J. Exerc. Nutr. Biochem. 2015;19(2):99-106
ISSN : 2233-6834 (Print) ISSN : 2233-6842 (Online)
http://dx.doi.org/10.5717/jenb.2015.15060507

JENB
Exercise Nutrition & Biochemistry

ORIGINAL ARTICLE

The effect of physical activity on serum IL-6 and vaspin levels in late elementary school children

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(History: Received: 2015/04/13, Revised: 2015/06/01, Accepted: 2015/06/05, Published: 2015/06/30)

Hye-Ryun Hong, Chang-Duk Ha, Young-Yun Jin and Hyun-Sik Kang. The effect of physical activity on serum IL 6 and vaspin levels in late elementary school children. *JENB*., Vol. 19, No. 2, pp.99-106, 2015 **[Purpose]** This study investigates the effects of physical activity on serum IL-6 and vaspin in late elementary school children. **[Methods]** Those who (n = 220) completed the 7-day physical activity monitoring underwent a second round of measurements including body fat, serum glucose and insulin, and serum IL-6 and vaspin. One way ANOVAs followed by LSD post hoc tests were used to test for significant differences in dependent variables across incremental physical activity levels at $p = 0.05$. Multivariate stepwise linear regression analyses were used to determine significant predictors for serum IL-6 and vaspin levels at $p = 0.05$. **[Results]** The results showed significant inverse linear trends for body fat parameters across incremental physical activity levels (from low to high); the lower the body fat, the higher the physical activity levels. On the other hand, there were no significant linear trends for insulin resistance markers or dietary intake across incremental physical activity levels. Multiple stepwise linear regression analyses were used to determine significant predictors for individual variations in serum IL-6 and vaspin in the study population. We found that body mass index ($p = 0.002$) and low- and moderate-intensity physical activities ($p = 0.002$ and $p = 0.0045$, respectively) were significant determinants of serum IL-6. In addition, low- and moderate-intensity physical activities ($p = 0.01$ & $p = 0.022$, respectively) were significant determinants of serum vaspin levels in this study population. **[Conclusion]** In summary, the findings of the current study suggest that promotion of physical activity along with a healthy diet should be key components of lifestyle interventions to improve serum cytokine profiles associated with insulin resistance syndrome in late elementary school children. **[Key words]** physical activity, body fat, serum cytokines, IL-6, vaspin

INTRODUCTION

The increasing trend in childhood obesity can be attributed to energy imbalance, meaning relatively low energy utilization compared to the caloric intake [1]. In the long term, this imbalance results in not only surplus subcutaneous fat, but also in ectopic fat accumulation of neutral lipids in both the skeletal muscles and in hepatic tissue.

Body fat itself is a very important tissue that serves an energy repository with endocrine functions [2]. It also controls functions related to body metabolism, such as insulin sensitivity, fatty acid synthesis, glycometabolism, and appetite, in peripheral tissues including skeletal muscles and the liver [3]. On the other hand, excessive body fat, especially ectopic fat, increases the expression of insulin resistant cytokines (C-reactive protein, tumor necrosis factor-α, interleukin-6, retinol binding protein-4, leptin), reducing the expression of insulin sensitive cytokines (adiponectin, visfatin, vaspin) and having a compensatory effect on insulin resistance. Primarily, it causes an inflammatory reaction due to the imbalance of cytokine expression [4,5]. Secondly, it results in defunctionalization of the buffer action of adipose tissue, inducing insulin function degradation in the liver and in skeletal muscles. Ultimately, excessive body fat is known to play a key role in the development of insulin resistance and type 2 diabetes [6].

