Теорія та методика фізичного виховання
Physical Education Theory and Methodology
Teorìâ ta Metodika Fìzičnogo Vihovannâ

ISSN 1993-7989 (print)
ISSN 1993-7997 (online)
ISSN-L 1993-7989

ORIGINAL SCIENTIFIC ARTICLE

OSTEOGENIC EFFECTS OF AEROBIC BOTH SIDES UTILIZED BALL VERSUS AEROBIC STEP TRAINING IN PREMENOPAUSAL WOMEN

Achariya Anek[1ABCD] and Witid Mitranun[1ABCD]

[1]Srinakharinwirot University

Authors' Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Funds Collection

Corresponding Author: Witid Mitranun, E-mail: mitranunwitid@hotmail.com
Accepted for Publication: May 9, 2023
Published: June 30, 2023

DOI: 10.17309/tmfv.2023.3.04

Abstract

Study purpose. Exercise training plays an important role in increasing bone mass. Nevertheless, the osteogenic effects of exercise training using various bench surfaces are unknown. Therefore, this study aimed to compare the osteogenic effects of exercise with a soft surface bench and an aerobic both sides utilized (BOSU) ball with those of aerobic step exercise training (STEP).

Materials and methods. Fifty-two sedentary female participants aged 30–45 years were recruited and randomly divided into three groups. Seventeen participants were in the STEP, 17 in the BOSU, and 18 in the control group. The exercise programs of the STEP and BOSU groups were designed to have the same intensity and heart rate range during each stage of the program. During training, music was used to set the tempo for workouts.

Results. After week 24, both training groups showed significant improvements in physical fitness, body composition, and body stability ($p<0.05$). Increased levels of procollagen type I N-terminal propeptide (P1NP), an osteogenesis marker, were observed in both STEP and BOSU groups. Increased bone mineral density was only seen in the BOSU group ($p<0.05$).

Conclusions. Both STEP and BOSU programs effectively improved P1NP levels, muscle strength, and postural control, but only the aerobic BOSU ball training improved bone mineral density in premenopausal women.

Keywords: bone formation, postural control, premenopause.

Introduction

There are several ways to measure bone density, including measuring procollagen type I N-terminal propeptide (P1NP) levels and quantifying bone mineral density (BMD). P1NP is a bone formation marker and predictor of BMD. Lower levels of P1NP predicted BMD loss over 12 months in patients with premenopausal systemic lupus erythematosus (Seguro et al., 2015). In addition, low levels of P1NP and BMD may predict osteoporosis (Krege et al., 2014), which increases the risk of bone fractures.

Pharmacological strategies may constitute the main treatment for osteoporosis; however, some medications cause adverse effects (McClung et al., 2013). Exercise and non-pharmacological strategies are recommended to maintain/improve bone health (Xu et al., 2016). The long-term effects of exercise include increased BMD (Park et al., 2008; von Stengel et al., 2007) and body stability in postmenopausal women (Anek et al., 2015). A recent systematic review and meta-analysis documented the benefit of life-long exercise in maintaining bone health in women (Xu et al., 2016). In premenopausal women, specific impact exercises (vertical jumps or hops) improve the BMD of the femoral neck, lumbar spine, and greater trochanter. Thus, one of the main objectives of exercise in this stage of a woman's life is to increase the peak bone mass to prevent bone loss after menopause.

Several studies have confirmed that impact exercises such as jumping and step aerobics could enhance bone mass, muscle strength, and balance stability in pre- and postmenopausal women (Anek et al., 2011; Marques et al., 2013; Sherrington et al., 2008). Exercise programs of shorter durations might increase P1NP levels before changes in BMD are observed. A study reported that a 48-week combined exercise training program enhanced body stability and BMD of the trochanter and femoral neck (Park et al., 2008). Essentially, significant changes in BMD from exercise interventions may require a long duration, while increases in P1NP levels have been observed following short

© Anek, A., & Mitranun, W., 2023.

ТМФВ
ТОВ ОВС

experiments (Alkahtani et al., 2019; Scott et al., 2011). Using shorter durations, Anek et al. (2011) investigated the effects of an aerobic step (STEP) program in postmenopausal women. After 12 weeks, an increase in bone formation marker (P1NP/beta-Crosslaps) levels was observed in the training group, suggesting that hard surfaces should be used in exercises for managing bone health (Anek et al., 2011).

