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Research Article

Rebound Training Modifies Body Composition, Muscular Strength and Bone Health Indicators in Adult Women

Karine Angélica Malysz[2], Enrico Fuini Puggina[3], Mari Lúcia Sbardelotto[2], Daniela Regina Sposito Dias Oliva[1], Luciano de Oliveira Siqueira[1] and Hugo Tourinho Filho[3]*

[1]*Biological Sciences Institute, University of Passo Fundo, Passo Fundo, RS, Brazil*

[2]*Regional Integrated University of High Uruguay and Missions, Erechin, PR, Brazil*

[3]*School of Physical Education and Sport of Ribeirao Preto, University of Sao Paulo, Ribeirao Preto, SP, Brazil*

***Corresponding Author**: Hugo Tourinho Filho, School of Physical Education and Sport of Ribeirao Preto, University of Sao Paulo, Ribeirao Preto, SP, Brazil.

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Abstract

Rebound training is an alternative exercise performed on a trampoline that is becoming very popular. In this sense, the aim of this study was to investigate and compare the effects of rebound exercise performed on land and in water on anthropometry, muscular strength, bone mineral density, and bone remodeling. Twenty-seven women (33.9 ± 3.3 years) were divided into two groups; rebound training in water (G1, n = 14) and rebound training on land (G2, n = 13). Each group trained twice a week for sixteen weeks. Percentage of fat (%F), lean body mass (LBM), body mass index (BMI), hip waist ratio (HWR), one repetition maximum (1-RM), twenty repetition maximum (20-M), alkaline phosphatase (ALP), bone specific alkaline phosphatase (bone ALP), acid phosphatase (ACP), tartrate resistant acid phosphatase (FTR), lumbar bone mineral density (lumbar DMO), and femoral neck bone mineral density (fneckDMO) were measured before and after the protocol. The Shapiro-Wilk test was used to verify data normality and the Wilcoxon and Mann-Whitney tests were used to compare the anthropometric, muscular strength, bone mineral density, and bone remodeling markers ($p < 0.05$). Reductions in LBM and %F were found. Muscular strength increased in the 1-RM and 20-RM tests for both groups. ALP activity was reduced and increases in bone ALP, ACP, and FTR were found for both groups. The fneckDMO improved in both groups while lumbar DMO increased in the G2. The findings suggest that rebound training performed in the water and on land efficient for producing improvements in body composition, muscular strength, and bone health.

Keywords: *Rebound Training; Body Composition; Bone Health; Muscle Strength*

Introduction

Body changes related to aging are a major concern for health professionals regarding the progressive loss of functional capacity and consequent inability to perform daily tasks satisfactorily. In the case of bone tissue, the deposition dynamics of bone matrix occur on average until twenty years of age, increasing bone mass [1]. However, after the third decade of life, a subtle process of bone mass reduction is triggered, resulting in losses of 0.5% per year [2]. Additionally, menopausal women may lose up to 8% of bone mineral mass each decade after entering the menopausal period [3].

Several factors may interfere in the bone deposition and bone removal processes, as well as the preservation of bone mass. Among them, it is possible to mention eating habits, heredity, the endocrine profile, and systematic practice of physical exercise, the final variable being essential for the acquisition and fixation of bone matter, resulting in the prevention of diseases related to decreased bone mineral density [4].

For this purpose, aquatic exercises such as swimming and water aerobics have been frequently proposed for individuals with medical indications to exercise [5]. The purpose of this practice is often associated with control of the bone removal process and consequent prevention of osteoporosis. Additionally, there are many benefits of exercising in water due to the physical characteristics of the environment [6], such as improvements in cardiovascular fitness, muscular endurance, neuromuscular fitness, and bone health [7-9]. Positive effects of physical exercise performed in the aquatic environment have been described in many studies [1,10]. In this sense, other activities, such as running and jumping, which were originally designed to be performed on land, have been adapted to the water environment. Among these practices, the mini trampoline, also known as rebound exercise, emerges as an alternative exercise, which is conducted on an individual elastic trampoline. This device is composed of a flexible surface surrounded by a system of springs enclosed in a rigid structure. The design allows the elastic energy applied to the equipment to be returned to the practitioner. Acting together with the physical properties of the aquatic environment, the mini trampoline requires the generation of additional epiphyseal torque from the practitioner, in both eccentric and concentric phases of the movement [11]. In addition, the use of mini-trampolines has been shown to reduce the need to squat during the jump, due to reductions in elastic energy and through facilitation of the movement, maximizing the jump action [12].

