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Effects of an exercise program on health-related physical fitness and IGF-1,C-peptide, and resistin levels in obese elementary school students

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Abstract : Abstract: Childhood obesity causes a higher risk of obesity, premature death and disability in adulthood. In addition, obese children experience an increased risk of respiratory problems, hypertension, cardiovascular disease, insulin resistance and psychological effects. This study aimed to investigate how an exercise intervention affects health-related physical fitness and inflammatory-related blood factors in obese children after. We hypothesized that there would be positive effects on serum levels of insulin-like growth factor-1 (IGF-1), connecting peptide(C-peptide) and resistin, as well as in muscle and cardiovascular-related physical capacities, after an exercise intervention in obese children. Thirty-seven obese children haveperformed health-related fitness tests and provided blood samples for the analysis of changes in circulating biomarkers, both before and after an 8-week exercise intervention, which includes stretching, aerobic exercise, resistance exercise and sports games. The results indicate that exercise training beneficially affects body compositions, especially percentage body fat and muscle mass, without influencing to body weight and height. The results of the physical fitness tests show that muscle and cardiovascular capacity were increased in obese children in response to exercise training. Simultaneously, the exercise training decreased circulating levels of C-peptide, which equated to a “large” effect size. Although there were no significant effects on the levels of IGF-1 and resistin, they show a “small” effect size. Therefore, our findings suggest that the exercise intervention have beneficial effects on body composition and physical fitness levels in obese children, whichmight be associated with the decline in circulating C-peptide.

Keywords : obese children, Health-related fitness, IGF-1, C-peptide, Resistin

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1. Introduction

According to the organization for economic co-operation and development(OECD) [1], the worldwide prevalence of obesity has been doubled since the 1980s. The obese population in Korea has also been increasing steadily over the past decades. Obesity is one of the main risk factors for many chronic diseases such as cardiovascular disease, diabetes and cancer. While it was only considered asa problem in high-income countries in the past, the proportion of the population that is overweight or obese is now increasing in low- and middle-income-leveled countries, particularly in urban areas [2]. Moreover, the prevalence of obesity has been increased substantially in children and adolescents worldwide [3]. Childhood obesity has the danger of premature death, disability and obesity in adulthood [4]. In addition, obese children experience higher risks of respiratory problems, hypertension, cardiovascular disease, insulin resistance and psychological effects. It is known that these risk factors caused by obesity are associated with the metabolic insulin resistance syndrome, with glucose and lipid metabolism, insulin signaling, inflammation and even cell proliferation and differentiation [5].

It has been recognized that physical activity is essential in the treatment of obesity, since it positively affects body compositions and physical fitness. Indeed, achronic exercise intervention leads to a reduction in the body fat of obese adolescents [6]. Muscle mass is an important component of physical fitness, including strength and balance, and it is positively changed by regular exercises [7]. Therefore, a physical exercise intervention may induce apositive adaptation in the body composition of obese children, as well as improving health-related physical fitness.

It is well known that exercise enhances insulin activity so that controls blood glucose. Insulin-like growth factor 1 (IGF-1), connecting-peptide (C-peptide) and resistinare known as factors related to insulin sensitivity. IGF-1 is a hormone structurally similar to insulin. It has been reported that difference in IGF-1 level in serum has been associated with insulin sensitivity both in human and animal models [8]. The main organ contributes to circulating IGF-1 levels is a liver, but it also has been revealed that muscles and adipose tissues also influence to IGF-1 serum levels, while the detailed mechanism how IGF-1 level is altered by muscles and adipocytes is still unclear [9]. C-peptide is a small peptide that connects dimeric insulin molecule's chains. It is also reported that C-peptide may exert some effects on the adipocytes [10]. Resistin is a peptide hormone produced by adipocytes;it regulates insulin sensitivity throughout the body and it is highly expressed in visceral white fat [11]. However, the effects of exercise on insulin-related inflammation biomarkers and related organs involved in the development of childhood obesity remain to be examined.