Unstable surfaces with whole-body vibration training increased BMD in postmenopausal women (de Oliveira et al., 2019). Moreover, a recent study reported that both stable and unstable surface balance training enhanced static balance and functional ability in middle-aged women. Nevertheless, unstable balance training with an aerobic both sides utilized (BOSU) ball showed greater improvements (Nepocatych et al., 2016). BOSU ball training has two main objectives: maintaining lateral balance and timing efficiency during the ascending and descending phases of movement (Wing, 2014). The degree of ground reaction force during BOSU exercises may differ from that during the STEP program, thus promoting a more distinct effect on bone status in the long term. Interestingly, no studies have investigated its effects on bone markers. Moreover, there is a need to assess the combination of box jumping and different surfaces on bone markers; however, no studies have compared the effects of training on stable and unstable surfaces when performing box jumping on P1NP levels and BMD in premenopausal women. Therefore, the objective of this study was to investigate the effect of a 6-month exercise program, using either 1) a soft surface bench with aerobic BOSU ball training (BOSU) or 2) a hard surface (STEP), on P1NP levels, BMD, and postural control. We hypothesized that these programs would yield distinct positive effects on bone status and body stability.

Materials and methods

Study participants

This study employed an experimental research design conducted in sedentary 30–45-year-old women (n=80) based on the criteria for premenopausal women reported in a previous study (Anek et al., 2011). Activity levels were evaluated using a questionnaire, with “sedentary” defined as not meeting the minimum threshold of 75–150 min/week of moderate-to-vigorous intensity physical activity. Medical history and general qualifications were evaluated before the exercise program was selected. The selection instruments were a participant selection form, health questionnaire, and dual-energy X-ray absorptiometry (DEXA Scan, Hologic Inc., Marlborough, MA) to measure BMD. None of the participants were diagnosed with osteoporosis based on DEXA or were smokers or alcohol consumers. Those who drank tea or black coffee consumed no more than two standard cups daily (250 mL/cup). None of the participants received hormonal replacement therapy or calcium supplements, and none of the patients had a body mass index of >30 kg/m^2. The exclusion criteria were premenopausal status with heart disease, known obstructive lung disease, inability to complete the exercise program, and severe injury during training. A total of 52 participants were included in the study, with 17 participants in the STEP, 17 in the BOSU, and 18 in the CON groups (Fig. 1). After recruitment, the participants were randomized into three groups: 1) control (CON) group, 2) BOSU group, and 3) STEP group, using a Microsoft Excel random number generator program. Participants were also excluded if they dropped out or completed less than 80% of the training schedule.

The participants in the CON group were instructed to remain sedentary. The exercise training groups underwent 24-week exercise training programs involving exercising thrice weekly for 30 min a day. The BOSU and STEP group programs were divided into two phases: the intensity was 60%–70% of maximum heart rate (determined by the Tanaka equation, i.e., 208 − 0.7 × age) in phase 1 (weeks 1–4), and 70%–80% of maximum heart rate in phase 2 (weeks 5–24). In each phase, compliance with the heart rate training zone was ensured using a heart rate monitor (Polar Team 2 Pro, Polar Electro Inc., Lake Success, NY, USA) during the exercise sessions. A pilot study was conducted before the project to identify correlations between program intensity and music rhythm to achieve the same heart rate during each program stage. The heights of the STEP bench and BOSU ball were similar (15 cm). During training, music was used to set the tempo for the aerobic and BOSU training workouts. The two modes of exercise included dynamic stretching before and after training as well as warm-up and cool-down periods totaling 10 min (Fig. 2).

This study was approved by the ethics committee of the institution (No. SWUEC-440/2561E) and conducted in accordance with the guidelines of the Helsinki Declaration. Informed consent was obtained from all participants.