Considering the evident tendency to use exercises in the liquid medium for the care of various aspects of human health, the importance of investigating these types of exercise and their effects on the body is clear. Therefore, studies dedicated to understanding the effects of different protocols using alternative devices and environments on the various systems of the human body are extremely desirable for health professionals and regular exercise practitioners.

Purpose of the Study

Thus, the purpose of this study was to investigate the impact of a 16-week training program with a mini trampoline, performed on land and in water, on anthropometric variables, bone mineral density, and bone turnover markers in adult women.

Methods

Subjects

Twenty-seven women aged between 30 and 40 years volunteered to participate in the study. They were randomly divided into two groups; mini-tramp in the liquid environment (G1, n = 14, 33.2 ± 3.06 years) and mini-tramp on land (G2, n = 13, 34.4 ± 3.4 years). The subjects were evaluated for anthropometric characteristics, bone remodeling, and bone mineral density at the beginning and end of the experimental protocol. The volunteers signed an informed consent and were informed about the risks and benefits of the study. The experimental protocol was approved by the ethics committee of the University of Passo Fundo, Brazil under registration number 0037.0.398.000-11 and was conducted in accordance with the Declaration of Helsinki.

The inclusion criteria were: aged between 30 and 40 years, presenting at least one year without performing exercises, having medical clearance to practice exercise, and a BMI between 19 and 30 kg/m^2. The exclusion criteria were: presence in less than 90% of the training sessions; participation in other physical exercise programs; and cardiac and musculoskeletal impairments that compromised participation in the training and testing sessions. A complete familiarization training session was performed 48 hours prior to beginning the training program.

Anthropometric variables

To determine %F and LBM, the Jackson and Pollock [13] equation for women was used. Tricipital, iliac crest, and thigh skin folds were measured three times using a CESCORF Scientific Plicometer (CESCORF®, Porto Alegre, Brazil) with a precision of 0.01mm, and the median value was used to calculate body density, from which the Siri equation was used to obtain %F [14].

The WHR was measured using a flexible tape (Sanny @, Sao Bernardo do Campo, SP, Brazil). The perimeters of waist and hip were measured in the horizontal plane, the waist being measured at the median distance between the last rib and the iliac crest at the end of a normal expiration. The WHR was obtained by dividing the waist by the hip measurement [15]. BMI was obtained by dividing body weight (Kg) by height (m) squared.

After calculating BMI, subjects were classified according to the WHO [16].

Muscular strength

Aiming to determine the 1-RM in the squat exercise, the Marins and Giannichi [17] method was used. The protocol was initiated with a warm up of 5-10 repetitions (40% to 60% of predicted 1-RM) followed by a 1 min interval of performing stretching exercises [18]. Next the subjects performed a series of 3 to 5 repetitions with a moderate load (60% to 80% of predicted 1-RM), followed by an interval of 2 minutes. Subsequently, a series of 2 to 3 repetitions was performed with a high load (approximately 90% of predicted 1-RM) and an interval of 3 to 5 min. Finally, in an attempt to obtain the 1-RM, the load was increased for the first attempt to reach the 1-RM. In the case of success in the first attempt, after an interval of 3 to 5 minutes, the volunteers performed a new effort with an increased load; the 1-RM was obtained in a maximum of three attempts.

To assess strength-endurance in the squat exercise [17], the 20-RM test was used. The test started with a brief warm up with a 20% load and stretching exercises. The 20-RM was conducted with the predicted load to perform twenty movements. If the volunteer was not able to accomplish the task, 3 to 5 minutes rest was allowed, and another attempt was made. The 1-RM and 20-RM were performed on different days, with 48 hours between the tests.

