

A Study of Correlation between Change of Ratings of perceived exertion (RPE) and Blood Components in Strengthening Abdominal Muscular Power

This study has been conducted on the subjects of eight undergraduate students with abdominal obesity and eight undergraduate students with normal weight to find out correlation between substantial fatigue and Ratings of perceived exertion through analysis of their blood components when they took exercises to strengthen their abdominal muscular power. Comparatively analyzing HDL-C, LDL-C and lactic acid before and after they took sit-up at level of RPE 19-20, no statistically significant differences in HDL, LDL, lactic acid measures were observed between groups, but a significant difference in RPE was noted between groups ($p < 0.05$)

Our findings suggest that control group showed no significant difference in increase of fatigue material whereas the obese group showed a lower frequency of sit-up, though both groups took the same abdominal exercise. Additionally, the lower frequency of sit-up in obese group results from relatively higher Ratings of perceived exertion rather than increase of substantial fatigue material. This study invites future research that examines the effect of a comprehensive obesity exercise program combined with dietetic on ratings of perceived exertion in individuals with obesity.

Key words : *abdominal obesity; fatigue; Ratings of perceived exertion; HDL-C; LDL-C; lactic acid*

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Received : 27 December 2009

Accepted : 20 January 2010

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INTRODUCTION

Obesity, in general, indicates an abnormal excess of body fat. Presently obesity index by using of body mass index(BMI) for measuring is universal, and in Asia including Korea, 23~24.9kg/m² of BMI is defined to be 'overweight' and 25kg/m² and over is 'obese'. Apart from the mere obesity indicating increase in total body fat, abnormal accumulation of body fat in subcutaneous tissues and viscera anatomically is defined as 'abdominal obesity'(1).

Abdominal obesity can be divided into visceral obesity and subcutaneous obesity according to distribution

of visceral and subcutaneous fats. Because appearances of fat distribution are different based on age, gender, and hormones, visceral fats are accumulated more notably in those who are older, and males rather than females. Females tend to be abruptly accumulated of visceral fats after postmenopausal period(2).

Weight control is most important in order to treat obesity as a main factor of complications(3). Dietotherapy such as low calorie diet(LCD) and very low calorie diet(VLCD), kinesiotherapy, behavioral modification, drug treatment, and operation serve as methods of weight control, and dietotherapy is used

most easily(4). However, dietotherapy decreases basic metabolism at rest and reduces both body fat and muscles. Therefore, a method of kinesitherapy with dietotherapy is generally presented to be an idealistic way for weight loss(5).

Gunnar Borg, professor of psychology in Stockholm, University developed Ratings of perceived exertion(RPE) that is not disturbed by behaviors and can be used easily without physiological measurements, recognizing problems of VO_2 max measurement by using of direct measurement and problems of VO_2 max measurement by using of heart rate(6).

Sensuous expressions of the RPE is used as the most appropriate indicator when physical tension is expressed subjectively by using of perceived exertion and characteristic in psychological expression of physiological reactions against exercise. Reactions of perceived exertion based on intensity of exercise are reported to show high correlation with physiological & metabolic functions including VO_2 max, heart rate, breathing capacity, and blood lactate concentration(7). In particular, the Borg's 15-category scale, presenting information of physiological reactions against dynamic exercise, is being used in laboratories and clinics in order to observe exercise programs, prescription and assessment of exercise, state of training, and works in workplace. Because the RPE is highly correlated with VO_2 max more than heart rate is in various situations under diversified conditions, it is being presented to be useful in prescription of exercise intensity(6).

The RPE during exercise test can be divided into 'a little hard', 'hard', and 'very very hard'. Most people have ventilation threshold(VT)(VO_2 peak 60~75%) at 'a little hard'(RPE 13-14) or at 'hard' (RPE 15-16), and reach limitation of subjective fatigue at 'very very hard'(RPE 19-20)(6).

Human body is sure to be accompanied with fatigue in exercise. Exercise fatigue serves as a restrictive factor during process in which exercise capacity is displayed efficiently, inducing muscle fatigue that makes it hard appropriate performance of muscles having chief functions in exercise. Muscle fatigue indicates a state that voluntary display of strength cannot be maintained, reducing exercise capacity to fail to satisfy a required level(8).

