The Effect of Four Months of TRX Training on Lumbar Bone Mineral Density and its Relationship with Serum Adiponectin Level in Osteopenic Women

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Abstract

Background: Osteoporosis is a systemic skeletal disease augmenting the risk of fractures. The biological mechanisms of bone osteogenic response to mechanical loads are not fully understood. This study aimed to determine the effects of four months of TRX training on lumbar bone mineral density (BMD) and its relationship with serum adiponectin in osteopenic women.

Methods: In this quasi-experimental study, 30 osteopenic women were selected by purposive sampling and then randomly divided into two groups of TRX (n=15), and control (n=15). The experimental group performed TRX exercise protocol for four months, three sessions a week, and 45-60 minutes per session. At the beginning and end of the intervention, blood samples were obtained to determine serum adiponectin using a specific ELISA kit (Bio vendor, Czech Republic). The bone mineral density of the lumbar was assessed by 2D Dexa instrument (LEXXOS DIGITAL, USA). Data analysis was performed applying paired and independent sample student t-test and Pearson correlation in SPSS 20 software.

Results: Lumbar BMD (Pvalue=0.000) and serum adiponectin level (Pvalue=0.000) significantly increased in the TRX group compared to the control. In within-group comparison, significant elevations were observed in lumbar BMD (Pvalue=0.000) and serum adiponectin level (Pvalue=0.004) after TRX exercise. A statistically significant positive correlation was observed between lumbar BMD and serum adiponectin in osteopenic women (Pvalue=0.000).

Conclusions: According to the results, it seems that TRX exercise can improve lumbar BMD and serum adiponectin levels in osteopenic women.

Keywords: Osteopenia, TRX exercise, Lumbar bone mineral density, Adiponectin.

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Introduction

Osteoporosis is a skeletal disease because reduced bone mineral density (BMD) is associated with an increased risk of bone fractures. The world health organization (WHO) has recognized osteoporosis as one of the elderly problems.[1] Bone mass is one of the determinants of bone mechanical capacity against fracture, and it is important to consider this parameter in assessing the bone condition in elders.[2] Along with aging and destruction of microstructures, osteoporosis, although unequal, occurs in both genders.[3,4] This process is primarily characterized by the destruction of trabecular microstructures of spongy bones, which then affects the metaphysis of long bones and the body of vertebrae.[5] Osteoporotic fractures of the vertebrae and neck of the femur, in addition to disability, imposes high treatment costs. It has been estimated that 22 million women and 5.5 million men are affected with osteoporosis in the EU and that osteoporosis-related treatment costs will increase by 25% by 2025. Assuming no changes in sex-related risk factors, the number of hip fractures due to osteoporosis is expected to be doubled over the next 50 years.[6] In Iran, 50% of men and 70% of women over the age of 50 suffer from osteoporosis.[7] Although there are many preventive and therapeutic medications for osteoporosis, their long-term use is limited due to side effects. Therefore, researchers are looking for easily accessible non-pharmacological alternatives without side effects to prevent and treat the disease, as well as strengthen muscles and increase the balance to reduce the rate of falls that lead to fractures.

One of the factors that may be effective in increasing bone mass and preventing osteoporosis is adequate physical activity and exercise, which probably increase force transmission towards bones. Although the exact mechanism by which physical activity affects bone is not yet known, it has been noted that exercise or mechanical loading may regulate hormones, cytokines, and related signaling pathways.[1] It is well documented that physical activity can affect the skeletal resistance of bone to convert mechanical loads into electrical energy, which is then transported into bone cells and interfere with their metabolism. Studies have shown that exercise can increase bone density; however, the effects of the type and intensity of exercise on the maximum anabolic stimulation of bone have not yet been established. Furthermore, biological processes during the bone Osteopenic response to exercise-triggered mechanical loads are not fully understood.[1] Despite many studies on the effects of exercise on preventing and controlling osteoporosis, the results of these studies have been inconsistent. Laura et al. (2014) showed that resistance training can have an osteogenic effect on the bones that can tolerate the total body weight.[8] In contrast, Kemler et al. (2004) showed that a series of resistance exercises involving the muscles adjacent to the trunk and proximal femur could maintain bone density.[9] In this regard, in a study on the effects of different rates of resistance exercise on lumbar, proximal femoral, and whole-body BMD in elderly men and women, it was shown that depending on the intensity and frequency, resistance exercise improved lumbar and proximal femoral density.[10] In contrast, Khan et al. (2019) showed that osteoanabolic compared to aerobic and resistance exercise increased BMD in

osteoporotic women.[11] Ahmadi Kakavandi et al. (2019) found that six months of air pump training improved lumbar BMD in postmenopausal women; however, no effects were noted on the bone density of the neck of the femur, and forearm.[12] This finding indicates variable effects of the same exercise protocol on different bones.