Bone mineral density

The BMD was calculated using a densitometer Lunar DPX X-Ray Bone Densitometer version 4.7e (GE Healthcare Bio-Sciences, Pittsburg, PA, EUA). The BMD was measured for the lumbar spine (L1-L4) and hip (femoral neck). The coefficient of XRay absorption is indicated as an index of BMD in grams/centimeters^2 of the bone surface expressed on a scale of 0 to 1.

Firstly, information about age, sex, body mass, height, and ethnicity were entered in the equipment, as well as specific values of parameterization of the system and specific parameters of collimation of the radiation source, sample size, width and height in millimeters and angulation of the X-ray source.

Bone remodeling markers

The ALP activity was obtained through the enzyme kinetics technique using a commercial *kit,* Alkaline Phosphatase Liquiform (Labtest Diagnostica, Lagoa Santa, MG, Brazil). Samples were analyzed twice and in duplicate; the first measurement after incubation at 37ºC for ten minutes to obtain the total activity of plasmatic ALP and the second after incubation at 56ºC for five minutes to determine the thermostable plasmatic ALP. Both measurements were performed using a 405nm wavelength.

To determine the ACP activity, a colorimetric kit from Labtest Diagnostics (Labtest Diagnostica, Lagoa Santa, MG, Brazil) was used according to the specifications of the manufacturer (37°C and 580 nm wavelength) following the proposal of Roy., *et al* [19].

Bone ALP activity was performed using 4-nitrophenyl phosphate as a substrate (10mM) in acetate buffer (sodium acetate at 50 mM; sodium tartrate at 10 mM, pH 2.8; 37ºC, 60 minutes incubation). The reaction was stopped with the addition of 5 ml of 0.1 M NaOH (410 nm at 37°C).

All tests were calibrated with the control serum Qualitrol (Labtest Diagnostica, Lagoa Santa, MG, Brazil) and read in a spectrophotometer BioSystem BTS-350 (BioSystems, Barcelona, Spain).

Training program

The volunteers underwent a sixteen-week training program with a mini trampoline on land and in the aquatic environment (total of 32 training sessions). Training sessions were composed of five minutes of standardized warm-up, 30 minutes of aerobic exercises, and 10 minutes relaxation (total of 45 minutes) controlled by the heart rate in relation to the maximum HR obtained in the training session performed on land [20] and in the pool [21]. The CR-10 scale was also used to monitor the training intensity of the exercise sessions [22].

The training program was organized in two blocks. Each block was composed of five exercises, applied sequentially during the training sessions and modified every minute. The exercises were the same for both groups. In the first block, stationary running, jumping with abduction and adduction of the lower limbs, front kicks, jumps with anteroposterior hold-off, and jumps with abduction of the lower limbs and knee flexion were performed.

In the second block stationary running, back kicks, squats with a simultaneous kick of the opposite leg, jumps with an abduction of the lower limbs, knee flexion, and sidekicks were carried out. The exercises were performed maintaining the HR in the predetermined training zone. For volunteers that performed the training with the mini trampoline on land (G2), the determination of training HR was carried out using the equation proposed by Karvonen [20]. In the aquatic environment (G1), the determination of training HR was conducted using the formula proposed by Graef and Kruel [21], considering the immersion bradycardia. The characteristics and intensity of each training session are described in table 1.

Period	Weeks	Intensity
1º Period	1 - 4	55 to 65% HR
2° Period	5 - 8	65 to 75% HR
3° Period	9 - 12	75 to 85% HR
4° Period	12 - 16	85 to 90% HR

Table 1: *Training characteristics in each one of the proposed training periods.*
HR: Heart Rate.

Statistical analysis

To meet the proposed objectives of the study, data were treated using the Statistical Package for Social Science (SPSS) for Windows® version 20.0 (SPSS Inc., Chicago, IL, EUA). The normality of the data was verified using the Shapiro-Wilk test, and for the anthropometric variables, bone mineral density, and bone turnover markers, the nonparametric Wilcoxon test was used for dependent samples and the Mann-Whitney for independent samples, both at the level of significance of 5%.

