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Original Article

The Effects of Resistance Training and Swedish Massage on Changes in Plasma Levels of Liver Enzymes in Overweight Women: "Resistance Training, Massage, and Liver Enzymes"

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Abstract

Background: Overweight people suffer from elevated liver enzymes. Today, the only definite treatment for non-alcoholic fatty liver (NAFL) is losing weight. Therefore, this study aimed to compare the effects of resistance exercise and Swedish massage on changes in plasma levels of liver enzymes in overweight women.

Methods: In the current study, 24 overweight women were divided into three groups of eight (Swedish massage, resistance exercise, and control). The training protocols for Swedish massage and resistance exercise were implemented for eight weeks, three sessions per week. Alanine transaminase (ALT) and aspartate transaminase (AST) were measured before and after the eight-week interventions.

Results: Post-test results showed a significant difference ALT levels in the resistance exercise group ($P=0.001$) and the Swedish massage group ($P=0.001$) with the control group. Also, the two intervention groups significantly differed in ALT ($P=0.032$). AST levels in the resistance exercise group ($P=0.001$) and the Swedish massage group ($P=0.003$) significantly differed from the control group. Meanwhile, the two intervention groups had no significant difference in AST ($P=0.083$).

Conclusions: High-intensity resistance training and Swedish massage could effectively control and reduce liver enzyme levels and conditions such as fatty liver disease, overweight, and obesity.

Keywords: Swedish massage, Resistance training, ALT, AST, Overweight

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Introduction

Obesity is a condition in which excess fat is accumulated in the body. The accumulation of excess body fat tissue can affect health indicators like mean life expectancy and quality of life (1). The liver and its enzymes are essential in body metabolism and hormone regulation. The first step in diagnosing liver damage is performing simple bloodwork and several biochemistry tests. The most essential of these tests is measuring aminotransferase enzyme activity levels (alanine transaminase [ALT] and aspartate transaminase [AST]) (2).

Increased activity of liver enzymes such as AST, ALT, and alkaline phosphatase (ALP) in blood is reported as a clinical indicator for muscle and liver damage and essential markers for heart damage. The liver contains many of these three enzymes, so any damage to liver cells causes their release into the blood (3).

ALT is a cytoplasmic enzyme, and AST is a mitochondrial enzyme; besides the liver, they both also exist in the heart, skeletal muscles, kidney, etc. (4). Fatty liver disease consists of a range of conditions resulting from the accumulation of fat in liver cells, potentially causing fibrosis, followed by cirrhosis, the chronic and irreversible condition resulting from the destruction of liver cells. Metabolic syndrome conditions such as high blood pressure, elevated blood lipids, obesity, and diabetes have been associated with fatty liver disease. Therefore, some researchers consider fatty liver disease as the hepatic manifestation of insulin resistance or metabolic syndrome (5).

When the liver is damaged, ALT is released into the bloodstream before any apparent signs, such as jaundice, are observed. The normal level ranges from 9 to 25 units/L for women and 10 to 40 units/L for men. In healthy people, AST levels are low, if the liver is damaged, this enzyme is released into the bloodstream from the cells, increasing for up to 12 hours and remaining in the bloodstream up to 5 days (2). Although ALT and AST serum activities increase when liver cell integrity is compromised by diseases, ALT test results are more specific to the liver. The increased activity of ALT lasts longer than the activity of AST (6). It is reported that among hepatic alanine transferases, the plasma levels of ALT are better predictors for fatty liver

(7); therefore, a decrease in the levels of these enzymes is a symptom of improvement in fatty liver.

It seems that physical exercise should be considered an effective intervention without side effects; however, the role of different kinds of exercises and the mechanism by which they affect fatty liver have not been identified completely (8), and the effect of physical exercise on liver enzymes is not consistent in all of the studies (5). One of the important factors endangering the health of patients with non-alcoholic fatty liver (NAFL) is obesity, which is increasing worldwide. Different studies have reported contradictory results about the effect of exercise of different types, intensities, and durations on liver enzymes in fatty liver patients. One study showed that resistance exercises reduced the amount of hepatic fat in fatty liver patients. The enzyme plasma concentration of AST was not significantly different after these exercises, whereas there was a significant reduction in ALT concentration (9).