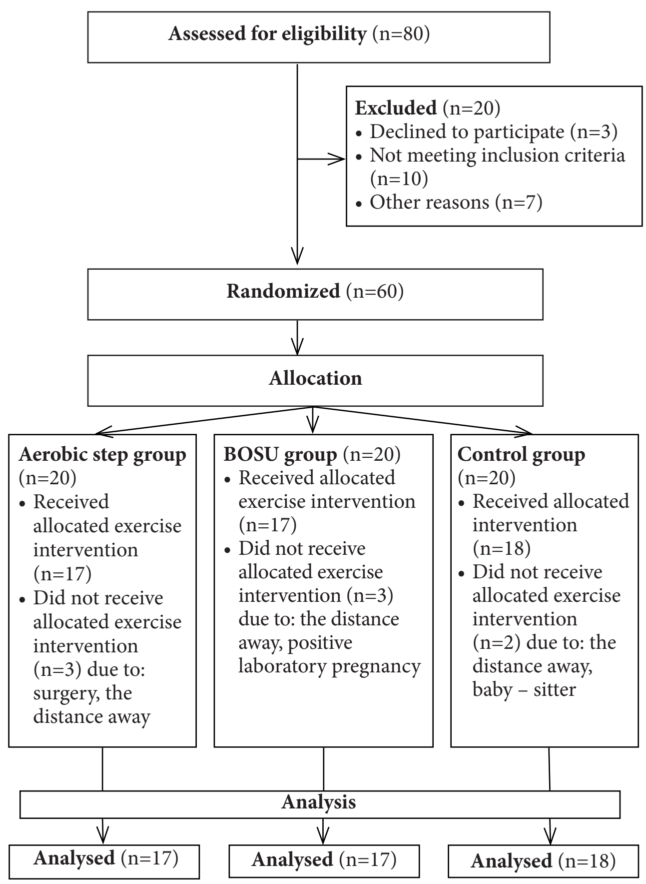

Fig. 1. CONSORT flow chart

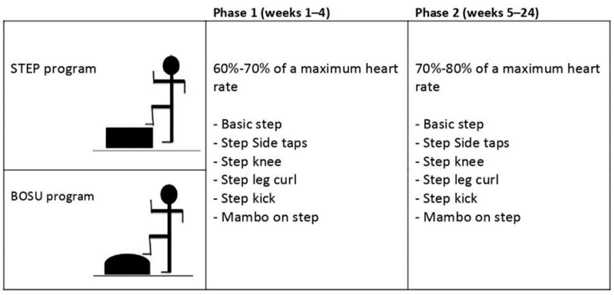

Fig. 2. STEP and BOSU programs: STEP, aerobic step exercise training; BOSU, aerobic both sides utilized ball

Study design

At baseline and after 24 weeks, the participants were evaluated for general physiological status, biochemical bone markers, BMD, physical fitness, and balance performance.

Measurements

Measurement of biochemical bone markers

Venous blood was drawn on arrival following a standard 8-h overnight fast. The P1NP level was measured using a standard procedure in the clinical laboratory (BRIA lab, Bangkok, Thailand). Blood collection was performed at the same time of day for the pre- and post-training tests to avoid diurnal changes in blood chemistry variables. Three hours after breakfast, the participants were asked to undergo body composition, BMD, balance, and physical fitness assessments.

Physical fitness measures

Body composition was evaluated using DEXA. Muscle strength measurements were obtained using a Nautilus-type weight machine (leg extension and leg curl) using the one repetition maximum (1RM) method.

Balance performance measures

The participants were tested on both hard and soft surfaces on balance plates to assess static balance ability (Leme et al., 2022) using the balance error scoring system, consisting of three stances as follows: single-leg stance (standing on the nondominant leg with hands on the hips), double-leg stance (hands on the hips), and tandem stance (dominant foot in front of the nondominant foot) in a heel-to-toe fashion. The stances were performed on hard and soft surfaces with the eyes closed, and errors were counted during each 20-s trial. An error was defined as lifting hands off the hips, opening the eyes, stepping, abducting the hip by more than 30°, or falling out of position after more than 5 s. Balance performance measures were collected by the same operator. The intra-rater reliability of measures was determined using intraclass correlation coefficients with 95% confidence intervals. The intra-rater reliability of double-leg stance on firm surface, single-leg stance on firm surface, tandem stance on firm surface, double-leg stance on foam surface, single-leg stance on foam surface, and tandem stance on foam surface was 1.00, 0.97 (0.81–0.99), 0.82 (0.31–0.95), 0.96 (0.88–0.99), 0.95 (0.86–0.98), and 0.90 (0.69–0.97), respectively.

Measurement of body composition and bone mineral density

We measured whole-body fat, muscle mass, and BMD at the lumbar spine (L1–L4) using DEXA (T-score values greater than −1) to assess body composition and BMD. BMD scans were analyzed using the World Health Organization criteria for total bone mass density. BMD measurements were expressed in g/cm2. These scores were then sex-, age-, and mean peak BMD-matched.

Statistical analysis

Data are expressed as mean ± standard deviation. All data were tested for normality. Differences among the three groups were tested using analysis of covariance and Bonferroni post hoc test. Mean values were compared before and 24 weeks after the exercise program using repeated measures analysis. A p-value of <0.05 was considered statistically significant.

Results

The mean age, anthropometrics, and body mass indexes of the participants are presented in Table 1. There were no significant differences in demographic data among the groups at baseline (p >0.05).

Table 1. Participant characteristics at baseline

Characteristic	STEP group (n = 17)	BOSU group (n = 17)	CON group (n = 18)
Age (years)	39.2±4.3	38.2±3.5	39.2±3.5
Weight (kg)	59.9±2.6	59.1±7.9	58.4±4.0
BMI (kg/m²)	24.9±2.3	24.0±2.2	24.1±2.3
Height (cm)	160.2±5.4	159.8±4.4	157.4±3.9
SBP (mmHg)	117.1±7.1	114.7±5.7	115.3±7.0
DBP (mmHg)	75.8±9.2	75.1±7.6	77.3±6.6

Values are presented as mean ± standard deviation. CON, Control; STEP, Aerobic step exercise training; BOSU, Both sides utilized ball; BMI, body mass index; SBP, systolic blood pressure; DBP, diastolic blood pressure.