Results

Regarding the anthropometric measurements, there were no differences for BM, BMI, or WHR before or after the training programs in either group. For MCM, there were significant intragroup differences before and after the training program ($p \leq 0.05$). However, there were no changes between groups. The %F presented alterations comparing pre-and post-training in both groups, however a greater decrease was observed from pre to post training in the G1, resulting in differences between groups after the training program ($p \leq 0.05$) (Table 2).

During the sixteen-week training period, a significant increase in strength from pre to post training was observed (intragroup evaluation). However, when comparing the effect of training between groups, it was not possible to detect differences (Figure 1).

Observing the results for lumbar BMD, changes were not observed for G1, but in G2 improvements were observed. For femoral neck BMD, there were changes in the values found for both G1 and G2, however when comparing the groups, no differences were observed (Figure 2).

Variables	Group	X pre	X post	p*	Difference of means (G1 x G2)	p**
Stature (cm)	G1 G2	159.5 ± 5 163.1 ± 3,7				
Body mass (kg)	G1 G2	63.90 ± 8.51 62.88 ± 7.04	63.20 ± 8.69 62.68 ± 6.65	0.06 0.576	-0.70 ± 1.81 -0.20 ± 1.39	0.512
BMI (kg/m^2)	G1 G2	25.15 ± 2.79 23.68 ± 2.51	24.86 ± 2.81 23.72 ± 2.30	0.180 0.789	-0.29 ± 0.68 0.04 ± 0.53	0.808
WHR	G1 G2	0.76 ± 0.06 0.75 ± 0.07	0.74 ± 0.05 0.75 ± 0.06	0.180 0.789	-0.01 ± 0.04 -0.01 ± 0.05	0.808
LBM (kg/m^2)	G1 G2	39.98 ± 2.64 41.87 ± 4.57	41.33 ± 3.64 42.72 ± 4,48	0.018* 0,005*	1.35 ± 2.16 0.85 ± 0,76	0.089
% F	G1 G2	36.81 ± 5.63 32.92 ± 6.61	33.40 ± 5,31 31.69 ± 6,33	0,001* 0,007*	-3.41 ± 2.25 -1.23 ± 1.26	0.003*

Table 2: *Means and standard deviations of anthropometric variables of G1 and G2.*
**: Wilcoxon; **: Mann-Whitney*
**: p≤ 0,05; BMI: Body Mass Index; WHR: Waist-Hip Ratio; LBM: Lean Body Mass; %F: Fat Percentage.*

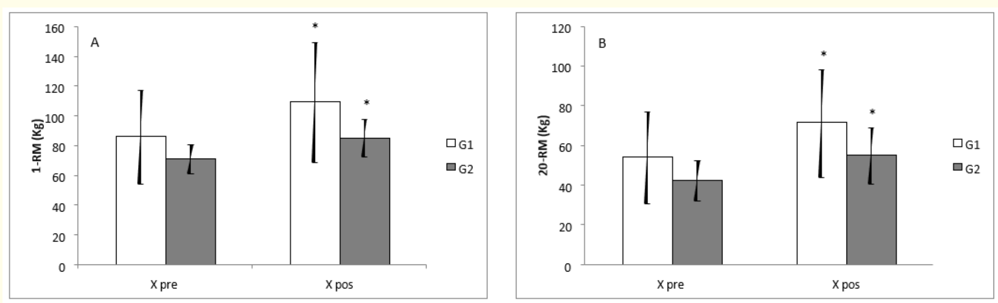

Figure 1: *Means and standard deviations of strength indicators (1-RM -A- and 20-MR -B-) of G1 and G2 before and after the training program. * = p< 0.05 compared to X pre.*