Meanwhile, metabolism in human body is altered variously in exercise, and lipoprotein is particularly related to obesity. Various lipid syntheses in serum are related to cardiac deaths, and among them, amount of cholesterol is reported to be the most important factor(9). Excessive cholesterol is a risk

factor inducing arteriosclerosis and coronary artery diseases, and is considered clinicopathologically crucial because it, with serum lipids, is used as health indicator(10). Lipoproteins are divided into high-density lipoproteins(HDL), low-density lipoproteins(LDL), and very low density lipoproteins(VLDL)(11).

Also, it is reported that regular exercise reduces lipids closely related to coronary artery diseases while increases HDL-C that is helpful to prevent various heart diseases(12).

As above-mentioned, many domestic & foreign researches on the effects of exercise on obesity have been reported, but few studies have been performed on tendency of frequent fatigue of obese people in exercise.

In this study, the author asked young college students in their twenties to take exercise for strengthening of abdominal muscular force, and analyzed the bloods of those having abdominal obesity and normal ones to identify correlation between practical fatigue and the RPE.

MATERIALS AND METHODS

Subjects

The subjects of this study were 16 college students (8 with abdominal obesity and 8 who are normal) between 20 and 30 in their age. They had no pathologically abnormal findings in their upper and lower limbs in nervous and musculoskeletal systems and took no regular exercise for strengthening of muscular force. All the subjects were explained sufficiently and participated in this study after consent.

Measurement of Abdominal Obesity and Selection of Ones with Abdominal Obesity

Measurements of fat distribution for diagnosis of abdominal obesity include waist circumference, waist-to-hip ratio, skinfold thickness, ultrasound, computed tomography, and magnetic resonance image, and waist-to-hip ratio was used in this study. By using of this method, the subjects were divided into two groups: the experiment group included those having abdominal obesity with at least 1.0 in the ratio; and the control group included those having normal weight with less than 1.0 in the ratio. As for the waist circumference, the middle region between lowest hypochondrium and pelvic iliac crest was measured when the subjects were in upright position that is admitted by the WHO, and the

measuring tape was maintained at a level with the floor. As for the hip circumference, the location of greater trochanter or the widest circumference was measured by using of the measuring tape when the subjects stood naturally with their legs somewhat opened.

Exercise Program

Push-ups were applied as the exercise for strengthening of abdominal muscular force. Without deciding the numbers of push-ups, the numbers when the subject felt 'a little hard'(RPE 13–14), 'hard'(RPE 15–16), and 'very very hard'(RPE 19–20) in the measurement of the RPE were identified. The push-ups were performed when the subjects felt 'very very hard'.

Blood Collection and Component Inspection

After at least 12-hour of fasting, 10ml of venous blood was collected before and after the exercise, respectively, from the antecubital veins of the subjects. The collected blood was compared and analyzed of blood HDL, LDL, and Lactic Acid by the Laboratory Medicine of the Hallym University Hospital.

Data Analysis

All the collected data were analyzed by the SPSS 10.0/PC after encoding through three phases.

In the first phase the frequency and the percentage were calculated by using of descriptive statistics in order to identify the distribution by properties of the subjects.

In the second phase, the means and the standard deviations of exercises before and after the exercises

performed by normal and obese people were evaluated, and the means and the standard deviations were evaluated when before and after the exercises were established as the results of this study.

In the third phase, Mann–Whitney *U* Test was used with significance level of $\alpha = 0.05$, in order to identify the test for difference in the results between normal and obese people.

RESULTS

General Properties of Subjects

Physical Properties of Subjects

The mean weight of the total subjects was 71.75kg and the standard deviation was 14.40. The mean weight of the normal ones was 64.00kg and the standard deviation was 14.72, while the mean weight of the obese ones was 79.50kg and the standard deviation was 9.50. The weight of the normal ones was relatively lower than that of the abdominally obese ones.

The mean height of the total subjects was 168.56cm and the standard deviation was 9.87. The mean height of the normal ones was 169.50cm and the standard deviation was 9.49, while the mean height of the obese ones was 167.63cm and the standard deviation was 10.80. The height of the normal ones was relatively higher than that of the abdominally obese ones.

The mean waist of the total subjects was 82.57cm and the standard deviation was 9.74. The mean waist of the normal ones was 69.75cm and the standard deviation was 4.50, while the mean waist of the obese ones was 95.38cm and the standard deviation was 6.59. The waist of the abdominally obese ones was higher than that of the normal ones.