There were no significant differences among the groups in terms of P1NP levels, BMD, muscle strength, or postural control (p >0.05).

Both exercise groups had significantly lower weight, body mass index, and heart rate at rest (p < 0.05) after the training intervention. Body composition data revealed significantly lower arm fat percentages in both exercise groups (p <0.05). At week 24, android fat percentage significantly decreased only in the STEP group, while lean mass significantly increased only in the BOSU group ($p < 0.05$). In terms of muscle strength at week 24, both exercise training groups showed significant improvement in leg extension and leg curl measures ($p < 0.05$). Regarding the balance ability after the exercise intervention, single-leg and tandem stance had significantly lower error scoring in both exercise groups after the training, while the double-leg stance on the foam surface was significantly lower in terms of error scoring only in the BOSU group ($p < 0.05$, Table 2).

We found significantly greater P1NP levels in both exercise and training groups. However, after the training

Table 2. Response of physiological data, body composition, muscle strength, balance, PINP, and BMD

Variable	STEP group (n = 17)				BOSU group (n = 17)				CON group (n = 18)			
	Pre	Post	p^a	Effect size	Pre	Post	p^a	Effect size	Pre	Post	p^a	p^b
Physiological data												
Weight (kg)	59.9±2.6	58.7±2.9^c	0.01	0.05	59.1±7.9	58.4±7.4^{c,d}	0.01	0.03	58.4±4.0	58.5±4.0^d	0.60	0.01
BMI (kg/m^2)	24.9±2.3	24.5±2.2^c	0.01	0.32	24.0±2.2	23.0±1.9^d	0.01	0.28	24.1±2.3	23.7±2.5^c	0.90	0.01
HR Rest (bpm)	75.9±5.3	71.6±6.9^c	0.01	0.59	74.4±5.9	70.5±6.8^c	0.01	0.75	75.1±6.8	75.6±6.8^d	0.24	0.01
SBP (mmHg)	117.1±7.1	115.2±9.2^c	0.06	0.09	114.7±5.7	113.4±7.0^c	0.08	0.13	115.3±7.0	114.5±8.2^c	0.48	0.29
DBP (mmHg)	75.8±9.2	74.6±11.7^c	0.21	0.19	75.1±7.6	73.9±9.1^c	0.14	0.27	77.3±6.6	76.1±8.1^c	0.20	0.93
Body composition data												
Body fat percentage (%)	40.2±7.1	39.4±7.3^c	0.14	0.62	39.6±5.0	39.5±4.5^{c,d}	0.62	0.59	41.3 ± 4.4	41.8±3.9^d	0.11	0.04
Right arm fat percentage (%)	34.6±7.5	32.7±7.2^c	0.01	0.49	35.1±6.9	33.5±6.5^c	0.01	0.34	35.3 ± 5.6	35.3±5.3^d	0.97	0.01
Left arm fat percentage (%)	34.7±7.5	32.7±7.2^c	0.01	0.49	35.1±6.9	33.5±6.5^c	0.01	0.34	35.3±5.6	35.3±5.3^d	0.97	0.01
Right leg fat percentage (%)	42.0±7.8	41.0±7.6^c	0.07	0.87	42.1±7.8	41.4±7.6^{c,d}	0.05	0.79	44.6±4.7	45.1±4.7^d	0.11	0.01
Left leg fat percentage (%)	41.9±7.8	41.3±3.6^c	0.08	0.69	41.9±3.2	41.3±7.8^c	0.05	0.69	44.6±4.7	45.1±5.5^c	0.38	0.10
Android fat percentage (%)	44.1±9.0	41.9±9.5^c	0.01	0.54	43.6±8.2	42.8±7.9^{c,d}	0.07	0.32	43.9±4.8	44.1±4.1^d	0.63	0.01
Gynoid fat percentage (%)	48.7±5.4	48.5±5.9^c	0.29	0.35	48.0±3.8	47.5±3.3^c	0.16	0.12	47.1±4.2	47.0±4.3^c	0.87	0.50
Lean mass (kg)	34.6±3.8	33.5±3.8^c	0.55	0.76	32.4±3.1	33.1±2.8^c	0.02	0.67	30.1±4.2	30.1±4.5^c	0.86	0.34
Muscle strength												
Leg extension strength (kg/bw)	62.7±12.9	66.1±14.1^c	0.01	0.73	62.1±10.5	64.9±11.3^c	0.01	0.59	58.4±16.1	60.0±8.3^c	0.60	0.40
Leg curl strength (kg/bw)	40.0±7.7	41.9±9.1^{c,d}	0.04	0.52	39.3±6.7	42.0±7.6^c	0.01	0.59	37.6±6.7c	37.1±8.3^d	0.58	0.03
Balance												
Double-leg stance on firm surface (errors)	0.0±0.0	0.0±0.0	NA	NA	0.0±0.0	0.0±0.0	NA	NA	0.0±0.0	0.0±0.0	NA	NA
Single-leg stance on firm surface (errors)	5.9±3.2	3.7±2.3^c	0.01	0.27	4.4±2.8	2.1±2.0^c	0.01	0.80	3.0±1.4	3.3±1.5^d	0.21	0.01
Tandem stance on firm surface (errors)	2.2±0.8	0.6±0.7^c	0.01	0.65	2.6±0.2	1.0±0.7^c	0.01	0.50	1.7±0.8	1.4±0.8^d	0.06	0.01
Double-leg stance on foam surface (errors)	0.5±0.6	0.3±0.6^c	0.08	0.17	0.5±0.6	0.2±0.4^c	0.02	NA	0.3±0.5	0.2±0.6^c	0.43	0.64
Single-leg stance on foam surface (errors)	7.0±1.6	4.6±1.4^c	0.01	0.27	6.3±2.3	3.1±1.4^c	0.01	0.41	4.3±2.5	4.0±2.2^d	0.38	0.01
Tandem stance on foam surface (errors)	2.4±0.9	1.2±0.8^c	0.01	0.42	2.4±1.0	1.7±1.1^c	0.02	NA	2.4±1.2	1.7±1.2^c	0.11	0.41
Biochemical bone markers												
P1NP (ng/mL)	42.7±6.1	44.2±7.0^{c,d}	0.01	0.14	43.0±8.1	45.9±9.5^c	0.01	0.37	42.8±7.4	43.2±7.3^d	0.21	0.01
Bone mineral density												
Whole-body BMD (g/cm^2)	1.19±0.09	1.20±0.07^c	0.06	1.13	1.11±0.08	1.14±0.08^c	0.03	0.38	1.13±0.11	1.11±0.08^d	0.21	0.01
Lumbar spine BMD L1 (g/cm^2)	1.18±0.17	1.17±0.16^c	0.52	0.50	1.11±0.12	1.12±0.12^c	0.67	NA	1.15±0.11	1.12±0.10^c	0.05	0.30
Lumbar spine BMD L2 (g/cm^2)	1.25±0.17	1.23±0.17^c	0.14	0.47	1.16±0.14	1.17±0.14^c	0.21	0.13	1.18±0.10	1.15±0.15^c	0.17	0.13
Lumbar spine BMD L3 (g/cm^2)	1.26±0.14	1.26±0.13^c	0.86	0.60	1.21±0.13	1.21±0.14^c	0.83	0.10	1.19±0.10	1.20±0.10^c	0.57	0.90
Lumbar spine BMD L4 (g/cm^2)	1.24±0.10	1.24±0.13^c	0.94	1.00	1.18±0.17	1.20±0.19^c	0.36	0.50	1.15±0.10	1.16±0.08^c	0.54	0.84
Lumbar spine BMD L1–L4 (g/cm^2)	1.21±0.13	1.22±0.13^c	0.55	0.67	1.18±0.14	1.18±0.15^c	0.70	0.22	1.20±0.12	1.16±0.09^c	0.08	0.05
Lumbar spine BMD L2–L4 (g/cm^2)	1.25±0.12	1.24±0.13^c	0.75	0.60	1.17±0.13	1.19±0.15^c	0.17	0.10	1.18±0.09	1.18±0.10^c	0.47	0.63