Resistance training (RT) is a type of physical exercise focusing on contracting the muscles and increasing their strength, stamina, and size. If resistance training is executed correctly, it could benefit the health and strength of muscles, bones, ligaments, and tendons. Researchers seek the best training methods through resistance training by manipulating training variables such as repetition, duration, execution, times, and rest intervals (10). Different studies have shown that discontinuing training and exercises changes body composition, accumulating fat in fat tissue and increasing blood lipids (11). The popularity of resistance training has increased, and it has become a social trend, but there is no consensus about its positive effect on improving the health of different types of patients (5). Khosravi showed that low-intensity resistance training does not significantly change enzyme levels (12).

According to some evidence, there is a strong positive correlation between basal metabolism rate (BMR) and lean body mass (LBM). Increased LBM brings about elevated BMR. In this regard, resistance training is reliable for increasing LBM (13). Fatty liver syndrome occurs when liver cells begin to accumulate lipid droplets (mostly triglyceride). Today, weight loss is the only definite treatment for non-alcoholic fatty liver disease (NAFLD), and lifestyle interventions are just one part of managing this condition. Achieving weight loss and maintaining it is difficult. Exercise and physical activity can potentially be effective in reducing liver fat (5).

Massage is the oldest treatment for the soul and the body (14). Generally, it is used to temporarily reduce pain, anxiety, depression, and high blood pressure, increase the release of endorphin and metabolism rate, and improve lymphatic blood flow, sleep quality, and circulation of nutrients in the blood and muscles. After exercise, massage facilitates the absorption of micronutrients and muscle recovery, and by increasing blood flow, it causes the body to excrete waste materials such as lactic acid and carbonic acid accumulated in muscles during training. Also, continuous massage increases white blood cell production and boosts the immune system (15).

Swedish massage is one of the most popular and common forms of massage. It contains two sets of strokes. The first set includes gentle, slow, and long, and the second set includes regular and slightly more forceful strokes. Swedish massage is a soothing, energizing, and effective experience. It can also be used to treat minor injuries (16). Therefore, the current study was conducted to compare the effects of resistance training and Swedish massage on changes in plasma levels of liver enzymes in overweight women.

Methods

This study compared the effects of resistance training and Swedish massage on changes in plasma levels of liver enzymes in overweight women. The subjects were selected voluntarily via convenience sampling and randomly assigned to either the control or intervention group. Eight weeks of Swedish massage and eight weeks of resistance training were implemented for members of the intervention groups. As many variables were not under control, this study is quasi-experimental. A pretest and post-test blood draw was performed on the subjects to measure possible changes in related factors.

The research population for the current study included inactive overweight women. Twenty-four individuals 30 to 45 years of age with BMIs ranging from 25 to 30 were selected via convenience sampling and divided into three groups: control, massage, and training. The sample size was calculated using the Cochran formula, the most widely used method of calculating the sample size. Convenience sampling was conducted among overweight women at the gym.

This study was conducted in Aligoudarz county in Lorestan province, in a gym and a massage parlor in 2022. The most important inclusion criteria were having no cardiovascular and gastrointestinal conditions and willingness to enter the study. They also included not using prescription drugs or supplements and not smoking or consuming alcohol in the last six months. Liver enzymes, including aspartate aminotransferase and alanine aminotransferase, were measured using a kit made by ROCH company, USA.

The intervention for the Swedish massage group included eight weeks of Swedish massage, three 45-minute sessions per week. The control group had no activity during this period. After the intervention, the variables were measured again.

The study's design, potential risks, and benefits were explained to each subject, and each of them filled out and signed an informed consent form before the beginning of the study. One week before the study protocol was implemented, the subjects were familiarized with the research stages and examined to confirm their health.

The intervention process

The protocol for the massage group included the following 45-minute Swedish massage:

1. Stroke (effleurage): 50% in 20 minutes
2. Friction: 5% in 2 minutes
3. Compression: 15% in 10 minutes
4. Petrissage (kneading): 20% in 9 minutes
5. Vibration: 2% in 1 minute
6. Shaking/Jostling: 1% in 30 seconds
7. Percussion/Tapotement: 2% in 30 seconds
8. Approximation/Distraction: 5% in 2 minutes

These techniques were performed in the following order: First, the subject lay prone on the bed. The techniques were performed in order on the back, hands, neck, hips, and legs. Then, the subject changed their position to supine, and the strokes were performed on the abdomen, chest, hands, legs, and planta. First, the proximal organs and then the distal ones were massaged. For a thorough massage, the strokes were directed towards the heart, i.e., from distal to proximal. When compression and distraction techniques were being performed, the subject inhaled and exhaled so as to avoid the Valsalva maneuver (17).

