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ORIGINAL PAPER

The effect of muscle power training with elastic band on blood glucose, cytokine, and physical function in elderly women with hyperglycemia

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Eun Hee Jin, Sok Park and Jae Moo So. The effect of muscle power training with elastic band on blood glucose, cytokine, and physical function in elderly women with hyperglycemia. *JENB*., Vol. 19, No. 1, pp.19-24, 2015 **[Purpose]** The purpose of this study was to identify the effects of muscle power training with elastic band on body composition, glucose relation factor, and physical function in elderly women with hyperglycemia. **[Methods]** A total of 16 elderly women volunteered to participate in this study as subjects, and they were randomly assigned into one of the following two groups: muscle power training group (MPT: n = 8) and control group (CON: n = 8). The muscle power training group took exercise program using elastic band for 12 weeks, and the other group did not receive any exercise program during the same period. Before and after the experiment, both of the two groups received measurement in body composition (BMI, %Fat, skeletal muscle mass), glucose, cytokine (interleukin 6, adiponectin), and physical function (IPPB, grip strength). With these methods, the following conclusions were achieved. **[Results]** The results showed significant increases in adiponectin (p = 0.006), interleukin 6 (p = 0.018), SPPB (p = 0.024), and grip strength (P=.014). Blood glucose was significantly decreased in exercise group than contruo group. **[Conclusion]** It shows that the muscle power training with elastic band can give positive effects in elderly women with hyperglycemia. **[Key wordsds]** Power training, elderly women, band exercise, hyperglycemia

INTRODUCTION

Aging generally refers to the biological, physical, and mental declining of properties and functions; and along with the atrophy of physiological and physical functions, psychological change also occurs, which is the state when the self-sustained function and the social role function of an individual is weakened [1].

Aging brings many changes in the functional aspect of the human body. Among them, the representative ones are the decreases in muscular strength and function. When the decrease in the muscle function occurs due to the aging, strengths such as muscle endurance, agility, and flexibility are decreased [2]. These decreases in the strength can cause negative effect to the everyday life, such as when carrying things, climbing up the stairs, and standing up from a chair. This decrease in muscle function can cause difficulty in independent living; and moreover, it can induce chronic diseases reducing the life span [3]. Especially, the decrease in the muscle function reduces the glucose storage capability, resulting in diabetes [4].

Diabetes is caused by this effect, as well as by the hormones secreted from the pancreas, or by the defect of both; and it is a chronic metabolic disorder featuring hyperglycemia [5]. Chronic hyperglycemia is an important cause increasing the complications of the vascular diseases in the diabetic patient [6]. Hyperglycemia is reported that even without diabetes, when the complications such as cardiovascular disease occur, the patient with temporarily high blood glucose can have a bad prognosis [7]. Therefore, for the prevention and treatment of diabetes and complications, managing the blood glucose is important. The goal of the current diabetes treatment is to control the metabolic disorder and to prevent the occurrences of complications to disable the progress. For the

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therapeutic methods, there are dietary treatment, exercise therapy, and drug treatment [8]. Among these, the exercise therapy is useful in enhancing the physical strength and preventing complications, which are known to be effective in diabetes treatment [9]. Regular exercise reduces the glucose concentrations in the blood [10], increases the insulin sensitivity of the peripheral tissue including the muscles [11], and also helps to control the weight of obese diabetic patients [12]. Aerobic exercises are generally practiced by diabetic patients until now, but the elderly patients with diabetes have difficulty in performing exercises; this is because they have problems of diabetic complications or retrogression in functional capabilities due to obesity, degenerative arthritis, cardiovascular disease [13]. Therefore, for the patients with difficulty in performing aerobic exercises consisting of sustaining weight for the duration of workout, it is reported that resistance exercise can be a good alternative for these diabetic patients [14].