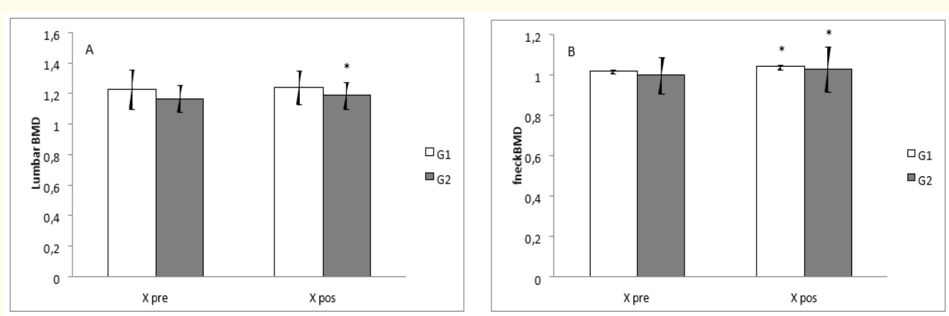

Figure 2: *Means and standard deviations of Bone Mineral Density -BMD- (LumbarBMD A- and fneckBMD -B-) of G1 and G2 before and after the training program. * = p< 0.05 compared to X pre.*

The results of ACP activity demonstrated increases between pre-and post-training for both the G1 and G2, however when comparing the groups, no differences were observed. For the ALP activity, the G1 and G2 presented decreases, with no changes in the comparison between groups (Table 3).

Variable	Group	X pre	X post	p*	Difference of means (G1 x G2)	p**
ALP	G1 G2	46.86 ± 8.95 49.54 ± 13.88	21.64 ± 2.59 21.69 ± 2.90	0.001* 0.002*	-25.21 ± 8.37 -27.85 ± 13.47	0.716
Bone ALP	G1 G2	21.93 ± 6.75 27.85 ± 9.14	35.14 ± 9.21 40.85 ± 14.90	0.002* 0.017*	13.21 ± 9.58 13.00 ± 17.54	0.680
ACP	G1 G2	17.07 ± 4.68 18.62 ± 3.20	53.79 ± 12.75 60.77 ± 16.11	0.001* 0.002*	36.71 ± 14.42 42.15 ± 16.72	0.244
FTR	G1 G2	13.86 ± 2.41 16.46 ± 3.38	18.57 ± 2.47 17.69 ± 1.75	0.005* 0.182	4.71 ± 3.81 1.23 ± 3.37	0.012*

Table 3: *Means and standard deviations of bone remodeling markers in G1 and G2. * Wilcoxon; ** Mann-Whitney; *p ≤ 0,05; ALP: Alkaline Phosphatase; bone ALP: Bone Specific Alkaline Phosphatase; ACP: Acid Phosphatase; FTR: Tartrate-Resistant Acid Phosphatase.*

Increases in bone ALP activity were found for the G1 and G2 after 16 weeks of training, with no differences between groups. Finally, we found that the activity of FTR (a marker of bone reabsorption), was increased pre and post training for the G1, which did not occur in the G2, revealing differences when comparing groups.

Discussion

Currently, the number of studies performed to verify the effectiveness of the aquatic environment on different variables such as bone remodeling, is increasing. In the present study, it is possible to observe that exercise programs in the aquatic environment, specifically in the case of the mini trampoline, revealed improvements in anthropometric variables, and muscular strength, and offered an overload on the bone, stimulating osteoblastic activity in order to promote increased BMD.

Alonso., *et al*. [23] investigated the effects of a sixteen week training program performed on a mini trampoline controlled by HR and did not find improvement in %F, LBM, BMI or WHR in adult women, contrary to the findings of the present study for LBM and %F. These differences are probably due to the type of training applied, as the intensity of the exercise was not increased during the training sessions.

Anjos., *et al*. [24] studied anthropometric variables (BMI and WHR) during a mini trampoline training program performed on land and in the water in 20 to 35 year old women over sixteen weeks. Reductions in BMI were found in both groups while for WHR, reductions were found only for the group that trained in the aquatic environment, contrary to the results found in the present study. It should be noted that in the study of Anjos., *et al.* [24], the increase in the training load occurred with increasing intensity referenced by the music played during the training sessions, unlike the present study, where the increases in intensity occurred through increasing the %HR every period.

With a training intensity and sample size similar to the present study, Tomassoni., *et al.* [25] observed the effects of a mini trampoline on land in 21 sedentary women, aged between 18 and 28 years, over eight weeks, training at 75 - 80% maximum HR. Intra and inter-group differences were found in BM and %F after training. In this case, it may be inferred that the present study had a longer training period, which may have resulted in changes in LBM and %F.