Resistance training protocol

This protocol included resistance training in the gym for eight weeks, three sessions per week. Each session began with a 10-minute warm-up, including stretching and light movements with light weights, followed by resistance training. This program involved eight movements: leg press, chest press, rowing motion, knee flexion (hamstring muscles), shoulder press, triceps, lounges (quadriceps femoris muscle), and dumbbell curls. The exercise program was designed to become heavier once every two weeks. The program involved two sets and 12 reps for the first and second weeks, three sets and 10 reps for the third and fourth weeks, three sets and eight reps for the fifth and sixth weeks, and four sets and six reps for the seventh and eighth weeks. In addition to that, the intensity of training increased from 40% 1RM in the first week to 70% 1RM in the last week (increasing by 10% per week). Each session ended with a 10-minute cool down (7) (Table 1).

Data analysis method

The Shapiro-Wilk test was used to determine the normality of data. In this test, the data distribution is normal when the P value is higher than the critical point of 0.05. Since the data distribution was normal, a one-way ANOVA, LSD post hoc test, and dependent t-test were performed to analyze the data and test the hypothesis.

Results

The mean and standard deviation for demographic information of the subjects of all three groups, including age, height, weight, and BMI are presented in Table 2.

Pretest and post-test results showed no significant difference in AST in the control group (Table 3). However, there were significant differences in the Swedish massage group ($P=0.001$) and in the resistance training group ($P=0.02$). Also, these results showed significant

Table 1. Resistance training protocol

	First week	Second week	Third week	Fourth week	Fifth week	Sixth week	Seventh week	Eighth week
Number of sets	2	2	3	3	3	3	4	4
Reps	12	12	10	10	8	8	6	6
1RM	40%	40%	50%	50%	60%	60%	70%	70%

Table 2. The mean and standard deviation distribution for subjects' demographic information

Variable	Group	Number	Mean	Standard deviation	*P* value
Age (y)	Resistance training	8	35.25	1.78	0.852
	Swedish massage	8	37.37	1.89	
	Control	8	38	1.93	
Height (cm)	Resistance training	8	161.12	4.18	0.878
	Swedish massage	8	160.12	4.1	
	Control	8	160.62	4.12	
Weight (kg)	Resistance training	8	69.42	3.4	0.397
	Swedish massage	8	68.28	3.1	
	Control	8	69.57	3.23	
BMI	Resistance training	8	28.17	1.67	0.134
	Swedish massage	8	27.57	1.55	
	Control	8	22.07	1.20	

BMI, body mass index.

Table 3. The dependent *t*-test results of AST and ALT variables

Variables	Groups	Pretest	Post-test	*P* value
AST (IU/L)	Resistance training	24.37 ± 4.68	16.87 ± 4.82	0.02
	Swedish massage	26.37 ± 5.99	20.62 ± 3.96	0.001
	Control	27.75 ± 3.10	27.62 ± 3.37	0.87
	P value	0.094	0.001	
ALT (IU/L)	Resistance training	20.25 ± 3.53	16.62 ± 2.26	0.001
	Swedish massage	24.87 ± 5.46	20.37 ± 3.54	0.001
	Control	27.50 ± 4.41	27.62 ± 3.77	0.7
	P value	0.013	0.001	

differences in ALT in the Swedish massage and resistance training ($P = 0.001$) groups but no significant difference in the control group ($P = 0.7$).

A one-way ANOVA was used to compare the intergroup ALT and AST variables at the post-test stage. The results showed a significant difference in AST among the three groups (Swedish massage, resistance training, and control groups) ($P = 0.001$). The results also showed a significant difference in ALT among the three groups ($P = 0.001$). After that, the LSD test was used to determine the intergroup difference, as reported in Table 4.