The resistance exercise increases the amount of muscle for the diabetic patients to improve glucose intolerance and insulin sensitivity. As a result, it brings improvement to glycometabolism and reduction in glycated hemoglobin [14,15]. Also, it is reported to increase the capillary ratio of the muscle fiber and improve the storage capacity of glycogen within the muscle [16]. Therefore, as a diabetic person ages, resistance exercise and muscular reinforcement exercise are required with the general exercise amount, because improving the muscular strength and endurance are helpful for the treatment of diabetes [17]. The traditional resistance exercise is recommended with 50-80% range of weight for 1RM of elders [18]. But, the power training has recently been known to be performed in relatively low intensity of 40% of weight for 1RM in fast speed concentric contraction, which not only increases muscle power and strength but is also effective on improving the functional performance [19,20]. It has been reported that an exercise requiring fast concentric contraction of the muscle is required in order to increase the muscle power [21]. The muscle power training using the band increases muscular strength and improves flexibility, parallelism, and walking; furthermore, it is also reported to have the advantages of minimizing the impact from muscular activation and movements in various angles [22]. Taking these results into account, the muscle power training by using exercise bands is considered to be the appropriate in performing low-intensity, fast-speed concentric contraction exercise in the elderly people.

Therefore, the effect of band exercise will be verified in this study, by applying the protocols of muscle power training to the elderly woman with blood glucose disorder.

METHODS

Subject characteristics

The subjects of this study were elderly women who are studying at Y Elder's College in Seoul; and the recruited subjects did not have any medical diseases or exercise habit. Among them, 16 people with hyperglycemia met the Impaired Fast -ing Glucose standard provided by the ADA, with the fasting blood glucose level of over 100mg/dl (5.6mmol/liter). These subjects were selected and randomly classified into exercise group (n = 8) and control group (n = 8) for this study. The characteristics of subjects are listed in Table 1.

Test procedure

Physical measurement

For the physical measurement of the study subjects, bio-electrical impedance analysis (Inbody 370, Biospace, Seoul, Korea) was used to measure the height, weight, muscle mass, and body fat (% body fat).

Exercise program

The detail on exercise program of this study is provided in <Table 2>. For the low-intensity muscle power training

Table 1. Characteristics of subjects

Variables	Control group	Exercise group
Age (years)	76.11 ± 2.01	74.27 ± 0.62
Height (cm)	151.81 ± 2.53	151.75 ± 1.17
Weight (kg)	59.56 ± 4.32	58.24 ± 1.28
Body fat (%)	36.53 ± 1.23	37.91 ± 1.56
Muscle mass (kg)	19.35 ± 1.21	19.08 ± 0.61
Blood glucose (mg/dl)	118.13 ± 4.34	122.28 ± 2.45

Table 2. Muscle power training program

Exercise level	Contents	Intensity	Rest
Warming-up (10 min)	Stretching		
Main exercise (40 min)	Elbow flexion/extension		
	Reverse files		
	Upright row		
	Side Bend		
	Hip flexion/extension	10 rep/2set	15-20 sec/set
	Hip abduction/adduction		
	Mini-squat knee extension		
	Leg press		
	Ankle planter-flexion		
Cooling-down (10 min)	Stretching		

using the band, the power training program [23] of fast, stop (1 second) in the concentric contraction stage, and 2 second in the extensional contraction stage was used. For the strength of the band color, green (Hygenic Corporation, USA) was used, and subjective exercise strength (RPE) was set as 12-13. The exercise was applied with graded exercise principle, and the strength of the exercise was gradually increased every 4 weeks. According to the ASCM recommendation, the exercise group performed for 60 minutes per session, which included the warm-up (10 minutes), main exercise (40 minutes), and cooling-down (10 minutes); and elastic band exercise was practiced twice a week, and home-based exercise was practiced three times a week, over a total duration of 12 weeks.

Blood collection and analysis

Blood collection

Before the blood collection, over 12 hours of fasting was required to minimize the dietary effect. The pretest of blood collection was done 48 hours before the exercise, and the post test was performed 2 hours after the 12 weeks of elastic band exercise was finished. The medical technologist used the single-use syringe on the antecubital vein to gather 10ml of blood; and the blood samples were stored in the evacuated blood collection tubes treated with EDTA (ethy diamine tetra acetate; EDTA).

Blood glucose analysis

To analyze the blood glucose, whole blood was inserted into the plain vacutainer (sterile vacutainer) and was left at room temperature for 30 minutes; it was then centrifuged for 10 minutes at 3,000 rpm speed, and the serum was separated. The specimen was classified into standard and blank; 20 ul of plasma was classified to the specimen, and 20 ul of standard regent was classified to the standard. The color developing reagent of 20 ml was mixed into each specimen, and they were left in water bath at 37℃. Then, the absorbance was measured in 505 nm wavelength.