Values are presented as mean ± standard deviation. CON, control; STEP, aerobic step exercise training; BOSU, both sides utilized ball; NA, not available; BMI, body mass index; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; P1NP, procollagen type 1 N-terminal propeptide ; BMD, bone mineral density. $p < 0.05$; ^{a}, repeated measures analysis; ^{b}, analysis of covariance (ANCOVA); ^{c,d}, Different superscripts in the same row mean that the values are significantly different ($p < 0.05$) according to ANCOVA and Bonferroni post hoc test.

intervention, BMD showed significant enhancement only in the BOSU group ($p < 0.05$, Table 2). No changes in physical characteristics, postural control measures, biochemical bone formation markers, or BMD were observed in the CON group.

Discussion

The main findings of this study are that both BOSU and STEP programs enhanced physical fitness, bone status, and body stability; however, significant improvements in total BMD were observed only in the BOSU group. Our results suggest that BOSU training improves physical fitness, bone status, and body stability in premenopausal women.

Aerobic training, involving high intensity and speed, can prevent a decrease in BMD in patients with osteoporosis (Bendetti et al., 2018). The National Osteoporosis Foundation (n.d.) recommends high-impact weight-bearing training, that is, dancing, high-impact aerobic exercise, hiking, jogging/running, jumping, stair climbing, and tennis, to yield beneficial effects on bone health in women. Our training was designed according to the concept of high impact to increase gravitational and muscle forces.