Studies have been actively conducted on the hormones and cytokines that induce insulin resistance and those secreted from body fat. Among them, the concentration of interleukin-6 (IL-6) secreted from subcutaneous adipocytes is three times higher than that from visceral adipocytes. The secreted IL-6

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stimulates neutral lipid synthesis in each tissue through the circulatory system to cause hypertriglyceridemia [7]. Also, the serum IL-6 concentration is not only significantly higher in insulin resistant and obese patients compared to normal people, but is also known to be an independent predictive factor for the risk of type 2 diabetes [8,9]. Especially from the perspective of causing insulin resistance, the IL-6 excessively secreted in the obese state originates from the fat within the abdominal cavity and directly circulates to the liver, where it stimulates the secretion of triglyceride. It was also reported to create insulin inducing sugar damage in the hepatocyte, and to damage the insulin signal transmission from the adipocyte [10].

Meanwhile, vaspin, which was recently discovered, is a member of the serine protease inhibitor family of cytokines that increases insulin sensitivity. The fact that extreme obesity or blood insulin level is apparent in the visceral adipose tissue of maximum age obese rat Otsuka Long-Evans Tokushima fatty (OLETF) was first reported recently by Hida *et al*. [11]. Serum vaspin concentration is stated to increase as a compensatory mechanism according to an increase in BMI or an increase in insulin resistance. According to the above study related to serum vaspin, vaspin expression and blood level are higher in overweight men and women compared to normal weight or obese individuals. As age increases while diabetes continues to progress, vaspin expression and blood level decrease. Therefore, decreased vaspin expression and blood level in diabetic and aging individuals can be recovered by diabetes treatment drugs such as insulin and thiazolidinedione (TZD) and through exercise. A notable point is that the increase in vaspin expression through exercise was the same level of increase in response to the administration of TZD. It is also known that the administration of recombinant human vaspin (rhVaspin) decreases the leptin, resistin, and TNF- a levels in rats that consumed high-fat, hyperglycemic diets and also significantly increases GLUT4 and adiponectin [12,13]. Additionally, it was reported that for non-active individuals, the vaspin concentration in the blood is increased by exercise training.

Thus, due to excessive intake energy, the increase in body fat subsequently increases the expression of insulin resistant cytokines in the peripheral organs, resulting in insulin resistance in peripheral organs such as the liver and skeletal muscles. Adipocyte, similar to vaspin in having a compensatory function on insulin resistance, secretes insulin sensitive cytokines to contribute to the maintenance of homoeostasis. Youn *et al*. [12] reported that the serum vaspin level of the normal weight group and the diabetic patients increased significantly after aerobic exercises such as regular running, cycling, and swimming for 4 weeks. Although there is no clear explanation available for increased serum vaspin secondary to physical activity, both serum vaspin and physical activity improve the insulin resistance syndrome, which is a common pathological denominator of diabetes, hyperlipidemia, and cardiovascular disease.

Physical activity not only burns adipose tissue, but is also an essential factor effecting insulin resistance and sensitivity. However, existing domestic studies on physical composition, insulin resistance and cytokines in the blood mostly involved obese patients including female university students and obese middle-aged women and therefore, lack quantified objective data on the role of physical activity on the insulin resistance and sensitivity of late school aged children. Therefore, the main purpose of this study was to identify the increase of body fat during adolescence in late school aged children, and to verify the role of physical activity on the level of cytokines in the blood.

METHODS

Study subject

For this study, a total of 220 students, 91 male students and 129 female students in the fifth and sixth grades of elementary school in S-city, Gyeonggi-do were recruited to perform all variable measurements including body mass index, insulin resistance index, serum interleukin-6 and vaspin content. The amount of physical activity and dietary intake were measured and statistical analysis was performed. Before the study, the content, purpose and related procedures were fully described to the subjects and their guardians. The participants voluntarily signed consent forms to participate in the study.

Measurement and analysis items

Measurement of all dependent variables was performed after 12 hours of gastric emptying. Height and weight measurements were performed by the researchers after receiving training according to the guidelines for standardization. The subjects were measured in comfortable clothes.