The LSD test results of the post-test in Table 4 show that the resistance training group and the Swedish massage group were significantly different in AST from the control group ($P = 0.001$) ($P = 0.003$); however, there was no significant difference in AST between the two interventions groups (0.081). Also, the post-test showed that the resistance group significantly differed from the ALT of the control group ($P = 0.001$). This was also the case for the Swedish massage group ($P = 0.001$). There was a significant difference between the two intervention groups in ALT ($P = 0.032$).

Discussion

The results showed a significant difference between these two exercise methods, but both reduced liver enzyme levels (ALT and AST) between the pretest and the post-test.

Many studies have proven the effectiveness of consistent exercise in reducing liver enzyme activities. Barani et al observed a significant reduction of liver enzymes following eight weeks of resistance and combined training and reported that eight weeks of resistance training reduced liver fat by 13%. During submaximal intensity training, fat oxidation increased without any change in body weight (5).

Studies indicate that AST increases 12 hours after the beginning of the training, reaches a maximum on the second day, and returns to its normal amount in 4 to 5 days. Meanwhile, ALT increases 4 to 6 hours after the beginning of the training, reaches its maximum of 12 times more than its normal amount, and returns to normal on the third day. Although the serum activities of both enzymes

Table 4. LSD test results to determine intergroup difference in AST and ALT

Variable	Group (I)	Group (J)	Mean deviation	Standard deviation	Significance level
AST (IU/L)	Resistance	Massage	3.75	2.04	0.081
		Control	10.75	2.04	0.001
	Massage	Control	7.00	2.04	0.003
ALT (IU/L)	Resistance	Massage	3.75	1.63	0.032
		Control	11.0	1.63	0.001
	Massage	Control	7.25	1.63	0.001

increase whenever the integrity of hepatocytes becomes affected by diseases, ALT is more specific to the liver. Lab methods are also responsible for the results since each enzyme's half-life, storage conditions, and measurement are different. Lack of adequate attention to these issues might alter the results (5).

According to the studies, the more intense and the longer the exercise and training, the more engaged liver enzymes are in producing ATP. According to the theory of enzyme release from inside the cells through the cytoplasmic membrane, the release of AST and ALT into the bloodstream may increase (5).

The reason for the difference in the results of the current study from the above-mentioned studies might be that resistance training was used in this study. This type of training may have induced cellular adaptability, strengthening the membrane and ultimately leading to the release of ALT and AST into the bloodstream. The significant reduction in AST and ALT following exercise can be attributed to increased insulin sensitivity in tissues and the liver, enhanced hepatic oxidation, decreased and restrained activity of lipogenic enzymes, and consequently, reduced liver fat (6). Physical activity can help to reduce hepatic steatosis, prevent the progress of cirrhosis, and improve insulin sensitivity and cardiovascular conditions, which are the main reasons for fatality among these patients.

Various mechanisms have been suggested as the reason for the positive impact of exercise on NAFLD patients. Exercising reduces insulin resistance and visceral and subcutaneous fat and increases the removal of free fatty acids by the liver (7).

AST and ALT are among the enzymes engaged in hepatic metabolism. Since the liver is more active in endurance activities, the possibility of damage to liver cell membranes in endurance and long-term training is high. If the training consists of heavy resistance exercise, the greatest part of the necessary energy is supplied by anaerobic activity, and liver cells, especially their enzymes, are not much engaged to supply energy; therefore, damage to them is minimal (8). The type, duration, and intensity of physical exercise can also be effective on enzyme activities. Aminotransferases have low activity in normal serum but increase during endurance, short-term intense, and eccentric exercises. One of the vital organs engaged in various physical exercises is the liver, and its ALT and AST might increase after training (8).

Suzuki et al showed that regular training significantly reduced serum ALT (18), and Aali et al showed that eight weeks of resistance training in obese men reduced ALT, AST, and gamma-glutamyl transferase (GGT) (19). These results are consistent with the results of the current study.

Rajabi et al investigated exercise program (resistance and aerobic interval) reduced liver fat independent of weight loss. It is possible that women with fatty liver could benefit from this program as an adjunctive non-pharmacological treatment to improve fatty liver disease. (8).

Behzadimoghadam et al investigated the effect of an eight-week resistance training and low-calorie diet on plasma levels of liver enzymes and liver fat in NAFLD patients; the AST of the intervention groups showed a significant reduction (20).