Therefore, the aim of this study was to investigate the effect of an exercise intervention on health-related physical fitness, IGF-1, C-peptide and resist in levels in obese children. This study hypothesized that an exercise intervention would positively change inflammatory-related blood factors, as well as improving health-related physical fitness, in obese children.

2. Experimental Methods

2.1. Participants

Thirty-seven obese boys aged 11-12 years (mean±standard deviation: 11.84±0.72 y) volunteered for this study. All of the subjects were selected according to their percentage bodyfat (%bodyfat) (36.48±6.97%). Subjects' demographic and physiological characteristics, including height, weight, muscle mass and %bodyfat, are presented in Table 1. All participants provided written informed consent and the study was approved by the

Institutional Human Research Committee. The purpose, practical application and experimental procedures were verbally explained to each participant. Prior to their participation, they were informed about the possible risks and any discomfort, which may result from involvement in the study.

2.2. Health-related fitness tests

Body composition(height [cm], weight [kg], %bodyfat, and muscle mass [kg]), flexibility (sit and reach test, cm), muscular strength (hand-grip strength, kg), muscular endurance (sit-up, times), and cardiopulmonary fitness (20m shuttle run, times), were evaluated for all of the subjects. The best score from three trials of the physical fitness test was used in the subsequent analysis.

2.3. Blood analysis

The subjects were advised to refrain from eating after 8:00 P.M. on the day prior to blood collection. Blood collection was performed at 8:00–9:00 A.M. Blood samples (10 mL) from the obese children were collected from the antebrachial vein by a medical laboratory technologist using a vacutainer tube and disposable syringe following the exercise program,(as described by the study protocol). The blood was collected in a serum separator tube and it was separated at a speed of 3500 g at 4℃. The serum was then separated and stored at −80℃. After serum separation, IGF-1 (ng/ml), C-peptide (ng/ml), and resistin (ng/ml), were quantified using commercially available ultrasensitive ELISA (enzyme-linked immunosorbent assay) kits, according to the manufacturer's instructions.

2.4. Exercise program

The 60-minute exercise program (including a 5-minute warm-up and warm-down),was performed three times a week for 8 weeks. The exercises consisted of stretching, aerobic exercise, resistance exercise and sports games. The exercises consisted of stretching, aerobic exercise, resistance exercise and sports games, based on the after-school exercise program modified by Ha and Baek [12]. The exercise program comprised 10 minutes of various resistance related exercises (push-ups, sit-ups and band exercises; seated rows, bicep curls, shoulder flexion, elbow flexion, hip flexion, hip extension, calf raises, leg presses and squats), 10 minutes of aerobic exercises (walking, skipping, shuttle run, running and burpee test), and sports games (soccer, badminton, basketball, and dodgeball). The warm-up and warm-down comprised static stretching. The exercise intensity was gradually increased to 50%–70% of the heart rate reserve (HRR) in weeks 1–4 and to 70%–80% HRR in weeks 5–8. Each training session was fully supervised by the researchers. Each subject wore a heart rate monitor for the entire training session to maintain the correct training intensity.

2.5. Statistical analysis

All data were analyzed using the Statistical Package for Social Sciences (SPSS for Windows release 21.0, SPSS Inc. Chicago, IL), and the mean and standard deviation(mean±SD). Paired *t*-tests were used to compare the pre- and post-trial data of the obese children. The post-trial valueswere divided by the pre-trial values and expressed as a percentage. The alpha value was set at 0.05. In addition to the above statistical tests, effect sizes (Cohen's *d*) were calculated using the differences between the pre- and post-trial data.