STEP and BOSU training, with their ascending and descending movements, make use of gravity, which may promote improved functioning of the vestibular apparatus. The possible mechanism might be that stronger muscles and consequently better nervous system functions improve balance (Kovács et al., 2012). Regarding the time course, a previous study reported significant improvements in balance and health-related physical fitness but not in P1NP levels following a 12-week program of circuit box jumping (Anek et al., 2011). Using a longer duration (24 weeks), our results demonstrated the benefits of STEP and BOSU training on body composition and physical fitness. Moreover, increased P1NP levels in both STEP and BOSU groups were observed after 24 weeks, suggesting that exercise duration should be considered when monitoring bone status in premenopausal women.

Both muscle and gravitational forces are critical to regulating bone health, as confirmed by several studies (Kohrt et al., 1997; Nikander et al., 2005; Shackelford et al., 2004). In the present study, we used aerobic exercise with a BOSU ball and bench of a similar height. Owing to the different surfaces, there might have been distinct muscle and gravitational forces. Both programs may improve awareness of body position due to increased proprioceptive input from the muscles, tendons, and joints (Park et al., 2008) and may lead to increased body stability, with the unstable surface of the BOSU ball providing more advantage in terms of balance (as seen by the changes in double-leg stance). Our balance results are similar to those of a previous study in which a greater improvement was observed in unstable surface training (Nepocatych et al., 2016). Long-term increases in BMD were observed only in the BOSU group; however, improvement in the levels of P1NP, a bone formation marker, was observed in both STEP and BOSU groups. The mechanism is unknown but is likely due to greater changes in ground reaction force (step down to the ground from the bench), which should be confirmed by further studies. Considering the different effects on BMD between the groups, differences in mechanical loading might be one of the possible mechanisms to explain why a lower level could lower cartilage degeneration, subchondral bone remodeling, secondary inflammation, and activation of the NLRP3 inflammasome, as previously seen in a male rat model of osteoarthritis (He et al., 2020). However, it is necessary to investigate the possible underlying mechanisms of these outcomes due to the combination of box jumping and different surfaces in future studies.

Limitations

This study has some limitations. First, considering the two phases of stepping on and down to the ground surface in both groups, stepping down to the ground surface would generate a relatively higher mechanical landing impact on the foot compared with stepping onto a surface. Ground reaction force measurement should be added to further studies to verify the mechanical impacts induced by two different interventions. Second, we did not measure the BMD of the lower limbs, which would have also received mechanical impact, and did not measure multiple time points of serum bone markers and BMD. Third, we only measured P1NP levels to identify the bone formation status. Other parameters, e.g., β cross-linked C-telopeptide of type 1 collagen (β-CTX), should be added in further studies to verify coupling effects (bone formation and resorption). Lastly, the number of subjects in the control, BOSU, and STEP groups was relatively small.

Conclusions

Both STEP and BOSU training programs enhanced health-related physical fitness, body stability, and P1NP levels; however, an improvement in total BMD was only observed in the BOSU group. Therefore, we recommend our BOSU training program to improve these parameters in premenopausal women.

Acknowledgment

This research was financially supported by the Faculty of Physical Education, Srinakharinwirot University, Thailand.

Conflict of interest

Authors state no conflict of interest.

References

Seguro, L.P., Casella, C.B., Caparbo, V.F., Oliveira, R.M., Bonfa, A., Bonfa, E., & Pereira, R.M.R. (2015). Lower P1NP serum levels: A predictive marker of bone loss after 1 year follow-up in premenopausal systemic lupus erythematosus patients. *Osteoporosis International, 26*(2), 459-467. https://doi.org/10.1007/s00198-014-2860-9

Krege, J.H., Lane, N.E., Harris, J.M., & Miller, P.D. (2014) PINP as a biological response marker during teriparatide treatment for osteoporosis. *Osteoporosis International, 25*(9), 2159-2171. https://doi.org/10.1007/s00198-014-2646-0

McClung, M., Harris, S.T., Miller, P.D., Bauer, D.C., Davison, K.S., Dian, L., Hanley, D.A., Kendler, D.L., Yuen, C.K., & Lewiecki, E.M. (2013) Bisphosphonate therapy for osteoporosis: Benefits, risks, and drug holiday. *American Journal of Medicine, 126*(1), 13-20. https://doi.org/10.1016/j.amjmed.2012.06.023

Xu, J., Lombardi, G., Jiao, W., & Banfi, G. (2016). Effects of exercise on bone status in female subjects, from young girls to postmenopausal women: An overview of systematic reviews and meta-analyses. *Sports Medicine, 46*(8), 1165-1182. https://doi.org/10.1007/s40279-016-0494-0