Table 1. Physical Properties of Subjects

Classification	Normal(n=8)		Abdominal Obesity(n=8)		Total(n=16)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
Weight(kg)	64.00	14.72	79.50	9.50	71.75	14.40
Height(cm)	169.50	9.49	167.63	10.81	168.56	9.87
Waist(cm)	69.75	4.50	95.38	6.59	82.57	9.74
Hip(cm)	93.75	2.43	94.45	7.07	94.10	5.66
Abdominal Obesity	0.74	0.04	1.01	0.04	0.88	0.07

The mean hip of the total subjects was 94.10cm and the standard deviation was 5.66. The mean hip of the normal ones was 93.75cm and the standard deviation was 2.43, while the mean hip of the obese ones was 94.45cm and the standard deviation was 7.07. The hip of the abdominally obese ones was relatively higher than that of the normal ones.

The mean obesity of the total subjects was 0.88 and the standard deviation was 0.07. The mean obesity of the normal ones was 0.74 and the standard deviation was 0.04, while the mean obesity of the obese ones was 1.01 and the standard deviation was 0.04.

RPE Analysis of Subjects

The mean 'a little hard' of the total subjects was 15.56 times and the standard deviation was 1.86. The mean of the normal ones was 16.50 times and the standard deviation was 1.41, while the mean of the obese ones was 14.63 times and the standard deviation was 1.85. The RPE of the normal ones were relatively higher than that of the abdominally obese

ones.

The mean 'hard' of the total subjects was 25.13 times and the standard deviation was 4.05. The mean of the normal ones was 27.25 times and the standard deviation was 4.43, while the mean of the obese ones was 23.00 times and the standard deviation was 2.27. The RPE of the normal ones were relatively higher than that of the abdominally obese ones.

The mean 'very very hard' of the total subjects was 32.00 times and the standard deviation was 3.71. The mean of the normal ones was 34.13 times and the standard deviation was 3.83, while the mean of the obese ones was 29.88 times and the standard deviation was 2.10. The RPE of the normal ones were relatively higher than that of the abdominally obese ones.

Therefore, according to the results of this study, the abdominally obese ones were lower in the push-up times in all the categories than the normal ones, having lower RPE.

Table 2. RPE Analysis of Subjects

(Unit : Time)

Classification	Normal(n=8)		Abdominal Obesity(n=8)		Total(n=16)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
A little hard RPE(13-14)	16.50	1.41	14.63	1.85	15.56	1.86
Hard RPE(15-16)	27.25	4.43	23.00	2.27	25.13	4.05
Very very hard RPE(19-20)	34.13	3.83	29.88	2.10	32.00	3.71

Table 3. Analysis of Blood HDL of Normal and Obese Ones

(Unit : mg/dl)

Classification	Before exercise(n=8)		After exercise(n=8)		Difference(n=8)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
Normal	68.13	15.23	70.75	16.10	-2.63	2.13
Abdominal Obesity	60.25	13.25	62.63	12.34	-2.38	2.92

Analysis Between Groups

Analysis of Blood HDL of Normal and Obese Ones

According to the results, the mean difference of HDL of the normal ones was -2.63mg/dl and the standard deviation was 2.13. The mean HDL before exercise was 68.13mg/dl and the standard deviation was 15.23, while the mean HDL after exercise was 70.75mg/dl and the standard deviation was 16.10.

The mean difference of HDL of the abdominally obese ones was -2.38mg/dl and the standard deviation was 2.92. The mean HDL before exercise was 60.25mg/dl and the standard deviation was 13.25, while the mean HDL after exercise was 62.63mg/dl and the standard deviation was 12.34.

Analysis of Blood LDL of Normal and Obese Ones

According to the results, the mean difference of LDL of the normal ones was -3.13mg/dl and the standard deviation was 2.90. The mean LDL before exercise was 73.00mg/dl and the standard deviation was 15.75, while the mean LDL after exercise was 76.13mg/dl and the standard deviation was 17.09.

The mean difference of LDL of the abdominally obese ones was -3.63mg/dl and the standard deviation was 3.74. The mean LDL before exercise was 88.75mg/dl and the standard deviation was 21.72, while the mean LDL after exercise was 92.38mg/dl and the standard deviation was 23.58.

Table 4. Analysis of Blood LDL of Normal and Obese Ones

(Unit : mg/dl)

Classification	Before exercise(n=8)		After exercise(n=8)		Difference(n=8)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
Normal	73.00	15.75	76.13	17.09	-3.13	2.90
Abdominal Obesity	88.75	21.72	92.38	23.58	-3.63	3.74

Analysis of Blood Lactic Acid of Normal and Obese Ones

According to the results, the mean difference of lactic acid of the normal ones was -35.35mg/dl and the standard deviation was 7.13. The mean lactic acid before exercise was 10.89mg/dl and the standard deviation was 4.97, while the mean lactic acid after exercise was 46.24mg/dl and the standard deviation was 5.39.

