몸무게**는 얼마입니까?
키: ( ) cm 몸무게: ( )kg

8. 학생이 **원하는 키와 몸무게**는 얼마입니까?
키: ( ) cm 몸무게: ( )kg

9. 학생은 체중 조절을 해본 경험이 있습니까?
① 있다 ② 없다 (☞ 13번 문항으로 가세요)

10. 체중조절을 해 본 경험이 있다면, 체중조절 노력을 계속한 기간이 최근 6개월 이상입니까, 미만입니까?
① 6개월 이상이다 ② 6개월 미만이다

11. 체중조절을 해 보았다면 그 이유는 무엇입니까?
① 움직이기 불편해서 ② 친구들이 놀려서 ③ 건강이 나빠져서
④ 날씬해지고 싶어서 ⑤ 멋있게 보이려고 ⑥기타 ( )

12. 학생은 살을 빼기 위해 노력한 경험이 있다면, 어떤 노력을 해 보았습니까?
해당 항목에 모두 ○표 해 주십시오.
① 식사량을 줄인다 ② 굶는다 ③ 간식을 먹지 않는다
④ 운동을 한다 ⑤ 다이어트를 하는 친구의 행동을 따라 한다
⑥ 병원에서 치료를 받는다. ⑦ 기타( )

13. 학생은 앞으로 6개월 이내에 몸무게 조절과 관리를 위한 노력을 할 계획이 있습니까?
① 있다 ② 없다

Ⅱ	다음은 학생의 신체활동에 관한 조사입니다

※ 다음은 사춘기에 접어든 학생들이 겪게 되는 신체적 성숙에 대한 질문입니다.
남학생과 여학생으로 구분하여 각각 응답해 주십시오.

☞ 남학생만 응답해 주세요

14. 사춘기가 되면 몽정(잠자는 동안 하얀 정액이 몸 밖으로 나오는 것)을 경험할 수 있습니다. 여러분은 이런 몽정을 경험한 적이 있습니까?
① 있다　　　　② 없다

☞ 여학생만 응답해 주세요

15. 사춘기가 되면 월경(생리)을 경험할 수 있습니다. 본인은 월경을 시작하였습니까?
① 예　　　　② 아니요

16. 월경을 시작했다면, **언제 처음 시작**하였습니까? □□□□년 □□월

지난 7일 동안 참여한 신체활동을 생각해 보십시오.
신체활동의 강도 및 방법에 따라 **△격렬한 신체활동, △중간 강도의 신체활동, △걷기, △좌식 활동으로 구분**하여 각각 응답해 주시기 바랍니다.

* **격렬한 신체활동** : 힘들게 움직이는 활동으로서 **평소보다 숨이 훨씬 더 차게 만드는 활동**입니다. **한 번에 적어도 10분 이상** 지속한 활동만을 생각해 보십시오.

** **중간 강도의 신체활동** : 중간정도 힘들게 움직이는 활동으로서 **평소보다 숨이 조금 더 차게 만드는 활동입니다. 한번에 적어도 10분 이상 지속한 활동**만을 생각해 보십시오.

1) 격렬한 신체활동

17. **지난 7일 동안**, 빠르게 운동장 달리기, 빠르게 줄넘기, 빠른 속도로 자전거 타기, 턱걸이, 아령들기, 농구, 축구, 인라인 스케이트, 에어로빅, 배드민턴, 탁구, 테니스 등과 같은 격렬한 신체활동을 며칠간 하였습니까?
① **일주일에** □일
② 격렬한 신체활동 없었음

18. 격렬한 신체활동을 실시한 날, **하루 평균** 실시한 시간이 얼마나 됩니까?
① **하루에** □□시간 □□분
② 모르겠다 / 확실하지 않다

2) 중간 강도의 신체활동

19. **지난 7일 동안**, 오름(등산), 천천히 운동장 달리기, 천천히 줄넘기, 천천히 자전거 타기, 배구, 볼링, 체조, 야구, 운동장이나 놀이터에서 놀기 등과 같은 **중간 강도의 신체활동을 며칠간** 하였습니까? 걷기는 포함시키지 마십시오.

① **일주일에** □일

② 중간정도 신체활동 없었음

20. 중간강도의 신체활동을 실시한 날, **하루 평균** 실시한 시간이 얼마나 됩니까?