Despite the positive effects of exercise on bone, there are some contradictions among studies regarding the effects of different types of exercises with variable intensity, duration, and frequency on the bone mass generation or degradation.[13] According to the results of systematic reviews and due to the greater susceptibility of mid-femur and lumbar bones to osteoporosis, exercise can exert osteogenic effects on these bones by inducing mechanical loads on them. In accordance, the effects of exercise on bone are site-specific being more pronounced on the bones which undergo mechanical loads.[14] Therefore, in the present study, TRX exercise was performed focusing on the distal trunk and proximal femur. This type of exercise is a developing form of resistance exercise, and there is a need for more scientific evaluations to establish its osteogenic effects. According to the researcher's knowledge, no study has been conducted on the effects of TRX exercise on improving bone mass. On the other hand, it is necessary to divulge factors besides BMD which affect bone metabolism, and scrutinize their relationship with BMD, which is a common approach for bone evaluation. In this regard, physical activity may affect bone health by modulating other BMD-independent factors. Obesity exerts a dual role being the main risk factor of cardiovascular and metabolic diseases and a stimulating factor of bone formation. However, the exact mechanism of obesity-induced bone formation has not been identified. The results of studies have shown that increasing body mass index (BMI) exerts additional force and pressure on bones promoting osteogenesis.[15] Also, an increase in adipocytes induces estrogen production, which inhibits the activity of osteoclasts (i.e. bone degeneration) and stimulates osteoblasts (i.e. bone synthesis).[16,17] Another study found that adipose tissue was associated with an increase in inflammatory cytokines and tumor necrosis factors (TNF), which led to bone reabsorption.[18] It has also been shown that BMI, directly and indirectly, modulates bone metabolism through adipose tissue-derived molecules such as leptin and adiponectin.[19] Adiponectin is an adipocytokine that is specifically expressed in the adipose tissue and other human and mouse tissues such as the bone. Adiponectin receptors which are expressed in bone-forming cells are inversely associated with various obesity- related quantities and insulin resistance indices and can be regulated by cellular post-translational mechanisms.[20] It has been shown that there is an inverse relationship between serum leptin level and the BMD of L2-4 vertebrates, as well as between serum adiponectin level and lumbar and femur BMD.[21] However, it has been reported that adiponectin fluctuations have no role in bone metabolism, and its level (and therefore bone density) can be influenced by several factors such as gender, age, the secretion of some hormones, etc. According to the above-mentioned, this aimed to evaluate the effects of four months of TRX exercise on lumbar BMD and its relationship with serum adiponectin level in osteopenic women.

Materials and Methods

The present study was an applied quasi-experimental research with a pre-test/post-test design. The statistical population of the present study consisted of osteopenic women between the age of 38 to 55 years, living in Zahedan. The sample population consisted of 30 osteopenic women within the mentioned age spectrum, who were purposefully selected by accessible sampling method. Demographic information, clinical history, and consent to participate were obtained at the beginning of the study. The food frequency questionnaire was completed by the participants weekly.

Inclusion criteria were having osteopenia or moderate risk of osteoporosis ($1\text{-}\geq T \geq 2.5$), being in the desired age spectrum, not having regular physical activity, not taking dietary supplements and any specific medication or vitamin, no smoking, not consuming alcohol, and no history of specific diseases or fracture at the target bones assessed in this study. After a physician approved the participants who fulfilled the inclusion criteria, they were randomly allocated to TRX exercise and control groups (n=15 per group) applying the rules of group matching for characteristics such as age, height, weight, BMI, and T score.

Before starting the 4-month training protocol (pre-test), the BMD of the L4+L5 area was measured. Also, in order to determine serum adiponectin level, 5 mL blood was taken from the brachial vein of all the participants after 12 to 14 hours fasting. The sera were isolated by centrifugation and frozen at -80 °C. Forty-eight hours after the pre-test blood sampling, the participants of the TRX group started to perform training protocols for 16 weeks, 3 days per week, 45-60 minutes a day. At the end of the intervention (post-test) and 48 hours after the last training session, BMD of L4+L5 was reevaluated, and blood samples were obtained following the same protocol mentioned for the pre-test phase. The blood samples were transferred to a laboratory to determine serum adiponectin level.