Finally Baum [26], comparing the effects of aerobic activity with the same intensity in the aquatic environment and on land revealed that water aerobic classes produced reductions of 2% in body fat, while the group who performed the same exercises on land presented reductions of only 1.1%.

Cardoso., *et al*. [10] investigated 35 women aged between 35 and 75 years over twelve weeks. They found increases in muscular strength of 11.62% in the hip adductors. Corroborating the results of this study and that of Cardoso., *et al*. [10], Muller [27] investigating 27 elderly women divided into three groups (control, traditional water aerobics, and water aerobics focused on strength), found improvements in the 1-RM test after the training protocol only in the group focused on strength. Although in the present study we analyzed the lower limbs, the percentage increases in strength were higher, indicating the efficiency of our training program, probably due to the longer training program (16 weeks).

Bassey., *et al*. [28] compared the effects of a 12-month mini trampoline training protocol on lumbar and femur BMD in pre and postmenopausal women and showed that 50 jumps six times weekly were able to increase BMD in premenopausal women. A possible explanation is that the effects of exercise with overload on the bones are local and specific, being verified by the results of BMD at the femoral neck [5]. Similar to the results of this research, some studies with positive results for BMD suggest that the structure where the load is applied is more suitable for changes in BMD [5].

Bálsamo [29] suggests that water activities are important in the gain of bone mass. Similarly, Tsukahara., *et al*. [30] showed increased lumbar BMD in 35 postmenopausal women who performed systematic water activities compared to beginners, and a decrease of 1% in the control group. These results indicate that regular participation in exercise programs in the aquatic environment is an important variable in preventing bone loss. In the present study, the femoral neck BMD demonstrated significant improvement between pre and posttest in the G1, which may be justified by the resistance imposed by the aquatic environment.

The results found in this study may be explained by the results reported by Frost [31], who concluded that sessions of jumps performed in water produce more pronounced compression in the lumbar region than regular walking on land.

In a study conducted in the Wingate Institute of Israel, with postmenopausal women who performed exercises in water and on land, it was found that the group of women who exercised in water presented increases in BMD of 1% compared to the group that trained on land, who showed an increase of 0.17% [32].

It is important to note that the information provided by bone turnover markers is limited, the variability between individuals is remarkable and there is considerable overlap between individuals [33] in addition to which bone turnover markers may be influenced by various factors such as menstrual cycle, kidney function, and liver function, which were not controlled in this study.

From the characteristics of each marker used in this study, bone ALP and FTR seem to be more stable and reproducible, explaining the differences in the results, especially in markers of bone formation, where we observed significant increases in bone ALP and decreased FTR. Through the results of BMD assessed by biochemical bone markers, it was concluded that BMD revealed positive changes in the present study, with an increase in ALP and a decrease in the reabsorption marker FTR, demonstrating osteoblasts and osteoclasts action respectively, resulting in the bone densitometry values measured in this study.

Bone metabolism markers have been used to monitor the effectiveness of exercise on bone remodeling in order to correlate the possible changes in BMD with blood and urine concentrations of these markers, thus becoming a dynamic assessment resource with regard to the effects of exercise when related to bone health [34,35]. However, the available literature is restricted regarding the use of these markers in physical activities performed in water, limiting the discussion to studies carried out on land.

It is important to stress the need for further research on the use of biochemical markers to evaluate bone metabolism as a dynamic way to assess the effects of exercise on bone remodeling allied to bone densitometry [34]. One of the limitations that occurs with the use of bone remodeling markers is that the results may represent an average of total bone remodeling in the body, disregarding specific regions [36], however, currently there is no biochemical method considered gold standard to monitor bone turnover. In this sense, serial and systematic determinations of a group of patients allow satisfactory applicability of these markers. It is also important to note that exercising in the aquatic environment has other benefits such as security, pleasure, and ease of performing the exercises, attracting more people of different age groups to the practice.

From the results obtained in the present study, it is possible to conclude that exercise programs performed in the aquatic environment, specifically the rebound exercise, produced improvements in the anthropometric variables and muscular strength, and provided an overload on bone tissue, stimulating osteoblastic activity and increasing BMD.

Conflict of Interest

There are no conflicts of interests regarding this study.

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