① **하루에** □□시간 □□분

② 모르겠다 / 확실하지 않다

3) 걷기

지난 7일간 **걷기를 수행한 시간을** 생각해 보십시오.
학교와 집에서, 교통수단을 이용하기 위해 걸은 것 뿐 만 아니라, 오락 활동, 스포츠, 운동, 여가 시간에 걷기를 한 것도 포함됩니다.

21. **지난 7일간**, 적어도 10분 이상 걸은 날이 며칠입니까?

① **일주일에** □일

② 걷지 않았음

22. 걷기를 실시한 경우, **하루 평균** 걷기를 한 시간이 얼마나 됩니까?

① **하루에** □□시간 □□분

② 모르겠다 / 확실하지 않다

4) 좌식활동

지난 7일간, **주중에 앉아서 보낸 시간(좌식활동)**에 대한 질문입니다.
학교와 집, 학업이나 여가시간에 앉아서 보낸 시간을 의미합니다.
예를 들어 책상에서 컴퓨터를 사용한 시간, 오락 게임한 시간, 텔레비전을 앉아서 또는 누워서 시청한 시간, 독서를 수행한 시간들이 포함됩니다.

23. **지난 7일간**, 하루 평균 앉아서 보낸 시간이 보통 얼마나 됩니까?

① **하루에** □□시간 □□분

② 모르겠다 / 확실하지 않다

24. **운동방해 이유에 관한 질문입니다.** 귀하의 운동 참여에 **방해가 되는 이유**들에 대하여 응답하여 주시기 바랍니다. 모든 항목에 표기해 주십시오.

문 항	그렇지 않다	가끔 그렇다	자주 그렇다
1) 운동을 하는 것은 체력적으로 너무 힘들다.	①	②	③
2) 운동을 하는 것이 왜 필요한지 모르겠다.	①	②	③
3) 운동을 함께 할 친구나 가족이 없다.	①	②	③
4) 운동을 하는 것이 재미가 없다.	①	②	③
5) 운동 용품이 없다.(공, 라켓 등)	①	②	③
6) 운동을 하기에 너무 춥거나 너무 덥다.	①	②	③
7) 운동을 하는 방법을 잘 모른다.	①	②	③
8) 운동을 할 장소나 공간이 없다. (운동장, 체육관 등)	①	②	③
9) 운동을 할 만큼 건강이 좋지 않다.	①	②	③
10) 운동을 하다가 다칠 것 같다.	①	②	③
11) 운동할 시간이 없다.	①	②	③
12) 기타 이유____________________	①	②	③

25. 다음은 운동이나 적극적인 신체활동에 관한 여러분들의 생각을 묻는 문항입니다. 자신의 느낌을 가장 잘 표현하는 문항에 ○표 해 주십시오.

문 항	매우 어렵다	조금 어렵다	전혀 어렵지 않다
1) 나는 시간이 없다고 느낄 만큼 바쁠 때에도 규칙적으로 운동을 할 수 있다.	①	②	③
2) 나는 토요일 일요일 같은 휴일에도 규칙적으로 운동을 할 수 있다.	①	②	③
3) 나는 비가 오는 날이나 추운 겨울날에도 운동을 할 수 있다.	①	②	③
4) 나는 기분이 나쁠 때에도 운동을 할 수 있다.	①	②	③
5) 나는 피곤할 때에도 운동을 할 수 있다.	①	②	③
6) 나는 텔레비전을 보거나 인터넷 혹은 컴퓨터 게임을 할 수 있는 여유 시간에도 운동을 할 수 있다.	①	②	③
7) 나는 학교가 끝난 후에 쉽게 뛰어 놀거나 운동을 할 수 있다.	①	②	③

Ⅲ 다음은 학생의 식생활에 관한 조사입니다

26. 식사할 때 먹고 싶은 마음(식욕)은 어느 정도입니까?
① 식욕이 많다. ② 보통이다. ③ 식욕이 없다.