The participants of the control group were asked not to perform any special sport activity during the study and only to follow their usual daily activities. At first and prior to the onset of the intervention, a training session was held to familiarize the experimental group's members with the method of performing a TRX exercise which consisted of an initial 10-min warm-up followed by 45 to 60 min of selected exercises under the supervision of the researcher. All the movements performed during the study were chosen based on the related references and articles published on suspension TRX exercises.[22,23] The protocol of the TRX suspension exercise was designed by the researcher who had 1-year of coaching experience in this field. The TRX training included exercises for different hip and trunk muscles (the hip muscles, rectus abdominis, internal and external oblique, transversus abdominis, lumbar multifidus, and erector spinae), in the regions where there is associated with the highest rate of bone fractures. The volume and intensity of exercise were adjusted in accordance with the FITT (frequency, intensity, time spent, and type of exercise) principles and then confirmed by a specialist physician.

The BMD of L4+L5 regions was measured by a DEXA densitometer device (DIGITAL 2D DENSITOMETER, LEXXOS, USA) with an accuracy of 99.5% at the radiology center of imaging medicine in Zahedan.

To measure serum adiponectin, an ELISA kit (Bio vendor, Czech Republic) with the sensitivity of 0.5 ng/mL was employed.

The subjects' body composition and BMI were determined using the bioelectric impedance method (In Body 2016 device, South Korea) 48 hours before the implementation of the exercise protocol. Height was assessed using SEKA 206 instrument (Germany), and body weight was determined using a standard SEKA medical scale. All the laboratory tests and methods of the present study were approved by the experts of the research council of the university of Sistan and Baluchestan (approval ID: 962/806/7924, 20 November, 2018).

The research findings were presented as mean±standard deviation. The KS and Levin tests were used to examine the data normality and homogeneity of variance, respectively. paired and independent t-tests were used to compare results between the pre-test and post-test phases, as well as between the two groups. Pearson correlation coefficient was employed to investigate any relationship between the research variables. Data analysis was performed in SPSS 20 software and significance level was set at 0.05.

Results

The anthropometric, physical, and T score parameters of TRX and Control groups are shown in table 1. According to this table, there was no significant difference in age, height, weight, body mass index, and T score of subjects at the beginning of the training protocol between the two groups.

According to table 2, based on the t-paired test, a significant increase in L4+L5 BMD and serum adiponectin was observed in the TRX group compared with pre values (respectively Pvalue=0.000 and 0.004) while, there was not such a significant increase in the control group (respectively Pvalue=0.2 and Pvalue=0.4). On the other hand, based on the t-student test, a significant increase in L4+L5 BMD and serum adiponectin was observed in the TRX group compared with the control group (respectively Pvalue=0.000 and 0.000). As it indicated in table 3, the results of the Pearson correlation test showed that there was a significant relationship between the L4+L5 BMD with serum adiponectin after 4 months of TRX training intervention (Pvalue=0.00).

Table 1. Anthropometric, physical and T score parameters of TRX and control groups (N=15)

variable	TRX group (X±SD)	Control group (X±SD)	Pvalue
Age (year)	49.53±6.30	50.74±5.30	0.48
Height (cm)	165.45±6.08	160.46±6.08	0.20
Weight (kg)	75.86±6.14	79.86±6.14	0.46
BMI (kg/m²)	25.49±2.02	24.49±2.02	0.19
T score	- 1.57±0.26	- 1.58 0.28	0.77

Table 2. Composition of L4+L5 BMD and serum adiponectin variables, before and after 4 months exercise

Variable	Group	Pre (X±SD)	Post (X±SD)	Mean difference	Pvalue
L4+L5 BMD (gr/cm²)	TRX	0.88±0.01	1.03±0.03* O	- 0.15	0.000
	Con	0.88±0.02	0.85±0.04	0.03	0.2
	Pvalue	0.83	0.00	-	-
Serum adiponectin (ng/ml)	TRX	55.90±3.82	62.02±4.80 *O	- 6.12	0.004
	Con	54.70±5.96	49.47±3.60	5.2	0.4
	Pvalue	0.74	0.00	-	-

All data represent mean±SD. TRX=TRX group; Con=Control group
BMD=bone mineral density;
Significantly different from the 'Pre, Pvalue< 0.05. *
O Significantly different from control group, Pvalue< 0.05.

Table 3. The correlation between L4+L5 BMD and serum adiponectin variables, after 4 months exercise