3. Results and Discussion

3.1. Effects of exercise training on health-related physical fitness

Although there were no differences in the baseline characteristics of obese children, including height and body weight, after 8 weeks of exercise training, there were

Table 1. Change of Health-related physical fitness levels after 8 weeks of exercise (*M*± *SD*)

Variable	Pre	Post	Δ value	%*diff*	*P* value	Effect size Cohen's *d*
Height (cm)	145.32±5.68	148.25±7.46	2.92±1.91	1.98±1.23	*NS*	.52
Weight (kg)	54.63±6.05	55.78±6.35	1.15±0.65	2.09±1.07	*NS*	.19
% Bodyfat (%)	36.48±6.97	31.63±2.87	-4.85±5.28	-11.71±12.59	$^{\$\$}p<.01$	-.70
Muscle mass (kg)	16.43±2.29	18.20±1.76	1.78±0.85	11.33±6.12	$^{\$\$}p<.01$	.77
Flexibility (cm)	5.90±3.14	7.45±4.54	1.55±1.80	27.53±23.41	*NS*	.49
Muscular strength(kg)	18.50±2.72	23.03±1.69	4.53±1.71	25.69±11.91	$^{\$\$\$}p<.001$	1.67
Muscular endurance(times)	21.75±8.56	33.25±17.23	11.50±8.70	46.96±21.78	$^{\$\$\$}p<.001$	1.34
Cardiopulmonary fitness(times)	20.50±12.61	27.25±11.79	6.75±6.85	47.92±62.72	$^{\$}p<.05$	.54

Values are *M*± *SD*, *NS*, not significant. Effect size range: |.20|≦small<|.50|, |.50|<medium<|.80|, |.80|≦ large.

significant changes in %bodyfat ($p < 0.01$) and muscle mass ($p < 0.01$) between the pre- and post-trials (Table 1 and Figure 1). The decrease in body fat and increase in muscle mass is supported by previous studies [12, 13, 14], and suggests that our exercise program beneficially effected obesity-related body composition.

We also measured health-related fitness levels in response to the 8-week exercise training program. There were significant increases in muscular strength ($p < 0.001$), muscular endurance ($p < 0.001$), and cardiopulmonary fitness ($p < 0.05$), but not in flexibility (Figure 1). Primarily, the effect sizes for muscular strength (d = 1.67) and endurance (d = 1.34) were large, and the effect size for cardiopulmonary fitness was medium (d = .54) (Table 1); suggesting that our exercise program improved muscular function more than cardiovascular function.

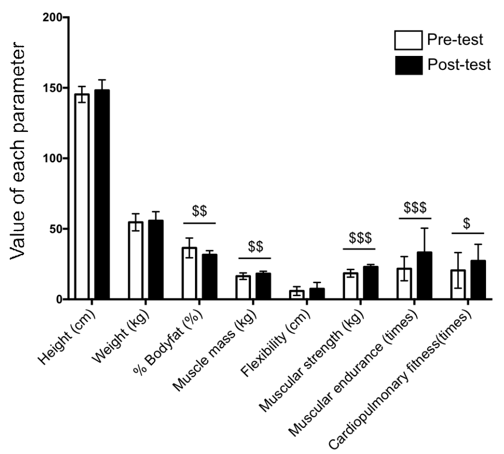

Fig. 1. Effects of 8-weeks exercise training on health-related physical fitness.
There was significant effect of exercise in body composition of obesity children such as percent of body fat and muscle mass.The exercise training increased the levels of muscle strength, muscle endurance, and cardiopulmonary fitness. All data are presented as mean ± *SD* (n = 37). Paired *t*-test was performed ($^{\$}p < 0.05$, $^{\$\$}p < 0.01$, $^{\$\$\$}p < 0.001$).

Table 2. Change of IGF-1, C-peptide and Resistin levels after 8 weeks of exercise (*M± SD*)

Variable	Pre	Post	Δ value	%diff	*P* value	Effect size Cohen's *d*
IGF-1 (ng/ml)	218.04±129.46	281.01±179.20	62.98±52.15	26.56±10.44	*NS*	.49
C-peptide (ng/ml)	2.95±0.91	2.07±0.24	-0.88±0.90	-25.20±22.89	$^{\$\$}p<.01$	-.97
Resistin (ng/ml)	21.90±6.41	19.87±5.28	-2.03±1.36	-8.64±4.39	*NS*	-.32

Values are *M± SD, NS*, not significant. Effect size range: |.20|≦small<|.50|, |.50|<medium<|.80|, |.80|≦ large.