The mean difference of lactic acid of the abdominally obese ones was -42.83mg/dl and the standard deviation was 12.64. The mean lactic acid before

exercise was 11.28mg/dl and the standard deviation was 1.87, while the mean lactic acid after exercise was 54.10mg/dl and the standard deviation was 13.28.

Effect Test

Mann-Whitney *U* Test was used with significance level of $\alpha=0.05$, in order to test statistically the differences in blood components between normal and obese people before and after exercise for strengthening of abdominal muscular force.

Table 5. Analysis of Blood Lactic Acid of Normal and Obese Ones

(Unit : mg/dl)

Classification	Before exercise(n=8)		After exercise(n=8)		Difference(n=8)	
	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)	Mean (M)	Standard Deviation (SD)
Normal	10.89	4.97	46.24	5.39	-35.35	7.13
Abdominal Obesity	11.28	1.87	54.10	13.28	-42.83	12.64

Comparison of Blood HDL Between Normal and Obese Ones

Table 6. Comparison of Blood HDL Between Normal and Obese Ones

Classification		N	Rank Sum	Z	p-value
HDL	Normal	8	67.5	-0.053	0.958
	Obesity	8	68.5		

p<0.05

As for blood HDL between the normal group and the obese group, Z was -0.053 and p-value was 0.958, showing no significant difference(p<0.05).

Comparison of Blood LDL Between Normal and Obese Ones

Table 7. Comparison of Blood LDL Between Normal and Obese Ones

Classification		N	Rank Sum	Z	p-value
LDL	Normal	8	72.5	0.473	0.637
	Obesity	8	63.5		

p<0.05

As for blood LDL between the normal group and the obese group, Z was 0.473 and p-value was 0.637, showing no significant difference(p<0.05).

Comparison of Blood Lactic Acid Between Normal and Obese Ones

Table 8. Comparison of RPE Between Normal and Obese Ones

Classification		N	Rank Sum	Z	p-value
Lactic acid	Normal	8	81	1.365	0.172
	Obesity	8	55		

p<0.05

As for blood lactic acid between the normal group and the obese group, Z was 1,365 and p-value was 0.172, showing no significant difference(p<0.05).

Comparison of RPE Between Normal and Obese Ones

As for the RPE between the normal group and the obese group, Z was 2.310 and p-value was 0.021, showing significant difference (p<0.05).

Table 9. Comparison of RPE Between Normal and Obese Ones

Classification		N	Rank Sum	Z	p-value
RPE	Normal	8	90	2.310	0.021*
	Obesity	8	46		

p<0.05

DISCUSSION

RPE Based on Exercise for Strengthening of Abdominal Muscular Force

There are many researches on establishing the perceived exertion against exercise efforts with heart rate reaction in dynamic exercise. In earlier studies, the RPE as a method of scaling the senses felt during exercise is systematized under the theory that heart rate raised in exercise shows straight-proportional correlation with perceived exertion scale. Thus, the psychological feelings expressed through cognitive signal system during exercise show increase identical with heart rate, a variable inducing physiological changes. In other words, the fact that the RPE is high can be utilized to identify risk factors with heart rate(13).

The RPE is a method for intensity establishment with considerably high safety on exercise because degrees of physical stress can be identified from subjective symptoms during exercise and risk signals in exercise can be diagnosed in advance(14).

Therefore, use of the RPE serves as a convenient way of establishing intensity of exercise and a sufficiently desirable indicator for preventing eventual accidents. In order to utilize the RPE in various exercises, it is needed to study physiological variables affecting the RPE regardless of types of exercises, and it may be proper to use the RPE abreast such variables.

According to the results of this study, those with abdominal obesity showed lower times of push-ups through the RPE.

Therefore, that those with abdominal obesity had lower times of push-ups may be caused by the RPE higher than that of normal ones rather than increase in practical fatigue substances.

Changes in Blood Components Based on RPE

Increase in blood lipids is recognized to be a major

risk factor of cardiovascular diseases and a factor accelerating arteriosclerosis. Wood et al. reported that increases in levels of serum cholesterol and LDL-C enhance the risk of coronary artery diseases and arteriosclerosis(15). Hargreaves et al. also reported that LDL-C is directly related to coronary artery diseases. Such blood components may be affected by diet, sex, age, diseases including diabetes mellitus, obesity, alcohol, smoking, as well as exercise(16).