Variable	Serum adiponectin (ng/ml)	
	r	Sig
L4+L5 BMD (gr/cm²)	0.788	*0.000

*Correlation is significant at the 0.05 level

Discussion

The present study aimed to evaluate the effects of four months of TRX exercise on lumbar BMD and its relationship with serum adiponectin level in osteopenic women. Our results showed that four months of TRX exercise significantly increased lumbar BMD. This observation was inconsistent with the findings of Khan et al. (2019) who showed the superiority of osteoanabolic exercises over aerobic and resistance training on increasing BMD in osteoporotic women. It seems that this difference can be related to the targeting of exercises on different anatomical locations in these studies. On the other hand, our results were in line with those of Laura et al. (2014) regarding the osteogenic effect of resistance exercise on weight-bearing bones. However, the results of Kemler et al. (2004) contradicted our findings as in the recent study, researchers noted that resistance exercise only preserved but did not improve BMD of the bones of the proximal femur and adjacent to the trunk muscles. The inconsistencies between the results of the present study with those of the above-mentioned can probably be explained by the research of Bemban et al. (2011) who clarified that the effects of resistance training programs on the BMD of the proximal femur and lumbar vertebrae were influenced by the intensity and frequency of exercise protocols.[10] In accordance, it has been declared that the intensity and duration of exercise are effective in increasing bone mass.[24]

It has been shown that exercise and physical activity, as non-pharmacological strategies, can prevent osteoporosis.[1] Based on research evidence, the effects of exercise on bone are site-specific and can only improve BMD at the points exposed to mechanical load.[14] Addressing the different effects of a same type of the exercise on two bony areas, Ahmadi Kakavandi et al. (2019) showed that six months of air-pumping exercise increased the BMD of the lumbar but not that of femur and forearm bones in postmenopausal women. Based on the results of the present study in which TRX exercise-induced mechanical forces particularly on the distal trunk and proximal femur regions, the observed osteogenic effects in these areas indicated that this type of resistance training was able to positively affect these bones which are susceptible to fracture.

Because of imposing and unevenly distributing mechanical forces, resistance training has been associated with structural bone changes. The optimal mechanical load and a high extent of strain in this type of exercise are possible contributors to improved bone quality.[25] Also, this type of exercise can affect bone mass by reducing bone destruction through inducing a reduction in the number of osteoclasts and increasing bone formation via intensifying the number of osteoblasts. However, it is still unclear whether the main reason for exercise-induced improved bone mass is the reduced bone destruction or increased bone formation. Some research; however, indicates the involvement of both pathways.[26] Regarding biomechanical studies, it has been shown that exercises that simultaneously generate multiple mechanical loads such as tensile, compression, and shear are capable of generating electrical signals which induce the activity of bone cells and the deposition of minerals at under pressure sites.

Considering the nature of the TRX exercise, this training protocol seems to be able to affect bone metabolism through the mentioned mechanism. It has beneficial effects in lowering bone destruction, as well as boosting its strength and preventing osteoporosis,[1] which can be attributed to TRX exercise-induced multiple mechanical loads on bone. It has been shown that the mechanical loads imposed on bone by physical activities trigger a gradient within the bone lacunar-canalicular fluid network that increases intracellular events such as calcium influx, matrix production, and osteogenesis.[27] In the present study, the TRX exercise concentrated on the distal trunk and proximal femur has probably imposed the required mechanical load on these regions to stimulate bone osteogenic response. Therefore, it seems that this type of exercise has been effective in inducing local bone formation in the lumbar region. The results of various studies indicate that the bone forming effects of exercise-triggered mechanical loads are markedly more pronounced at the trabecular than cortical tissues. This finding can be attributed to the structural features and a higher blood flow of the trabecular tissue, which increase its metabolic activity and mechanical loading capacity.[28] Considering that trabecular or spongy tissues are predominant in the lumbar region, TRX exercise seems to be able to exert beneficial effects on this bone.

Furthermore, the results of the present study showed that four months of TRX exercise significantly increased serum adiponectin level. The present study showed a significant positive correlation between the BMD of L2-4 and the level of serum adiponectin after four months of the exercise intervention. This finding was not in agreement with the results of Mottaqi et al. (2013) who described a negative correlation between serum adiponectin level and both the BMD of femoral neck and BMC of lumbar L2-4 in 40 to 60 years old postmenopausal women. This may be justified by the modulating effect of exercise on the relationship between BMD and serum adiponectin level. In a study by Graudit et al. (2019), although serum adiponectin level showed significant negative correlations with both the BMD and BMC of the femur neck and lumbar L2-4, the associations were no longer significant after adjusting for age, height, and BMI.[29] Investigating various training protocols to better understand the effects of different types of exercises on BMD and adiponectin level can help to develop an optimal training method with the highest osteogenic potential. Due to the lack of knowledge on the bone adaptations triggered by TRX exercise and considering the results obtained in the present study, it seems that this type of resistance exercise can have positive effects on bone mass.

The findings of the present study showed that TRX training as a type of resistance exercise effectively improved lumbar BMD and increased serum adiponectin level in osteopenic women. Based on our results, it can be concluded that the TRX exercise can be used as a strategy to induce osteogenic activity in the growing elderly population.

Acknowledgement

Conflict of Interest

The authors declare that they have no conflict of interest.

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