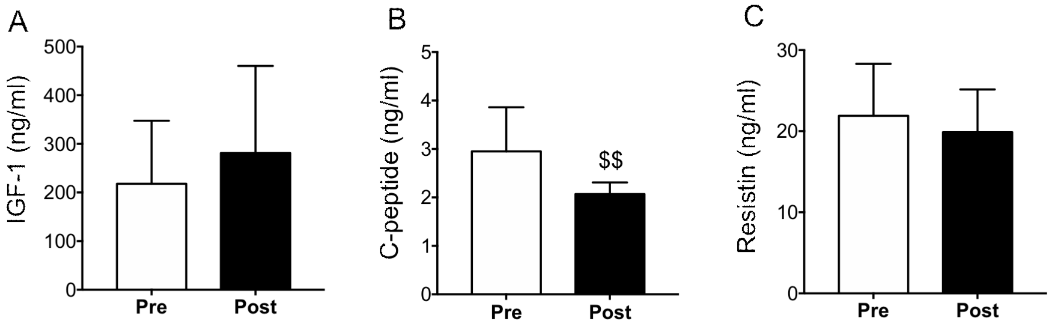

Fig. 2. Effect of exercise training on IGF-1, C-peptide, and resistin levels.
(A) There was no significant effect in serum IGF-1 levels between pre- and post-test. (B) Serum C-peptide levels were significantly decreased after exercise training. (C) There was no differences in serum resistin between pre- and post-test. All data are presented as mean ± *SD*. Paired t-test was performed ($^{\$\$}p < 0.01$).

Recently, a physical activity intervention has been shown to improve muscle mass [15]; this is consistent with our results which demonstrated changes in body composition. Furthermore, the 8-week exercise intervention used in this study also positively affected muscle strength and endurance.

3.2. Effects of exercise training on blood biomarkers

We also examined whether 8 weeks of exercise training affected inflammation-related serum biomarkers, including IGF-1, C-peptide, and resistin in obese children. The results of the serum parameters are presented in Table 2 and Figure 2. While average values of IGF-1, C-peptide, and resistin levels were changed after the exercise training (Figure 2), the effect on C-peptide level was statistically meaningful ($p < 0.01$), compared to IGF-1 and resistin levels (Table 2). The C-peptide level equated to a large effect size (d = -0.97). The effect sizes for IGF-1 (d = .49) and resistin(d = -.32) were relatively small. These results suggest that the reduced C-peptide levels following chronic exercise training are associated with enhanced physical fitness in obese children.

The associations between obesity and inflammation-related hormone peptides are well known .In particular, C-peptide, a proinflammation marker, is positively related to obesity indices such as body mass index (BMI), and theonset of type 1 diabetes mellitus

[16, 17]. This suggests that circulating levels of C-peptidemay be a potential diagnostic biomarker to facilitate monitoring obesity interventions. In this study, the exercise intervention reduced the C-peptide levels of obese children with a large effect size. Thus, our findings have advanced the notion that regular exercise, which decreases C-peptide, may be an effective lifestyle intervention for preventing or improving childhood obesity. Further research examining exercise and the role of C-peptide is required to support this novel approach to the study of obesity.

4. Conclusion

This study investigated the effects of an 8-week exercise program on health-related physical fitness and levels of IGF-1, C-peptide, and resistinin obese male elementary school students. We found that the exercise intervention has a positive effect on health-related physical fitness for obesity children. We also revealed that the exercise intervention directly influences to an inflammation-related factor, C-peptide level in obese children.

Although the effects of exercise training on IGF-1 and resistin levels were not statistically significant, we observed alterations of those levels in obese children after the exercise training. It could be 8-week exercise is short to see the direct effects on those serum levels. Thus, to further investigate the effect of exercise on IGF-1 and resistin levels, a long-term intervention will be examined as a continuation of this study.

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