Park, H., Kim, K.J., Komatsu, T., Park, S.K., & Mutoh, Y. (2008). Effect of combined exercise training on bone, body balance, and gait ability: A randomized controlled study in community-dwelling elderly women. *Journal of Bone and Mineral Metabolism, 26*(3), 254-259. https://doi.org/10.1007/s00774-007-0819-z

von Stengel, S., Kemmler, W., Kalender, W.A., Engelke, K., & Lauber, D. (2007). Differential effects of strength versus power training on bone mineral density in postmenopausal women: A 2-year longitudinal study. *British Journal of Sports Medicine, 41*(10), 649-655. https://doi.org/10.1136/bjsm.2006.033480

Anek, A., Kanungsukasem, V., & Bunyaratavej, N. (2015). Effects of aerobic step combined with resistance training on biochemical bone markers, health-related physical fitness and balance in working women. *Journal of the Medical Association of Thailand, 98*(Suppl 8), S42-S51.

Anek, A., Kanungsukasem, V., & Bunyaratavej, N. (2011). Effects of the circuit box jumping on bone resorption, health-related to physical fitness and balance in the premenopausal women. *Journal of the Medical Association of Thailand, 94*(Suppl 5), S17-S23.

Marques, E.A., Mota, J., Viana, J.L., Tuna, D., Figueiredo, P., Guimarães, J.T., & Carvalho, J. (2013). Response of bone mineral density, inflammatory cytokines, and biochemical bone markers to a 32-week combined loading exercise programme in older men and women. *Archives of Gerontology and Geriatrics, 57*(2), 226-233. https://doi.org/10.1016/j.archger.2013.03.014

Sherrington, C., Whitney, J.C., Lord, S.R., Herbert, R.D., Cumming, R.G., & Close, J.C. (2008). Effective exercise for the prevention of falls: A systematic review and meta-analysis. *Journal of American Geriatrics Society, 56*(12), 2234-2243. https://doi.org/10.1111/j.1532-5415.2008.02014.x

Alkahtani, S.A., Yakout, S.M., Reginster, J.Y., & Al-Daghri, N.M. (2019). Effect of acute downhill running on bone markers in responders and non-responders. *Osteoporosis International, 30*(2), 375-381. https://doi.org/10.1007/s00198-018-4673-8

Scott, J.P., Sale, C., Greeves, J.P., Casey, A., Dutton, J., & Fraser, W.D. (2011). The role of exercise intensity in the bone metabolic response to an acute bout of weight-bearing exercise. *Journal of Applied Physiology, 110*(2), 423-432. https://doi.org/10.1152/japplphysiol.00764.2010

de Oliveira, L.C., de Oliveira, R.G., & de Almeida Pires-Oliveira, D.A. (2019). Effects of whole-body vibration versus Pilates exercise on bone mineral density in postmenopausal women: A randomized and controlled clinical trial. *Journal of Geriatric Physical Therapy, 42*(2), E23-E31. https://doi.org/10.1519/JPT.0000000000000184.

Nepocatych, S., Ketcham, C.J., Vallabhajosula, S., & Balilionis, G. (2016). The effects of unstable surface balance training on postural sway, stability, functional ability and flexibility in women. *The Journal of Sports Medicine and Physical Fitness, 58*(1-2), 27-34. https://doi.org/10.23736/S0022-4707.16.06797-9

Wing, C.H. (2014). The BOSU ball: Overview and opportunities. *ACSM's Health & Fitness Journal, 18*(4), 5-7. https://doi.org/10.1249/FIT.0000000000000048

Leme, J., Candido, C.R., Nascimento, V., Dascal, J., & Okazaki, V.H. (2022). The reliability of measures provided by the Unstable Platform for Balance Analysis in young adults with and without visual information. *Human Movement, 23*(3), 104-112. https://doi.org/10.5114/hm.2022.107978

Benedetti, M.G., Furlini, G., Zati, A., & Letizia Mauro, G. (2018). The effectiveness of physical exercise on bone density in osteoporotic patients. *Biomed Research International, 2018,* 1-10. https://doi.org/10.1155/2018/4840531

National Osteoporosis Foundation. (n.d.). *What Women Need to Know.* Retrieved September 11, 2020, from https://www. http://nof.org/preventing-fractures/general-facts/what-women-need-to-know/

Kovács, E., Tóth, K., Dénes, L., Valasek, T., Hazafi, K., Molnár, G., & Fehér-Kiss, A. (2012). Effects of exercise programs on balance in older women with age-related visual problems: A pilot study. *Archives of Gerontology and Geriatrics, 55*(2), 446-452. https://doi.org/10.1016/j.archger.2012.01.009

Kohrt, W.M., Ehsani, A.A., & Birge, S.J. Jr. (1997). Effects of exercise involving predominantly either joint-reaction or ground-reaction forces on bone mineral density in older women. *Journal of Bone and Mineral Research, 12*(8), 1253-1261. https://doi.org/10.1359/jbmr.1997.12.8.1253