Body mass index

Wearing thin clothes, the weight was measured by using automatic measurement equipment (DS-102, JEnix Co., Korea). The percent body fat (%BF) was measured with the X-Scan Body Composition Analyzer (Jawon Medical Co.,

Korea), an automatic body composition analysis device utilizing bioelectric resistance. Body mass index (BMI) was calculated using the [weight(kg)/height(m)^2] formula, The waist measurement was obtained in the erect posture using a tape measure that circled the navel in parallel. The measurements were performed twice and the average was calculated to be used as the analysis data.

Insulin resistance index

To measure the serum-sugar level, after 12 hours of fasting, approximately 8ml of venous blood was collected from the brachial vein of the subject. A Green Vac-Tube in a gel-type activator was used to immediately perform centrifugation (3000rpm, 15 minutes) to separate the serum, which was stored in a -80℃ cryogenic refrigerator. The stored serum was analyzed for fasting blood glucose (FBG) by using the Vitro Chemistry DT60Ⅱ kit (Johnson & Johnson, NY, USA). Insulin was determined using the Human Insulin ELISA kit (ALPCO Diagnostics) (the CVs for intra- and interassays = 4.3% and 6.8%, respectively). For the Homeostasis model assessment of insulin resistance (HOMA-IR), [fasting insulin (μU/mL) × fasting glucose (mM)/22.5] was calculated, as described by Matthews *et al*. [14].

Serum interleukin-6 and vaspin

The serum obtained as described above and stored in the cryogenic refrigerator (-80℃) was used to analyze the concentration of serum interleukin-6 (Human IL-6 ELISA kit, DSL, Texas, USA) and vaspin (Human Vaspin ELISA kit, AdipoGen, Seoul, Korea).

Daily average physical activity and dietary intake

As the index of cardio pulmonary fitness, maximum oxygen intake was measured. For the maximum oxygen intake test, after over 4 hours of gastric emptying, an exercise tolerance test was performed with the Bruce protocol (1974), using a treadmill (Medtrack ST 65, Quinton, USA) and gas analyzer (True-one, Quinton, USA). The standard for reaching maximum capacity was first, 1.15 or higher respiratory exchange ratio, second, 17 or higher RPE, third, constant VO^2 value despite increased exercise intensity, and fourth, the subject stopping voluntarily. The subjects wore motion accelerometers (Life Coder EX, 2006, Suzuken, Japan) on the right side of the waist (center of the navel and the side line) to record 7 days of exercise and overall physical activity as well as normal life. Before starting the study, the individual's age, gender, height, weight, initial measurement date and time were inputted. Sleeping and shower times were excluded. The life coder used in this study was the uniaxial accelerometer, which can store 200 days of data such as amount of physical activity, exercise intensity, maintenance and calorie consumption corresponding to 4 second intervals using the METS concept. In this study, 1 day of average maintenance and exercise intensity were analyzed and are presented in <Table 1>. For the dietary intake, blank forms were distributed to the subjects to record the name and amount of food consumed for breakfast, snack, lunch, snack, dinner, and snack. The dietary intake was recorded for 3 days (Tuesday, Thursday, and Saturday) in 1 week and the average value was used. All types and amounts of food recorded were converted into weight (Korea Food Industry Association. Household measures of commonly used food items, 1998) and analyzed with the nutrition evaluation program developed by the Nutrition Information Center in the Korean Nutrition Society, CAN-Pro 2.0 (Computer Aided Nutritional Analysis Program), then converted to nutrient intake amount. The individual intakes of carbohydrate (%), fat (%), protein (%) and daily average calorie intake (kcal/day) were calculated.

Table 1. Classification of accelerometer-recorded physical activities and their metabolic equivalents (METs)

	Activity levels	Estimated MET
Light intensity	1.0	1.8
	2.0	2.3
	3.0	2.9
Moderate intensity	4.0	3.6
	5.0	4.3
	6.0	5.2
Vigorous intensity	7.0	6.1
	8.0	7.1
	9.0	8.3

(Kumahara *et al*., 2004)

Data analysis

All data measured in this study were indicated as average and standard deviation. For data analysis, the normal distribution state of the collected data was checked in advance, and if normal distribution was not apparent, log10 transformation was applied for normal distribution. One-way analysis of variance and LSD post-hoc examination were next used to verify the body mass index, insulin resistance index, physical activity, dietary intake, and the difference between the groups according to the physical activity level and the average levels of serum Il-6 and vaspin. Also in this study, multivariate linear regression analysis was used to set the body mass index, insulin resistance index, physical activity and dietary habit as prediction factors for all subjects, and the stepwise method was used to determine the independent

prediction factor for the serum vaspin and IL-6 levels. For all data processing, SPSS-PC (version 18.0) was used to verify statistical significance with $\alpha = 0.05$.