27. 식사속도는 어떠합니까? 어느 정도 입니까?
① 10분 이내 ② 10 ~ 15분 사이 ③15 ~ 20분 사이 ④ 20분 이상

28. 식사할 때 주로 무엇을 합니까?
① 먹기만 한다. ② 식구들과 이야기 한다.
③ 스마트폰이나 인터넷을 하며 먹는다 ④TV를 보면서 먹는다.
⑤ 책을 보면서 먹는다. ⑥ 기타 ( )

29. 저녁식사는 주로 어느 시간에 합니까?
① 저녁5~6시 ② 저녁6~7시 ③ 저녁7~8시 ④ 저녁8~9시 ⑤저녁9시 이후

30. 외식을 얼마나 자주 먹습니까?
① 거의 안한다 ② 한 달에 1~2번 ③ 한 달에 3번
④ 일주일에 1번 ⑤ 일주일에 2번 ⑥ 일주일에 3번 이상

31. 외식음식 중 가장 자주 먹는 것을 보기에서 골라 번호 순서대로 써주세요.
( ), ( ), ( )
① 삼겹살, 갈비 등의 육류 ② 생선류 ③ 중국음식 ④ 양식
⑤ 햄버거, 피자 등 패스트푸드 ⑥ 분식류 ⑦ 한식 ⑧ 기타( )

32. 외식 할 때 먹는 음식의 양은 평소의 식사량과 비교하면 어떻습니까?
① 평소보다 적게 먹는다. ② 평소와 비슷하게 먹는다. ③ 평소보다 많이 먹는다.

33. 배달음식은 얼마나 자주 먹습니까?
① 거의 안한다 ② 한 달에 1~2번 ③ 한 달에 3번
④ 일주일에 1번 ⑤ 일주일에 2번 ⑥ 일주일에 3번 이상

34. 배달음식 중 가장 자주 먹는 것을 보기에서 골라 번호 순서대로 써주세요.
( ), ( ), ( )
① 짜장면 등의 중국음식 ② 돈가스 등의 육류 ③ 양념 통닭 등의 튀김류
④ 햄버거, 피자 등의 패스트푸드 ⑤ 김밥, 떡볶기 등의 분식류
⑥ 도시락류 ⑦ 기타( )

35. 하루에 간식을 몇 번 먹습니까?
① 배일 3번 이상 먹는다 ② 배일 2번 먹는다 ③ 배일 1번 먹는다
④ 일주일에 3~4번 ⑤ 일주일에 1~2번
⑥ 간식을 거의 먹지 않는다

36. 간식을 먹는다면 주로 무엇을 먹습니까?
(가장 자주 먹는 간식 **세 가지**에 ○표 해주세요.)

1. 감자, 고구마	2. 빵	3. 떡	4. 과자	5. 김밥, 삼각 김밥
6. 햄버거	7. 피자	8. 치킨	9. 우유, 요구르트	10. 아이스크림
11. 탄산음료 (콜라, 사이다 등)	12. 라면, 컵라면	13. 떡볶이, 순대	14. 과일, 과일주스	15. 사탕, 초콜릿
16. 케이크, 도넛	17. 소시지, 핫도그	18. 기타 ( )		

37. 학교나 학원 주변에서 간식을 얼마나 사 먹습니까?
① 배일 3번 이상 먹는다 ② 배일 2번 먹는다 ③ 배일 1번 먹는다
④ 일주일에 3~4번 ⑤ 일주일에 1~2번
⑥ 간식을 거의 먹지 않는다

38. 학교나 학원 주변에서 주로 사먹는 간식은 무엇입니까?
(가장 자주 먹는 간식 **세 가지**에 ○표 해주세요.)

1. 감자, 고구마	2. 빵	3. 떡	4. 과자	5. 김밥, 삼각 김밥
6. 햄버거	7. 피자	8. 치킨	9. 우유, 요구르트	10. 아이스크림
11. 탄산음료 (콜라, 사이다 등)	12. 라면, 컵라면	13. 떡볶이, 순대	14. 과일, 과일주스	15. 사탕, 초콜릿
16. 케이크, 도넛	17. 소시지, 핫도그	18. 기타 ( )		

39. 간식을 자주 먹는 이유는 무엇입니까?
① 배가 고파서 ② 기분이 좋아서 ③ 기분이 나빠서
④ 심심해서 ⑤ 친구가 먹자고 해서 ⑥ 기타 ( )

40. 가장 좋아하는 음식의 맛은 어떤 것입니까?
① 단맛 ② 짠맛 ③ 신맛 ④ 쓴맛 ⑤ 감칠맛 ⑥ 매운맛

41. 음식의 짠맛 정도는 어떠합니까?
① 짜게 먹는 편이다. ② 보통이다. ③ 싱겁게 먹는 편이다.

42. 식습관 조사에 관한 문항입니다. **모든 항목**에 표기해 주십시오.