Nikander, R., Sievänen, H., Heinonen, A., & Kannus, P. (2005) Femoral neck structure in adult female athletes subjected to different loading modalities. *Journal of Bone and Mineral Research, 20*(3), 520-528. https://doi.org/10.1359/JBMR.041119

Shackelford, L.C., LeBlanc, A.D., Driscoll, T.B., Evans, H.J., Rianon, N.J., Smith, S.M., Spector, E., Feeback, D.L., & Lai, D. (2004). Resistance exercise as a countermeasure to disuse-induced bone loss. *Journal of Applied Physiology, 97*(1), 119-129. https://doi.org/10.1152/japplphysiol.00741.2003

He, Z., Nie, P., Lu, J., Ling, Y., Guo, J., Zhang, B., Hu, J., Liao, J., Gu, J., Dai, B., & Feng, Z. (2020) Less mechanical loading attenuates osteoarthritis by reducing cartilage degeneration, subchondral bone remodelling, secondary inflammation, and activation of NLRP3 inflammasome. *Bone & Joint Research, 9*(10), 731-741. https://doi.org/10.1302/2046-3758.910.BJR-2019-0368.R2

ОСТЕОГЕННІ ЕФЕКТИ ТРЕНУВАНЬ З БАЛАНСУВАЛЬНОЮ ПЛАТФОРМОЮ ДВОБІЧНОГО ВИКОРИСТАННЯ ПОРІВНЯНО З ТРЕНУВАННЯМИ ЗІ СТЕП-ПЛАТФОРМОЮ В ЖІНОК У ПРЕМЕНОПАУЗІ

Ачарія Анек[1ABCD], Вітід Мітранун[1ABCD]

[1]Університет Срінахарінвірот

Авторський вклад: A – дизайн дослідження; B – збір даних; C – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 7 с., 2 табл., 2 рис., 23 джерел.

Мета дослідження. Заняття фізичними вправами відіграють важливу роль у збільшенні кісткової маси. Тим не менш, остеогенні ефекти занять фізичними вправами з використанням різних стендових поверхонь невідомі. Таким чином, метою цього дослідження було порівняти остеогенні ефекти вправ зі стендом із м'якою поверхнею та балансувальною платформою двобічного використання (BOSU) з ефектами вправ зі степ-платформою (STEP).

Матеріали та методи. Для участі в дослідженні були набрані та випадковим чином розділені на три групи 52 учасниці, які ведуть сидячий спосіб життя, віком 30–45 років. Сімнадцять учасниць тренувалися в групі STEP, 17 – у групі BOSU, а 18 – увійшли до контрольної групи. Програми вправ для груп STEP та BOSU були розроблені таким чином, щоб мати однакову інтенсивність і діапазон пульсу на кожному етапі програми. Під час занять для встановлення темпу тренувань використовували музику.

Результати. Після 24-го тижня обидві тренувальні групи показали статистично значущі покращення у фізичній підготовці, композиції тіла та стані рівноваги тіла (p<0,05). В обох групах STEP та BOSU спостерігалися підвищені рівні N-термінального пропептиду проколагену I типу (P1NP), маркера остеогенезу. Підвищення мінеральної щільності кісткової тканини спостерігалося лише в групі BOSU (p<0,05).

Висновки. Обидві програми STEP та BOSU ефективно підвищили рівні P1NP, м'язову силу та контроль постави, але лише тренування з балансувальною платформою двобічного використання BOSU покращило мінеральну щільність кісток у жінок у пременопаузі.

Ключові слова: формування кісток, контроль постави, пременопауза.

Information about the authors:

Anek, Achariya: ozone_aut@hotmail.com; https://orcid.org/0000-0003-2665-6975; Department of Sports Science, Srinakharinwirot University, 114 Soi Sukhumvit 23, Khlong Toei Nuea, Watthana, Bangkok 10110, Thailand.

Mitranun, Witid: mitranunwitid@hotmail.com; https://orcid.org/0000-0002-9334-2696; Department of Sports Science, Srinakharinwirot University, 114 Soi Sukhumvit 23, Khlong Toei Nuea, Watthana, Bangkok 10110, Thailand.

Cite this article as: Anek, A., & Mitranun, W. (2023). Osteogenic Effects of Aerobic Both Sides Utilized Ball Versus Aerobic Step Training in Premenopausal Women. *Physical Education Theory and Methodology, 23*(3), 339-345. https://doi.org/10.17309/tmfv.2023.3.04

Received: 27.01.2023. Accepted: 09.05.2023. Published: 30.06.2023

This work is licensed under a Creative Commons Attribution 4.0 International License (http://creativecommons.org/licenses/by/4.0).