RESULTS

To examine the effects of normal physical activity on the dependent variable, 220 subjects who wore the accelerometer for 24 hours every day for a week were categorized by their physical activity levels. Those with low volume physical activity (LVPA) comprised the lower 25 percentile (daily average maintenance = 9755 ± 1281), the moderate volume physical activity group (MVPA) comprised the middle 50 percentile (daily maintenance = 12842 ± 7140), and the high volume physical activity group (HVPA) comprised the upper 25 percentile (daily average maintenance = 15877 ± 1875). The differences in the dependent variables between the groups were evaluated as shown below.

Comparison of body mass index between groups according to the physical activity level

Table 2 is the result of comparing the body mass index between the groups according to the physical activity level. Body mass index ($p < 0.001$), body fat ratio ($p < 0.001$), waist measurement ($p < 0.001$), and waist-hip ratio ($p < 0.001$) were significantly different between the groups. The results of LSD post-hoc examination on the variables with significant differences between the groups showed that the body mass index ($p < 0.001$), body fat ratio ($p < 0.001$), waist measurement ($p < 0.001$), and waist-hip ratio ($p < 0.001$) of the upper group with the highest physical activity were significantly lower than those of the moderate and low groups. The body mass index ($p < 0.001$), body fat ratio ($p < 0.001$), waist measurement ($p < 0.001$), and waist-hip ratio ($p < 0.001$) of the moderate group was also significantly lower than those of the low group.

Table 2. Body fat parameters across accelerometer-recorded physical activity levels

	LVPA (n = 55)	MVPA (n = 110)	HVPA (n = 55)	*P*
Age (years)	12.6 ± 0.5	12.5 ± 0.5	12.4 ± 0.5	0.303
BMI (kg/m^2)	22.1 ± 3.2^a	19.9 ± 3.4^b	18.0 ± 2.6^c	0.001
Body fat (%)	23.1 ± 6.0^a	18.8 ± 6.6^b	15.6 ± 6.2^c	0.001
WC (cm)	78.1 ± 8.8^a	71.1 ± 9.5^b	65.2 ± 6.2^c	0.001
WHR	0.87 ± 0.6^a	0.85 ± 0.1^b	0.83 ± 0.04^c	0.001

BMI: body mass index; WC: waist circumference; WHR: waist-to-hip ratio. LVPA: low volume physical activity; MVPA: moderate volume physical activity; HVPA: high volume physical activity. Different superscripts (i.e., a-b or a-c or b-c) in the same rows indicate statistically significant group differences at $p < 0.005$

Comparison of insulin resistance index between groups according to the physical activity level

Table 3 is the result of comparing the insulin resistance index between the groups according to the level of physical activity. The insulin resistance index including the fasting blood glucose, insulin and homa index was not significantly different between the low, moderate and high groups with low physical activity.