Cytokine analysis

For the analysis of IL-6, whole blood was inserted to the plain vacutainer (sterile vacutainer) which was left at room temperature for 30 minutes. Then, it was centrifuged for 10 minutes at 3,000 rpm speed, and the serum was separated. With the separated serum, IL-6 (Human IL-6 ELISA-kit, DSL, Texas, USA) was used for the analysis. For the Adiponectin, whole blood was inserted into the plain vacutainer (sterile vacutainer) which was left at room termperature for 30 minutes. Then, it was certrifuged for 10 minutes at 3,000 rpm speed, and the serum was separated. With the separated serum, commercial Human adiponectin (multimeric) ELISA kits (ALPCO, USA) was used to analyze through ELISA method.

SPPB (Short physical performance battery; SPPB) and grip test

SPPB

The SPPB test was used in this study, which was designed by the manifold study of EPESE (Established Population for Epidemiologic Studies of the Elderly) and supervised by the NIA (National Institute of Aging), for the physical performance evaluation in the lower limbs of the elderly participants. It is composed of the three items for sense of balance, speed, and standing up from a chair, which was done repeatedly for 5 times. For each task, 0 point indicated nonperformance, and 1 point to 4 points were given according to the differences in performance levels. When all 4 points were obtained for each task, a total of 12 points were recorded.

Grip test

In this study, the grip was measured through a representative method of measuring the upper limb strength (Stevena *et al*., 2012). The subject stood up in an erect posture with the arms spread apart straight to use the grip dynamometer (Takei, Japan). The left and right were measured 2 times with the start signal, and the mean value was recorded.

Data processing method

For all variables obtained in this study, SPSS statistics program (ver 18.0) was used to find the mean value and the standard deviation. For the significance test on the change in mean value, between the measurement variables of before & after exercise, Mann-Whitney U Test was performed. In the analysis, the level of significance was set as $P < 0.05$ for verification.

RESULTS

Change in blood glucose

The changes in blood glucose level of hyperglycemic elderly women, before and after the muscle power training using the band, are provided in <Table 3>. In this study, blood glucose ($p < 0.021$) was shown to be decreased, and the decreasing trend was shown within the exercise group. Therefore, it was observed that muscle power training using the band had positive effect on the improvement of blood glucose.

Table 3. Effect of elastic band power training on blood glucose

Variables	Control group		*Exercise group*		*P*
	Before	after	Before	after	
Blood glucose (mg/dl)	118.13 ± 4.34	116.10 ± 5.76	122.28 ± 2.45	103.12 ± 4.56*	0.021

Table 4. Effect of elastic band power training on cytokines

Variables	Control group		*Exercise group*		*P*
	Before	after	Before	after	
Adiponectin (pg/ml)	83.49 ± 3.11	85.40 ± 2.98	85.24 ± 2.11	94.92 ± 2.18*	0.018
Interleukin 6 (pg/ml)	47.43 ± 2.45	45.49 ± 2.98	45.92 ± 1.87	55.39 ± 2.01*	0.006

Table 5. Effect of elastic band power training on physical function

Variables	Control group		*Exercise group*		*P*
	Before	after	Before	after	
SPPB (score)	8.74 ± 0.21	8.63 ± 1.27	8.59 ± 0.32	9.66 ± 0.20*	0.024
Grip strength (kg)	16.77 ± 0.98	15.73 ± 0.58	15.32 ± 0.85	19.38 ± 0.83*	0.014

Change in Cytokine

The changes in cytokine of hyperglycemic elderly women, before and after the muscle power training using the band, are provided in <Table 4>. In this study, cytokine, adiponectin, and IL-6 were measured for the cytokine level related to blood glucose. It increased in the cytokine related to blood glucose of adiponectin ($p < 0.018$) and IL-6 ($p < 0.006$), and the increase was observed in all exercise groups. Therefore, it was observed that muscle power training using the band had positive effect on the improvement of cytokine related to blood glucose.

Change in physical function

The changes in physical functions of hyperglycemic elderly women, before and after the muscle power training using the band, are provided in <Table 5>. In this study, SPPB and grip were measured for the changes in physical functions. After intervention exercise, SPPB ($p < 0.024$) and grip ($p < 0.014$) were all increased, and they were all increased within the exercise group. Therefore, it was observed that low-intensity resistance exercise using the band had positive effect on the improvement of physical function.