Nejad salim et al studied the effect of eight-week resistance training on serum levels of AST, ALT, and ALP in overweight men with NAFLD, and there was a significant reduction of AST serum levels in the intervention group (7). All these results are consistent with those of the current study.

For example, Slantz et al (21) and Bemben et al (22) also showed that low-intensity resistance training does not bring about significant change in the amount of ALP. Moreover, according to the findings of Khalili et al, after a period of aerobic or resistance training, although visceral fat decreased, there was no change in serum levels of liver enzymes and insulin resistance. This is not consistent with the findings of this study (11). The findings of Barani et al indicated that eight weeks of resistance training with 60% to 70% intensity, one-repetition maximum (1RM), three times a week significantly reduces ALP in patients with fatty liver. However, it does not significantly affect AST and ALT (5). These results are not consistent with those of the current study. In these studies, differences in training type, participants' ages, and analyte types may account for the discrepancies.

The limitations of this study were (*a*) no prescribed diet for the groups due to lack of adequate resources, (*b*) no precise control over subjects' amount of physical exercise and rest during the study, and (*c*) no control over subjects' activities outside the intervention time.

Conclusion

The current study's findings showed that resistance training and Swedish massage significantly reduced serum levels of liver enzymes, AST and ALT. These results indicated the importance of high-intensity resistance training and massage in reducing risk factors associated with obesity and overweight. The increase in liver enzymes is an indicator of increased visceral fat and liver fat. Therefore, from the reduction of these factors in the current study, it can be elicited that high-intensity resistance training and massage can effectively control fatty liver, overweight, and obesity.

Authors' Contribution

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Competing Interests

None of the authors have any conflicts of interest.

Ethical Approval

This study was conducted under the ethics code IR.IAU.AGZ.REC.1402.001. All ethical principles were observed in this study. The participants were informed of the purpose and stages of the study. They were assured of the confidentiality of their information and that they could leave the study at any time. The results would be provided to the subjects if they wanted. A written consent form was acquired from each subject. This study received no financial support from government, public, commercial, or non-profit organizations. All the authors contributed equally to the study.

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References

1. Faramarzi S. The Effect of Observational Learning Based on Video Models on Eating Attitude, Eating Behavior and BMI of Elementary School Students [dissertation]. Faculty of Humanities, Sepahan Institute of Higher Education of Science and Technology, University of Isfahan; 2018. [Persian].
2. Naminezhad Z, Hosseini SA, Noura M, Naminezhad A. The effect of two weeks detraining following eight weeks aerobic training on alanine aminotransferase and aspartate aminotransferase of inactive male. Journal of Sport Bioscience Researches. 2014;15(4):55-71. [Persian].
3. Valipour Dehnou V, Sepahvand H, Omidali F. The effect of a course of Sustanon self-administration and omega-3 consumption on serum levels of total cholesterol, brain derived neurotrophic factor (BDNF), high density lipoprotein (HDL), low density lipoprotein (LDL), and alanine aminotransferase (ALT) in male body builders. Journal of Knowledge & Health. 2018;13(1):39-45. doi: 10.22100/jkh.v13i1.1912. [Persian].
4. Jamali R, Jamali A. Non-alcoholic fatty liver disease. Feyz Med Sci J. 2010;14(2):169-81. [Persian].
5. Barani F, Afzalpour ME, Ilbiegi S, Kazemi T, Mohammadi Fard M. The effect of resistance and combined exercise on serum levels of liver enzymes and fitness indicators in women with nonalcoholic fatty liver disease. J Birjand Univ Med Sci. 2014;21(2):188-202. [Persian].
6. Galedari M, Kaki A. The effect of 12 weeks high intensity interval training and resistance training on liver fat, liver enzymes and insulin resistance in men with nonalcoholic

fatty liver. Jundishapur Sci Med J. 2017;16(5):493-503. doi: 10.22118/jsmj.2017.53990. [Persian].