Comparison of physical activity and dietary intake between groups according to the physical activity level

Table 4 is the result of comparing the level of physical activity measured using the object accelerometer and the dietary intake collected through diary entries. Low intensity physical activity ($p = 0.002$), moderate intensity physical activity ($p < 0.001$), and high intensity physical activity ($p < 0.001$) showed significant differences between the groups. Post-hoc examination of the variables with significant differences between the groups showed that low intensity physical activity

Table 3. Insulin resistance markers across accelerometer-recorded physical activity levels

	LVPA (n = 55)	MVPA (n = 110)	HVPA (n = 55)	*P*
FBG (mg/dL)	89.5 ± 14.4	93.1 ± 16.5	90.4 ± 13.4	0.257
Insulin (uU/ml)	11.80 ± 7.90	10.40 ± 7.05	9.52 ± 8.48	0.241
HOMA-IR	2.56 ± 1.71	2.40 ± 1.78	2.17 ± 2.12	0.504

FBG: fasting blood glucose; HOMA-IR: homeostasis model of assessment for insulin resistance. LVPA: low volume physical activity; MVPA: moderate volume physical activity; HVPA: high volume physical activity.

Table 4. Physical activity and dietary intakes across accelerometer-recorded physical activity levels

	LVPA (n = 55)	MVPA (n = 110)	HVPA (n = 55)	*P*
LPA (min/day)	89.6 ± 68.8^a	132.5 ± 110.7^b	133.9 ± 100.7^c	0.002
MPA (min/day)	32.5 ± 27.7^a	54.7 ± 47.4^b	56.9 ± 42.5^c	0.001
VPA (min/day)	11.0 ± 11.7^a	20.3 ± 23.3^b	26.7 ± 28.5^c	0.001
CI (kcal/day)	1889.3 ± 387.7	1914.8 ± 591.3	1849.4 ± 367.3	0.699
CHO (%/day)	66.9 ± 4.0	66.5 ± 4.1	65.9 ± 4.6	0.499
PRO (%/day)	17.9 ± 2.4	18.1 ± 2.0	18.8 ± 4.2	0.222
FAT (%/day)	13.3 ± 2.3	13.9 ± 2.6	13.6 ± 2.4	0.342

LPA: low-intensity physical activity; MPA: moderate-intensity physical activity; CI: caloric intake; CHO: carbohydrates; PRO: protein; LVPA: low volume physical activity; MVPA: moderate volume physical activity; HVPA: high volume physical activity. Different superscripts (i.e., a-b or a-c or b-c) in the same rows indicate statistically significant group differences at $p < 0.005$.

($p = 0.003$ & $p = 0.002$), moderate intensity physical activity ($p < 0.001$ & $p < 0.001$) and high intensity physical activity ($p = 0.005$ & $p < 0.001$) in the group with the lowest level of physical activity were significantly lower than in the moderate and upper groups. However, the amount of physical activity at each intensity level was similar in the group with relatively moderate physical activity and the group with the highest amount of physical activity. Also, comparing the intake ratio of average caloric intake and main nutrients (carbohydrate, protein, fat) between the low, moderate and upper groups according to the level of physical activity showed that the daily average caloric intake and the intake ratio of carbohydrate, protein and fat were not significantly different between the groups.

Comparison of serum interleukin-6 and vaspin level between groups according to physical activity

Table 5 is the result of comparing the serum interleukin-6 and vaspin level between the groups according to the physical activity level. Vaspin (p = 0.009) and interleukin-6 (p = 0.032) showed significant differences between the groups. Post-hoc examination of the variables with significant differences between the groups revealed that the vaspin (p = 0.028) and interleukin-6 (p = 0.009) levels of the group with the highest physical activity amount was significantly lower than those of the lower group. Vaspin (p = 0.003) in the group with moderate levels of physical activity was significantly higher than in the upper group.

Table 5. Serum vaspin and IL-6 concentrations across accelerometer-recorded physical activity levels

	LVPA (n = 55)	MVPA (n = 110)	HVPA (n = 55)	*P*
IL-6 (ng/ml)	0.81 ± 0.86[a]	0.64 ± 0.62	0.51 ± 0.44[b]	0.032
Vaspin (ng/ml)	1.30 ± 3.37[a]	1.00 ± 3.05	2.88 ± 5.54[b]	0.009

LVPA: low volume physical activity; MVPA: moderate volume physical activity; HVPA: high volume physical activity. Different superscripts (i.e., a-b) in the same rows indicate statistically significant group differences at $p < 0.05$.