다음은 여러분의 **평소 식사 습관**에 대해 알아보고자 하는 문항들입니다.
다음 문항을 읽고 해당하는 곳에 ○**표** 해 주시기 바랍니다.

내 용	매일	5-6번 /1주	3-4번 /1주	1-2번 /1주	거의 먹지 않는다.
	항 상	자 주	보 통	아 주 가 끔	전 혀
1) 식사는 하루 3번 규칙적으로 먹는다.	①	②	③	④	⑤
2) 아침 식사를 규칙적으로 한다.	①	②	③	④	⑤
3) 음식은 배가 부를 때까지 먹는다.	①	②	③	④	⑤
4) 밥(정규식사)보다는 간식을 더 많이 먹는다.	①	②	③	④	⑤
5) 식사 후에 배가 불러도 맛있는 것이 있으면 또 먹는다.	①	②	③	④	⑤
6) 안 먹다가 한꺼번에 몰아서 많이 먹는다.	①	②	③	④	⑤
7) 아침이나 점심보다 저녁을 더 많이 먹는다.	①	②	③	④	⑤
8) 잠들기 전에 야식을 먹는다.	①	②	③	④	⑤
9) 밥은 1공기 보다 많이 먹는다.	①	②	③	④	⑤
10) 야채나 나물 반찬을 자주 먹는다.	①	②	③	④	⑤
11) 과일을 자주 먹는다.	①	②	③	④	⑤
12) 돼지고기, 닭고기, 소고기 등 육류음식을 자주 먹는다	①	②	③	④	⑤
13) 음식을 가려먹는다 (편식하는 편이다).	①	②	③	④	⑤
14) 맵고, 짠 음식을 자주 먹는다.	①	②	③	④	⑤
15) 콜라, 사이다와 같은 탄산음료를 자주 먹는다.	①	②	③	④	⑤
16) 외식이나 생일잔치에 가게 되면 과식을 하게 된다.	①	②	③	④	⑤
17) 가공식품(햄, 통조림, 냉동식품)을 자주 먹는다.	①	②	③	④	⑤
18) 인스턴트 식품(라면, 3분 카레 등)을 자주 먹는다.	①	②	③	④	⑤
19) 패스트푸드(피자 햄버거 등)를 자주 먹는다.	①	②	③	④	⑤
20) 기름에 튀긴 음식이나 볶은 음식을 자주 먹는다.	①	②	③	④	⑤
21) 군것질(사탕, 과자 등)을 자주 한다.	①	②	③	④	⑤
22) 배가 고프지 않아도 음식이 있으면 무조건 먹는다.	①	②	③	④	⑤

Ⅳ 다음은 학생의 일반적 사항에 관한 조사입니다

43. 학생의 **성별**은 무엇입니까?
① 남자　　　　② 여자

44. 학생의 **생년월일**은 언제입니까?
□□□□년　□□월

45. 현재 **거주하고 있는 지역**은 어디입니까?
(　　　　　)시　(　　　　　　)읍/면/동

46. 현재 **함께 살고 있는 가족**을 모두 표시하여 주십시오.
※ 다른 지방의 직장·학교에 다니는 등의 이유로 같이 살지 않는 가족을 포함해 주세요
① 할아버지　② 할머니　③ 아버지　④ 어머니
⑤ 형제 또는 자매　⑥ 기타________　⑦ 없음

47. 주로 어떤 방법으로 **학교로 등교**하고 시간은 얼마나 걸립니까?

① 걸어서	(　　　　) 분
② 부모님 또는 친구 부모님 자가용을 이용해서	(　　　　) 분
③ 버스 등 대중교통을 이용해서	(　　　　) 분
④ 자전거를 이용해서	(　　　　) 분
⑤ 기타 (　　　　　　　　)	(　　　　) 분

48. 학생은 **몇 살 때부터 제주도에서 살고** 있습니까?
① 태어나서부터
② (　　)살 때부터

<부모 설문지>

설문번호						
조 사 일	2015년 □□월 □□일					

제주 아동 비만 요인에 관한 학부모 설문조사

안녕하십니까?

최근 5년간 시행한 초등학교 학교건강검사 표본조사 통계에서 비만도를 기준으로 한 제주특별자치도의 **비만 유병률이 전국에서 가장 높은 것**으로 보고되고 있습니다.

이에 본 연구는 **제주 아동의 비만 요인을 파악**함으로써 우리 아이들의 **비만율을 낮추고 건강증진을 위한 종합대책 마련의 기초자료로 활용**하고자 수행하고 있습니다.

