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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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
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 glycemia 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 Fasting 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

| 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 1. Characteristics of subjects

| Exercise level | Contents                      |
|----------------|-------------------------------|
| Warming-up     | Stretching                    |
| (10 min)       |                               |
| Main exercise  | Elbow flexion/extension       |
| (40 min)       | 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   | Stretching                    |
| (10 min)       |                               |

Table 2. Muscle power training program
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°C. 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, 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.
Effect of exercise on blood glucose, cytokine and physical function in elderly women with hyperglycemia

| Variables          | Control group       | Exercise group   | P   |
|--------------------|---------------------|------------------|-----|
| 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   |
|--------------------|---------------------|------------------|-----|
| 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   |
|--------------------|---------------------|------------------|-----|
| 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 adiponectin 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.

**REFERENCE**

[1] Park DC, Yeo SC. Aging. Korean J Audiol. 2013;17(2): 39-42.
[2] Burtscher M. Effects of living at higher altitudes on mortality: a narrative revier. Aging Dis. 2013;5(4):74-80.
[3] Dela F, Kjaer M. Resistance training, insulin sensitivity and muscle function in the elderly. Essays Biochem. 2006;42:75-88.
[4] Hurley BF, Roth SM. Strength training in the elderly: effects on risk factors for age-related diseases. Sports Med. 2000;30:249-268.
[5] Fukuoka Y, Yamada Y. Lifestyle of elderly patients with diabetes mellitus. Nihon Rinsho. 2013;71(11):1965-1969.
[6] Corwell B, Knight B, Olivieri L, Willis GC. Current Diagnosis and treatment of hyperglycemic emergencies. Emerg Med Clin North Am. 2014;32:437-452.
[7] Ceriello A. Acute hyperglycaemia: a ‘new’ risk factor during myocardial infarction. Eur Heart J. 2005;26:328-331.
[8] Allen J, Moreli V. Aging and exercise. Clin Geriatr Med. 2011;27(4):661-671.
[9] Voulgarki C, Pagoni S, Vinik A, Poiner P. Exercise improves cardiac autonomic function in obesity and diabetes. Metabolism. 2013;62(5):609-621.
[10] Scholten RR, Thijssen DJ, Lotgering FK, Hopman MT, Spaanderman ME. Cardiovascular Effects of Aerobic Exercise Training in Formerly Preeclamptic Women and Healthy Parous Controls. Am J Obstet Gymecol. 2014; 9378:385-388.
[11] Marinho R, Moura LP, Rodrigues Bde A, Pauli LD,
Silva AS, Ropelle EC, Souza CT, Cintra DE, Ropelle ER, Pauli JR. Effects of different intensities of physical exercise on insulin sensitivity and protein kinase B/Akt activity in skeletal muscle of obese mice. Einstein. 2014;12:82-89.

[12] Miller CT, Fraser, SF, Levinger I, Straznicky NE, Dixon JB, Reynolds J, Selig SE. The effects of exercise training in addition to energy restriction on functional capacities and body composition in obese adults during weight loss: a systematic review. PLoS One. 2013;8:e81692.

[13] An Geun Hee. The Effects of Exercise Type on Body Composition, Cardiovascular Fitness, Physical Performance and Biochemical Variables in Type 2 Diabetic Patients. Korea Journal of Physical Education. 2005;44:451-463.

[14] Eves ND, Plotnikoff RC. Resistance Training and Type 2 Diabetes. Diabetes Care. 2006;29:1933-1941.

[15] Singal RJ, Kenny GP, Wasserman DH, Castaneda C. Physical activity/ exercise and type 2 diabetes. Diabetes Care. 2004;27:2518-2539.

[16] Christ-Roberts CY, Mandarino LJ. Glycogen synthase: key effect of exercise on insulin action. Exerc Sport Sci Rev. 2004;32:90-94.

[17] Honkola A, Forslin T, Eriksson J. Resistance training improves the metabolic profile in individuals with type 2 diabetes. Acta Diabetol. 1997;34:245-248.

[18] Porter MM. Power training for older adults. Applied Physiology Nutrition and Metabolism. 1993;31:87-94.

[19] Dongheon Kang, Heejae Kim, Donghyun Yoon, Jinsoo Kim, Wook Song. Effects of 12 Weeks High-speed Elastic Band Training on Cognitive Function, Physical Performance and Muscle Strength in Older Women with Mild Cognitive Impairment (MCI): A Randomized Controlled Trial. Korea J Health Promot. 2014;14:26-32.

[20] Sayers SP, Gibson KA. A comparison of high-speed power training and traditional slow-speed resistance training in older men and women. Journal of Strength and Conditioning Research. 2010;24:3369-3380.

[21] Steib S, Schoene D, Pfeifer K. Dose-response relationship of resistance training in older adults: a meta-analysis. Med Sci Sports Exerc. 2010;42:902-914.

[22] Page PA, Labbe A, Topp RV. Clinical force production of theraband elastic bands. J Orthop Sports Phys Ther. 2000;30:47-48.

[23] Ivy JL. Role of carbohydrate in physical activity. Clin Sports Med. 1999;18:469-484.

[24] Strasser B, Pesta D. Resistance training for diabetes prevention and therapy: experimental findings and molecular mechanisms. Biomed Res Int. 2013;2013:1-8.

[25] Steensberg A, Febbraio MA, Osada T, Schjerling P, van Hall G, Saltin B, Pedersen BK. Interleukin-6 production in contracting human skeletal muscle is influenced by pre-exercise muscle glycogen content. J Physiol, 2001; 537:633-639.

[26] Pajvani UB, Du X, Comb TP. Structure-function studies of the adipocyte secreted hormone Acrp30/adiponectin: implications for metabolic regulation and bioactivity. Biological Chemistry, 2003;278:9073-9085.

[27] Mann S, Beedie C, Balducci S, Zanuso S, Allgrove J, Bertiato F, Jimenez A. Changes in insulin sensitivity in response to different modalities of exercise: a review of the evidence. Diabetes Metab Res Rev. 2014;30:257-268.

[28] Sinclair A, Dunning T, Rodriguez-Mañas L. Diabetes in older people: new insights and remaining challenges. Lancet Diabetes Endocrinol. 2014;52213-8587:70176-70177.

[29] Pereira A, Izquierdo M, Silva AJ, Costa AM, González-Badillo JJ, Marques MC. Muscle performance and functional capacity retention in older women after high-speed power training session. Exp Gerontol. 2012;47:620-624.