Table 6. Stepwise linear regression model for serum IL-6 in the study population

Variance	β, estimates ± SE	95% C.I.	*P*
Intercept	1.184 ± 1.265	-1.331 ~ 3.700	
Age	0.125 ± 0.094	0062 ~ 0.312	0.190
BMI	0.043 ± 0.014	0.015 ~ 0.070	0.002
LPA	-0.001 ± 0.002	-0.009 ~ 0.003	0.002
MPA	-0.005 ± 0.002	-0.009 ~ 0.002	0.045

The β values are the multivariate regression unstandardized coefficients. LPA: low-intensity physical activity; MPA: moderate-intensity physical activity

Table 7. Stepwise linear regression model for serum vaspin in the study population

Variance	β, estimates ± SE	95% C.I.	*P*
Intercept	0.149 ± 0.685	-1.213 ~ 1.510	
LPA	0.039 ± 0.011	0.017 ~ 0.062	0.001
MPA	0.060 ± 0.026	0.001 ~ 0.009	0.022

The β values are the multivariate regression unstandardized coefficients. LPA: low-intensity physical activity; MPA: moderate-intensity physical activity

Multivariate regression analysis of serum interleukin-6 and vaspin

Table 6-7 is the result of applying multivariate regression to the somatometry, body mass index, insulin resistance index, physical activity and dietary intake as the independent predictive factors for serum IL-6 and vaspin levels. For the serum IL-6 level, age, BMI, low intensity physical activity, and moderate-high physical activity were independent prediction factors (Table 6). For serum vaspin level, low and moderate-high physical activities were independent prediction factors (Table 7). These results indicate a quantitative correlation with the age and BMI for serum IL-6 and a negative correlation with low and moderate intensity physical activities. On the other hand, serum vaspin level appeared to have a quantitative correlation with low and moderate intensity physical activities.

CONCLUSION

In this study, the body mass index, insulin resistance index, physical activity (maintenance amount, low, moderate, high intensity), dietary intake, serum interleukin-6 and vaspin levels in 220 male and female students aged 12~13 were analyzed. The daily average activity level measured with the accelerometer was quantified and segmented into the low volume physical activity group (LVPA) included in the lower 25 percentile (daily average maintenance = 9755 ± 1281), the moderate volume physical activity group (MVPA) included in the middle 50 percentile (daily maintenance = 12842 ± 7140), and the high volume physical activity group (HVPA) included in the upper 25 percentile (daily average maintenance = 15877 ± 1875) to verify the differences in all measured variables.

The group with low physical activity had higher BMI, fat mass, weight and waist-hip circumference ratio compared to the moderate and high groups. However, the amount of low, moderate and high intensity physical activity was relatively lower in this group. The low group had higher levels of serum

IL-6 compared to the upper group, but the serum vaspin level was lower. Multivariate regression analysis was performed using somatometry, body mass index, insulin resistance index, physical activity amount, and dietary intake as prediction variables to analyze independent prediction variables for serum IL-6 and vaspin level. The serum IL-6 level was interpreted to have a quantitative correlation with age and BMI and a negative correlation with low and moderate intensity physical activity. However, the serum vaspin level was found to have a quantitative correlation with low and moderate intensity physical activity. In other words, the study was performed based on the fact that serum vaspin increases insulin sensitivity while IL-6 reduces insulin sensitivity. The results indicated that increased physical activity in late school aged children and weight control through healthy diet increases cytokine vaspin levels, increasing insulin sensitivity and suppressing the level of Il-6 to reduce insulin sensitivity.

Studies that categorized total activity into three groups [15] and four groups [16] to examine the reduction in metabolic syndrome risk as the total activity level increased found a volume-reaction relationship. The results of measuring the daily physical activity and fat mass for 248 (140 boys, 108 girls) children aged 8~11 showed that fat mass had a significantly negative correlation with high intensity physical activity [17]. In other words, highly obese children had less than an average of 12 minutes of daily high intensity physical activity compared to low obesity children. Based on several preceding study results showing that daily physical activity was higher in low obesity groups compared to high obesity groups, it appears that obesity caused from lack of physical activity leads to the accumulation of excessive fat in the adipose tissue, changing the substance secreted from the adipose tissue and causing insulin resistance in peripheral tissue.