번거우시더라도 제주 아이들의 비만문제를 해결하고 건강하게 자라날 수 있도록 **동참하시어 가능한 사실에 가깝게** 답하여 주시기 바랍니다.

본 조사 결과는 **개인적 자료로 분석되는 것이 아니라 조사된 모든 학생들의 평균자료로 분석되며 연구 목적 외에는 다른 어떤 목적에도 쓰이지 않도록 엄중하게 관리**될 것입니다.

학부모님들의 참여에 감사드리며 내내 건강과 행복 누리시길 바랍니다.

감사합니다.

2015년 10월

제주시 보건소 / 제주대학교병원 / 제주대학교
아동비만 증가요인 조사연구팀

Ⅰ 다음은 학부모의 신체적 건강에 관한 조사입니다

1. 응답하시는 분은 학생과 어떤 **관계**이십니까?

① 아버지　　② 어머니
③ 새아버지　　④ 새어머니
⑤ 할아버지　　⑥ 할머니
⑦ 기타(　　　　　　) (예, 삼촌, 고모, 이모 등)

2. 병원에서 아래의 **질병에 대해 진단 받은 적**이 있으면 학부모님 각각 해당란에 "예", 없으면 "아니오"로 응답해 주십시오. 학부모님이 안 계신 경우, 기타보호자란에 응답해 주십시오.

진 단 명	질병 유무					
	부		모		기타보호자	
1) 고혈압	① 예	② 아니오	① 예	② 아니오	① 예	② 아니오
2) 고지혈증	① 예	② 아니오	① 예	② 아니오	① 예	② 아니오
3) 당뇨병	① 예	② 아니오	① 예	② 아니오	① 예	② 아니오
4) 심장병	① 예	② 아니오	① 예	② 아니오	① 예	② 아니오
5) 각종 암 질환	① 예	② 아니오	① 예	② 아니오	① 예	② 아니오

※ 학부모님들은 두 분 모두 각각 □ 안에 해당 응답 번호를 기재해 주십시오.
학부모님이 안 계신 경우, 기타보호자란에 응답 번호를 적어 주십시오.

3. 지난 **한달 중 몇 일** 정도 담배를 피우셨습니까?

① 전혀 안 피웠다
② 1~2일
③ 3~5일
④ 6~9일
⑤ 10~19일
⑥ 20~29일
⑦ 30일 모두

부	모	기타보호자

4. 담배를 피웠다면 **하루 평균 몇 개피의 담배**를 피웠습니까?

① 피우지 않았다
② 1개피
③ 2~5개피
④ 6~10개피
⑤ 11~19개피
⑥ 20개피 이상

부	모	기타보호자

5. 지난 **한달 중 몇 일 정도 술을 마신 적**이 있습니까?

① 없다
② 1~2일
③ 3~5일
④ 6~9일
⑤ 10~19일
⑥ 20~29일
⑦ 30일 모두

부	모	기타보호자

6. 지난 한달 동안 술을 마신 날 중, 몇 일 정도 **하루에 소주 5잔 또는 맥주 3병 이상**의 술을 마셨습니까?

① 없다
② 1~2일
③ 3~5일
④ 6~9일
⑤ 10~19일
⑥ 20일 이상

부	모	기타보호자

7. 귀하의 **신체적 이미지**에 대하여 스스로 어떻게 생각하십니까?

① 아주 마름
② 약간 마름
③ 정상
④ 약간 뚱뚱함
⑤ 아주 뚱뚱함

부	모	기타보호자

8. 귀하의 **신체적 이미지 관리를 위해 어떤 노력**을 하고 있습니까?

① 체중 감소
② 체중 증가
③ 안 함

부	모	기타보호자

Ⅱ	다음은 자녀의 신체적 건강에 관한 조사입니다

9. **학생**이 지금까지 다음과 같은 **질환을 치료받거나 진단**받은 경우가 있으면 해당질환에 모두 ○ 표를 하여 주십시오.