As for the relation between HDL and exercise, Cooper and Wallace reported that both aerobic and anaerobic athletes have similar HDL concentration(17, 18). Lehton and Viikari reported that anaerobic exercise for muscular force showed no effects on increases in HDL level(19).

On the contrary, when middle-aged females went jogging three times per week during 20 weeks in Kilbom's study(20) and when 15 old people took ergometer exercise at the intensity of 70 to 80% of VO_2 max three times per week for two months in Whitehurst, the HDL concentration increased significantly(21). Such differences in the results of studies may be because increases in HDL concentration by exercise are much affected by HDL level before exercise, enzymes & hormones, forms of exercise, period, frequency, intensity, degrees of body fat accumulation, age, sex, diet, and smoking(22).

According to the results of this study, as for the blood HDL between the normal group and the obese group, Z was -0.053 and p-value was 0.958, showing no significant difference(p<0.05).

As for the relation between LDL and exercise, when athletes with endurance exercise are compared to normal people, the athletes maintain considerably lower LDL, and the differences are reported to be more remarkable in experienced athletes of track-and-field or cycling(23). In studies in which normal people were subjects, LDL concentration decreases by training(24). According to the results of this study, as for blood LDL between the normal group and the obese group, Z was 0.473 and p-value was

0.637, showing no significant difference($p < 0.05$).

Changes in Blood Lactic Acid Based on RPE

Lactate threshold level is reported to be a method to improve VO_2 max and a training intensity with superior effects in many studies. In studies in which oxygen uptake in relative intensity and lactate threshold are compared, the method is reported to be a variable affecting training improvement more remarkably. Accumulation of lactic acid according to cumulative exercise stress induces increase in H^+ in muscles, reduction in pH concentration, and increase in acidity in cells leading to inhibition of enzyme activities, serving as a factor disturbing exercise capacity by muscular fatigue by inducing reduction in muscular contraction.

When lactic acid is accumulated by 4mmol/l or more during exercise, absorption of lactic acid in the liver is reduced and accumulation of lactic acid in blood rapidly increases. Increased content of lactic acid causes muscular fatigue to stop exercise or to considerably reduce the intensity of exercise.

Various factors have been presented as causes of fatigue based on peripheral organs during long-term, constant exercise. Among them, functional difficulty in stimulus conveyance in neuromuscular system(8), and remarkable increase in blood lactic acid concentration based on lactic acid accumulation within muscles(25) are considered to be the main factors.

As another mechanism, as a result of an experiment in which perceived exertion on exercise efforts is identified detailedly, identification of frequency of mobilizing exercise units and changes in types of mobilizing exercise units(26) indicate lactic acid accumulation within muscles can affect the RPE in local factors, through stimulus conduction of motor nerves in central nervous system or through feedback of sense information of muscular nerves(27).

According to the results of this study, as for blood lactic acid between the normal group and the obese group, Z was 1.365 and p-value was 0.172, showing no significant difference($p < 0.05$).

CONCLUSION

In order to investigate the effects of exercise for strengthening of abdominal muscular force on the RPE and blood components, the author in this study selected eight college students with abdominal obe-

sity and eight ones with normal weight. After exercise for strengthening of abdominal muscular force (push-ups) was performed with the intensity of 'very very hard' (RPE 19-20), the blood HDL, LDL, lactic acid, WBC, and RBC before and after the exercise were compared and analyzed as follows.

1. As for the blood HDL between the normal group and the obese group, Z was -0.053 and p-value was 0.958, showing no significant difference ($p < 0.05$).
2. As for blood LDL between the normal group and the obese group, Z was 0.473 and p-value was 0.637, showing no significant difference ($p < 0.05$).
3. As for blood lactic acid between the normal group and the obese group, Z was 1.365 and p-value was 0.172, showing no significant difference ($p < 0.05$).
4. As for the RPE between the normal group and the obese group, Z was 2.310 and p-value was 0.021, showing significant difference ($p < 0.05$).

There was no significant difference in increase in fatigue substances between people with abdominal obesity and normal people when exercise for abdominal muscle was taken, but people with abdominal obesity had lower times of push-ups through the RPE.

Therefore, the lower times of push-ups of people with abdominal obesity may be caused by the relatively higher RPE of them than that of normal people rather than increase in practical fatigue substances.

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