7. Nezhad Salim S, Gholami M. Effect of eight weeks resistance training on serum levels of hepatic enzymes including AST, ALT and ALP in overweight mens with nonalcoholic fatty liver disease. J Anim Biol. 2018;10(4):69-76. [Persian].
8. Rajabi S, Askari R, Haghighi AH, Razavianzadeh N. The effect of resistance-aerobic interval training on the fatty liver grade, liver dimensions, and liver enzymes in obese or overweight women with fatty liver. Community Health Journal. 2021;14(4):65-74. doi: 10.22123/chj.2021.238851.1539. [Persian].
9. Haghiparast S, Fadaei Chafy MR. The effect of six-week resistance training with vascular obstruction on growth hormone, strength, muscular endurance, power and body fat percentage in male bodybuilders. Journal of Physiology of Movement and Health. 2022;2(1):15-28. [Persian].
10. Etemad Z, Esmailnasab N. The effects of strength exercise program of anterior muscles on body composition and serum lipids. Sci J Kurdistan Univ Med Sci. 2010;14(4):20-8. [Persian].
11. Khalili A. Investigation of the Effect of Resistance Training with Different Intensities on the Levels of Liver Enzymes in Patients with Fatty Liver of Ahvaz Police Force [dissertation]. Faculty of Physical Education and Sports Sciences, Shahid Chamran University of Ahvaz; 2016. [Persian].
12. Khosravi A. Comparison of the Effect of Low-Intensity Aerobic and Resistance Training on Obesity Indices of Overweight Women [dissertation]. Semnan: Faculty of Physical Education and Sports Sciences, Shahrood University of Technology; 2013. [Persian].
13. Hosseini M. The Effect of Eight Weeks of Resistance Training with Massage on Some Hematological and Coagulation Factors of Elderly Men [dissertation]. Khorasan Razavi: Department of Physical Education and Sports Sciences, Non-Governmental Non-Profit Institute of Higher Education, Sanabad Golbahar; 2017. [Persian].
14. Thabit F. The Effect of Four Weeks of Swedish Massage on Some Biomechanical Parameters of the Knee Joint During Walking in Adult Women with Osteoarthritis of the Knee Joint [dissertation]. Kerman: Faculty of Sports Sciences, Shahid Bahonar University of Kerman; 2016. [Persian].
15. Fakhari H. The Effect of Eight Weeks of Swedish Relaxation Massage on Some Serum Growth Factors of Young Men [dissertation]. Faculty of Literature and Human Sciences, Qom University; 2017. [Persian].
16. Naghizadeh H, Azizbeigi k. Effect of 12 weeks of progressive resistance training on the serum levels of liver enzymes aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase in sedentary obese men. Metabolism and Exercise. 2019;9(2):163-85. doi: 10.22124/jme.2020.8548.91. [Persian].
17. Mirzaei M. Comparison of the Effect of 6 Weeks of Traditional Resistance Training and Theraband on Some Physical Fitness Factors and the Levels of Alanine Aminotransferase (ALT), Aspartate Aminotransferase (AST) and Alkaline Phosphatase (ALP) Teenage Swimmers [dissertation]. Faculty of Literature and Humanities, University of Qom; 2019. p. 21-8. [Persian].
18. Suzuki A, Lindor K, St Saver J, Lymp J, Mendes F, Muto A, et al. Effect of changes on body weight and lifestyle in nonalcoholic fatty liver disease. J Hepatol. 2005;43(6):1060-6. doi: 10.1016/j.jhep.2005.06.008.
19. Alie M, Matinhommaee H, Azarbayjani M, Peeri M. The effect of resistance training intensity on enzymatic and nonenzymatic markers of liver function in obese males. Indian J Fundam Appl Life Sci. 2015;5(2):101-10.
20. Behzadimoghadam M, Galedari M, Motalebi L. The effect of eight weeks resistance training and low-calorie diet on plasma levels of liver enzymes and liver fat in non-alcoholic fatty liver disease (NAFLD). Iran J Nutr Sci Food Technol. 2018;12(4):25-32. [Persian].
21. Slentz CA, Bateman LA, Willis LH, Shields AT, Tanner CJ, Piner LW, et al. Effects of aerobic vs. resistance training on visceral and liver fat stores, liver enzymes, and insulin resistance by HOMA in overweight adults from STRRIDE AT/RT. Am J Physiol Endocrinol Metab. 2011;301(5):E1033-9. doi: 10.1152/ajpendo.00291.2011.
22. Bemben DA, Palmer IJ, Abe T, Sato Y, Bemben MG. Effects of a single bout of low intensity KAATSU resistance training on markers of bone turnover in young men. Int J KAATSU Training Res. 2007;3(2):21-6. doi: 10.3806/ijktr.3.21.