의학적 병력	예	아니오	진단받은 연도
1) 선천성 심장질환	① 예	② 아니오	
2) 간질	① 예	② 아니오	
3) 당뇨병	① 예	② 아니오	
4) 천식	① 예	② 아니오	
5) 아토피 피부염	① 예	② 아니오	
6) 주의력 결핍장애	① 예	② 아니오	
7) 악성 종양	① 예	② 아니오	

10. 가족 중 과체중 또는 비만인 사람이 있습니까? 해당 항목에 ○표 해 주십시오.
① 본인 ② 배우자 ③ 본인 부모님 ④ 배우자 부모님
⑤ 본인 형제자매 ⑥ 배우자 형제자매 ⑦ 자녀( )

11. 자녀의 체형에 대해 어떻게 생각하십니까?
① 매우 마른 편이다 ② 마른 편이다 ③ 적당하다 ④ 뚱뚱하다 ⑤ 매우 뚱뚱하다

12. 자녀의 체형에 대해 만족하십니까?
① 매우 만족한다 ② 만족한다 ③ 보통이다
④ 만족하지 못 한다 ⑤ 매우 만족하지 못 한다

13. 자녀가 살을 빼기 위해 노력한 경험이 있습니까?
① 있다 ② 없다

14. 자녀가 살을 빼기 위해 노력한 경험이 있다면, 자녀 스스로 어떤 방법을 시도해 보았습니까? 해당 항목에 모두 ○표 해 주십시오.
① 식사량을 줄인다 ② 굶는다 ③ 간식을 먹지 않는다
④ 운동을 한다 ⑤ 다이어트를 하는 친구의 행동을 따라 한다
⑥ 병원의 비만클리닉을 방문한다 ⑦ 기타( )
⑧ 해당없음

III	다음은 학부모의 신체활동에 관한 조사입니다

지난 7일 동안 참여한 신체활동을 생각해 보십시오.
신체활동의 강도 및 방법에 따라 **△격렬한 신체활동, △중간 강도의 신체활동, △걷기, △좌식활동으로 구분**하여 각각 응답해 주시기 바랍니다.

* 격렬한 신체활동 : 힘들게 움직이는 활동으로서 **평소보다 숨이 훨씬 더 차게 만드는** 활동입니다. **한 번에 적어도 10분 이상** 지속한 활동만을 생각해 보십시오.

** 중간 강도의 신체활동 : 중간정도 힘들게 움직이는 활동으로서 **평소보다 숨이 조금 더 차게 만드는 활동입니다. 한번에 적어도 10분 이상 지속한 활동**만을 생각해 보십시오.

※ 학부모님은 두 분 모두 각각 □란에 해당 응답 번호를 기재해 주십시오.
학부모님이 안 계신 경우, 기타보호자란에 응답 번호를 적어 주십시오.

1) 격렬한 신체활동

15. **지난 7일간,** 무거운 물건 나르기, 달리기, 에어로빅, 빠른 속도로 자전거 타기 등과 같은 격렬한 신체활동을 며칠간 하였습니까?
① **일주일에** (　　　　) 일
② 격렬한 신체활동 없었음

부	모	기타보호자

16. 격렬한 신체활동을 실시한 날, **하루 평균** 실시한 시간이 얼마나 됩니까?
① **하루에** (　　　　) 시간 (　　　　) 분
② 모르겠다 / 확실하지 않다

부	모	기타보호자

2) 중간 강도의 신체활동

17. **지난 7일간,** 가벼운 물건 나르기, 보통 속도로 자전거 타기, 복식 테니스 등과 같은 중간 강도의 신체활동을 며칠간 하였습니까? 걷기는 포함시키지 마십시오.
① **일주일에** (　　　　) 일
② 중간정도 신체활동 없었음

부	모	기타보호자

18. 중간강도의 신체활동을 실시한 날, **하루 평균** 실시한 시간이 얼마나 됩니까?
① **하루에** (　　　　) 시간 (　　　　) 분
② 모르겠다 / 확실하지 않다

부	모	기타보호자

3) 걷기

19. **지난 7일간,** 적어도 10분 이상 걸은 날이 며칠입니까?
① **일주일에** (　　　　) 일
② 걷지 않았음

부	모	기타보호자

20. 걷기를 실시한 경우, **하루 평균** 걷기를 한 시간이 얼마나 됩니까?

① **하루에** (　　　　) 시간 (　　　　) 분

② 모르겠다 / 확실하지 않다

부	모	기타보호자

4) 좌식활동

21. **지난 7일간**, **하루 평균** 앉아서 보낸 시간이 보통 얼마나 됩니까?