DISCUSSION

The purpose of this study is to identify the effects of 12 weeks of muscle power training using the band on blood glucose, cytokine related to blood glucose, and physical function of the elderly women, who have fasting blood glucose disorder, which is known as the initial symptom of diabetes.

Aging brings many changes to the functional aspects of the human body. Among them, the representative ones are decreases in muscular strength and function. The cause of these physical changes can be loss of muscular fiber, decrease in exercise unit, and reduction of neuromuscular function. The muscular strength and function decline faster as aging progresses, and it results in glycometabolism imbalance which can eventually cause diabetes [4]. The representative cytokine regulating this glycometabolism is reported to be adiponection and IL-6 [24]. Adiponectin and IL-6 are decreased in secretion, as body fat increases due to aging; and when the muscles and their functions are improved, secretion also increases to regulate the glycometabolism [24]. IL-6 is known to be produced within the skeletal muscle by the muscle contraction during exercise, and decrease in glycogen concentration within the muscle to be released to the blood [25]. The regular exercise is reported to increase the adiponectin concentration within the blood to decrease the neutral fat and increase the insulin sensitivity [26]. In this study, after performing muscle power training using the band, the blood glucose decreased significantly, and adiponectin and IL-6 significantly increased with statistical significance. For this blood glucose control function, the main cause was regular resistance exercise increasing the capillary ratio of the muscular fiber, which improved the storage capacity of glycogen within the muscle and significantly decreased the glycated hemoglobin to activate the muscular tissue [27]. Recently, Mann *et al.* (2014) reported that resistance exercise improved insulin resistance to control glycometabolism, and also that aerobic exercise improves glycometabolism due to the increase in muscle and insulin receptor. The awareness about the importance of

muscular strength exercise, in glycometabolism of the elderly people, should help with the musculoskeletal weakening of the aging people. To prevent the decrease in muscular function, resistance exercise is considered to be effective. Especially, the muscle power training performed in this study is considered to activate the muscle and the nerve [23], increase storage space, and regulate the glucose intake to control the blood glucose level. Therefore, the result of this study proved that 12 weeks of muscle power training made improvement in the blood glucose disorder of the elderly women.

The decrease in physical function for the elderly women with hyperglycemia, who lacked physical activity, exposed them to danger of falls and disability in their everyday lives [28]. In order to reduce these risks, the nerve and muscle functions must be improved through regular exercise [19]. In this study, 12 weeks of muscle power program was subjected to elderly women with hyperglycemia, and the exercise group showed significant increase in the physical performance ability test (SPPB) and muscular strength test, which proved that exercise effected in the change of physical function. In connection to this, our results coincided with the advanced study [29], in which the regular exercise program improved the physical performance ability and muscular strength of elderly women. Through this result, the performance of movements such as core training, lunge, and squat in the band exercise not only increase the muscular strength and function, but it is also considered to increase the overall physical ability by improving the physical performance. Therefore, the regular muscle power program using the band in this study is considered to improve the muscle and nerve functions of elderly women, and it also improved parallelism, coordination, and flexibility at the same time to reduce the danger of falls and to improve the overall quality of life.

In the advanced study on the elderly subjects, the sampling was limited to diabetic patients, and the age could not be matched. Therefore, it was difficult to directly compare the differences of several results of this study to other study results. For the effect of exercise intervention for the early stage of diabetes or the fasting blood glucose disorder, studies are very much lacking; and it is considered that describing the characteristic result of the subjects with fasting blood glucose disorder is difficult. Developing and studying various exercise programs are considered to be necessary in the future. The subjects with fasting blood glucose disorder should improve their muscular strength and function to prevent falls, and study on improving the quality of life must be continued.

CONCLUSION

In this study, as a result of performing muscle power program using the band on elderly women with hyperglycemia, exercise intervention effect was identified through the significant changes in the blood glucose, cytokine related to blood glucose, and physical performance ability. Moreover, based on the study results, improvements were observed in glycometabolism regulation, as well as in physical function of the elderly women with hyperglycemia. This study is expected to have positive effect on developing specialized exercise intervention programs, which can be applied to the subjects with glycometabolism disorder. In the future study, developing the diabetes preventive exercise program can delay the contraction speed from the fasting blood glucose disorder stage to diabetic stage.

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