In the obese state, fat intake decreases in adipose tissue and free fatty acid increases in the blood due to the increase of lipolysis. Lipoprotein catabolic enzyme activation in skeletal muscles is also upregulated to increase fatty acid intake into skeletal muscles, accumulating fat and fatty acid metabolites within the skeletal muscles [18]. Free fatty acid is known to affect insulin receptors and the phosphorylation of proteins in skeletal muscles, causing insulin resistance [19]. Lipolysis is not suppressed in the event of insulin resistance, which results in the increase of free fatty acids in the blood and a change in adipokine secretion. In other words, as excess fat accumulates in adipose tissues, adipokines secreted from the adipose tissues function as chemoattractants to increase macrophage permeation into adipocytes. The secretion of cytokines subsequently increases in the activated macrophage and adipocytes, causing inflammatory changes that cause insulin resistance.

Cytokines that affect the occurrence of insulin resistance are leptin, which reduces the insulin reaction in adipocytes or skeletal muscle [20,21], IL-6, which suppresses insulin receptor substrate (IRS) phosphorylation to induce insulin resistance [10], TNF-α, which can cause a disorder in the insulin signal transmission system through IRS-1 serine phosphorylation in the skeletal muscle adipocyte and lead to insulin resistance [22], RBP4, secreted from adipose tissue to cause insulin resistance in skeletal muscle [23], and visfatin. Visfatin increases with increased abdominal fat rather than subcutaneous fat and plays an important role in the occurrence of insulin resistance related to obesity via an unknown mechanism [24,25]. It is also secreted in various tissues such as visceral fat tissue, skeletal muscle, liver, bone marrow and lymphocytes. Serum IL-6 level is affected by exercise intensity, therefore, one-time high intensity exercise with VO2max over 85% causes the production of IL-6 as a result of an inflammatory immune reaction due to muscle fatigue and local muscle damage from repeated muscle contractions [26]. IL-6 also induces an increase in IL-6 expression through a positive feedback process. Vaspin has the opposite function. It is related to insulin sensitivity and is a newly discovered cytokine secreted from adipose tissue. Though the function is not clear, vaspin is known to increase insulin sensitivity. However, mapping of the vaspin gene and partial understanding of the protein function occurred only recently. The authors of this study found only one study on the vaspin reaction with exercise training [12] and there were no domestic studies. After analyzing vaspin mRNA expression in visceral and subcutaneous fat, Youn *et al*. [12] reported that the vaspin mRNA expression was relatively higher in visceral fat compared to subcutaneous fat. They also stated that the serum vaspin concentration in humans increases as a compensatory mechanism in response to increases in BMI or insulin resistance [11-13]. Other studies reported that vaspin expression and serum levels are lower in overweight or obese individuals, in females, and in the initial state of insulin resistance and diabetes [27,28].

Existing studies reported significant correlations between serum cytokines, physical activity, and body mass index (BMI, fat mass, weight measurement) [29,30-33]. Physical activity appears to be significantly affected by serum cytokine and body mass index [34-36].

In conclusion, late school aged children that lack physical activity were confirmed to be at a higher risk of obesity, insulin resistance and type 2 diabetes despite growth acceleration related to secondary sex characteristics, with the acceleration of body fat accumulation. Therefore, increasing

physical activity in late school aged children and weight control through a healthy diet indicates the necessity for school physical education, after school activities and various types of mediatory programs to increase serum cytokine levels. This will increase insulin sensitivity and decrease serum cytokine levels, reducing insulin sensitivity.

ACKNOWLEDGMENTS

This work was done with the sports promotion fund from Korea Institute of Sport Science, Seoul Olympic Sports Promotion Foundation (KISS-12-A01001).

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