① **하루에** (　　　　) 시간 (　　　　) 분

② 모르겠다 / 확실하지 않다

부	모	기타보호자

Ⅳ 다음은 가족 식생활에 관한 조사입니다

22. 귀 댁의 **식사유형**은 어떠하십니까? 각 항목에 ○표 해 주십시오.

항 목	예	아니요
1) 가족 대부분이 한자리에 모여서 식사합니까?	① 예	② 아니오
2) 가족들은 아침을 규칙적으로 먹습니까?	① 예	② 아니오
3) 식사는 정해진 시간에 먹습니까?	① 예	② 아니오
4) 가족이 함께 간식 또는 야식을 자주 먹습니까?	① 예	② 아니오

5) 가족이 함께 간식 또는 야식을 먹는다면, 어떤 종류를 먹습니까?
자주 먹는 순으로 **2개만** ○표 하세요
( ), ( )
① 과자류 ② 튀김류(치킨류 등) ③ 빵, 케이크류 ④ 과일 및 주스류
⑤ 우유 및 유제품 ⑥ 라면 및 국수류 ⑥ 햄버거, 피자 등 ⑧기타 ( )

23. 가족의 한 끼 식사의 양은 어느 정도라고 생각하십니까?
① 적다 ② 조금 적다 ③ 적당하다 ④ 조금 많다 ⑤ 많다

24. 다른 가족과 비교하였을 때 우리 가족의 식사 속도는 어느 정도라고 생각하십니까?
① 느리다 ② 조금 느리다 ③ 보통이다 ④ 조금 빠르다 ⑤ 빠르다

25. 음식의 짠맛 정도는 어떠합니까?
① 짜게 먹는 편이다. ② 보통이다. ③ 싱겁게 먹는 편이다.

26. 자녀들과 함께하는 외식은 얼마나 자주 하십니까?
① 거의 안한다 ② 한달에 1~2번 ③ 한달에 3번
④ 일주일에 1번 ⑤ 일주일에 2번 ⑥ 일주일에 3번 이상

27. 외식 시, 드시는 음식의 양은 평소의 식사량과 비교하면 어떻습니까?
① 평소보다 적다 ② 평소와 비슷하다 ③ 평소보다 많다

28. 외식 시, **가장 자주 드시는 음식 3가지**를 골라 보기의 번호를 순서대로 써주세요.
( ), ( ), ( )
① 삼겹살, 갈비 등의 육류 ② 생선류 ③ 중국음식 ④ 양식
⑤ 햄버거, 피자 등 ⑥ 분식류 ⑦ 한식 ⑧ 기타( )

29. 자녀와 식사할 때 식사지도 나 식습관지도를 하십니까?
① 매일한다 ② 자주 한다 ③ 가끔한다
④ 거의 하지 않는다 ⑤ 전혀 하지 않는다

30. 자녀와 식사할 때 식사지도 나 식습관지도가 중요하다고 생각 하십니까?
① 매우 중요하다 ② 중요하다 ③ 그저 그렇다
④ 중요하지 않다 ⑤ 전혀 중요하지 않다

V 다음은 학부모의 일반적 사항에 관한 조사입니다

31. 학부모님의 연령, 학력, 신장 및 체중을 각각 응답해 주십시오. 학부모님이 안 계신 경우, 기타보호자란에 학생과의 관계를 기재하시고 해당 항목에 응답해 주십시오.

관 계	연령 (만)	학 력			신장(㎝)	체중(㎏)
		중졸 이하	고졸	대졸 이상 (전문대 포함)		
1) 부	만 □ □ 세					
2) 모	만 □ □ 세					
3) 기타 보호자 ( )	만 □ □ 세					

32. 학부모님의 현재 직업에 관한 문항입니다. 학부모님 각각에 대하여 ○표 해주십시오. 학부모님이 안 계신 경우, 기타보호자란에 해당항목에 대해 응답해 주십시오.

관 계	직업 유무		근무 형태		육체적 노동 강도				
	있다	없다	정상근무 (Full time)	시간제근무 (Part time)	매우 편함	비교적 편함	보통	비교적 힘듦	매우 힘듦
1) 부					①	②	③	④	⑤
2) 모					①	②	③	④	⑤
3) 기타보호자					①	②	③	④	⑤

33. 귀 댁의 가정형편(경제수준)이 어디에 해당한다고 생각합니까? 해당 항목에 ○표 해 주십시오.

매우 어렵다	비교적 어렵다	보통이다	비교적 여유롭다	매우 여유롭다
①	②	③	④	⑤