SWACSM Abstract

Effects of BioDensity Training on Bone Adaptations in Young Women: A Pilot Study

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ABSTRACT

Osteopenia and osteoporosis are a major public health issue in the United States, and current research suggests that moderate to high intensity resistance training is the most effective type of exercise for maintaining bone mineral density (BMD). Sclerostin is a protein secreted by osteocytes which potently inhibits bone formation by binding to the LRP4 in Wnt/β-catenin signaling. BioDensity is a novel resistance training machine that consists of four exercises performed for five seconds each, which applies mechanical loading to the bone and provides a quicker alternative to traditional resistance training. **PURPOSE**: To examine the effects of 12 weeks of supervised bioDensity training on BMD and sclerostin in young women. **METHODS**: Nine healthy, young female participants were recruited for the 1-repetition (1-REP) group, and another seven participants were recruited for the 2-repetition (2-REP) group with similar age, weight, height, and ethnicity. They underwent 12 weeks of supervised bioDensity training, once a week. Before and after the intervention, total body composition and BMD at major sites were measured by DXA and serum sclerostin levels were measured in ELISA. Independent sample t-test was used to compare the baseline between groups, and mixed measure ANOVA was used to compare the effects of training within and between groups. **RESULTS**: We did not find significant time, group, or time x group interaction effects in BMD or serum sclerostin levels after 12-week bioDensity training. There is a large effect size of time (η^2 = .214) at lumbar spine BMD after adjusting for height, and medium effect size of time (η^2 = .108) in sclerostin levels. No significant differences were found in the percent change of BMD, while the effect size between the two groups was large. **CONCLUSION**: Although no statistical changes of BMD and sclerostin were observed, the medium to large effect sizes in our pilot study suggest a potential training effect. The bioDensity exercise regimen is feasible and well tolerated in young women.

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INTRODUCTION

Osteopenia and osteoporosis are a major public health problem in the United States. Current research shows that moderate to high intensity resistance exercise is the most effective type of exercise to maintain and improve bone mineral density (BMD), which in turn can reduce fracture risk, especially in common sites of fractures such as the lumbar spine and hip (Kelly et al. 2001, Hamilton et al. 2022). However, despite the significant benefits it offers, it is often not the most practical type of exercise in certain populations due to its demand for time, training experiences, adequate balance, and risk of injury from poor form. In contrast to traditional resistance training, bioDensity (Performance Health Systems, IL), is a relatively new machine developed in 2005 to provide a quicker approach to stimulate bone formation through self-induced exercises. Its defining characteristic is that only four exercises are performed for five seconds each at the individual's optimal joint angles to ensure maximal performance throughout the session (Zheng et. al. 2019). Sclerostin is a protein secreted by osteocytes and expressed in the Sost/sclerostin gene, which potently inhibits bone formation by binding to the LRP4 in Wnt/β-catenin signaling pathway in bone (Delgado-Calle, et al. 2017). To our knowledge, there is few research studying the effects of bioDensity on BMD and sclerostin responses in women. This study will therefore examine the effects of 12 weeks of supervised bioDensity training on bone adaptations in young women.

METHODS

Study Design

We conducted a 12-week, nonrandomized controlled exercise intervention trial. This study consisted of 14 weeks in duration with 12 bioDensity training sessions. Testing was performed at baseline (week 1) and end of the 12 weeks (week 14). Participants were enrolled in the one-

repetition (1-REP) group first, then participants with similar age, weight, height, and ethnicity were matched into the two-repetition (2-REP) group. The 1-REP group endured one repetition of the four exercises on the bioDensity machine once per week, while the 2-REP group performed two repetitions of the exercises once per week.

Participants

Nine healthy, physically inactive, young female participants were recruited for the 1-REP group, and another seven female participants were recruited for the 2-REP group. Our exclusion criteria included: 1) Currently pregnant or may be pregnant in the next 3~4 months; 2) Current smokers; 3) Having recent fractures within the previous 12 months; 4) Physical disabilities or musculoskeletal injuries; 5) Metal implants or joint replacement at the hip, spine or forearm; 6) Outside of the limits of the iDXA table (weight over 450 lbs, height over 6'4'').

Measurements

During the first visit, participants completed the informed consent and health screening questionnaires to confirm their qualification. Once qualified, they underwent a familiarization session with the bioDensity and its exercise regimen. During the second visit, a blood sample was collected through venipuncture by a certified phlebotomist after fasting for 10-12 hours. Baseline bone mineral density (BMD) and body composition were assessed with the Dual Energy X-Ray Absorptiometry (DXA). A second familiarization session with bioDensity was followed. From this point forward, participants exercised on the bioDensity once a week for 12 weeks, either in 1-repetition or 2-repetition. Blood draws and DXA scans were repeated after the last training session. Serum sclerostin levels were measured in commercial ELISA (TECO medical, Switzerland).

Statistical Analysis

All statistical analyses were performed in SPSS version 28 (IBM Corp, NY). An independent sample t-test was used to compare baseline or percent changes between groups. Mixed

measure ANOVA (2 x 2) was used to compare the effects of time (pre and post) and intervention (1-REP vs. 2-REP) on BMD and sclerostin. Height was used as a covariant when comparing BMD between groups. Effect size was reported in Cohen's d in independent t-test and Partial Eta Squared (η^2) in ANOVA. The level of significant was set at $p \leq .05$.

RESULTS

Participant Characteristics

Table 1 described the baseline characteristics of the participants. There were no significant differences in age, weight, and BMD at major sites between the 1-REP and 2-REP groups, except that that 1-REP group was taller than the 2-REP group. Most of our participants are Hispanics: 7 of the 9 participants in the 1-REP group and 6 of the 7 participants in the 2-REP group. No adverse effects were reported in participants during the participation of the study.

Table 1. Participants Characteristics at Baseline (Mean ± SD)

Characteristics	1-REP (n=9)	2-REP (n=7)	*p*-Value
Age (years)	21.6 ± 2.9	22.8 ± 2.2	.388
Height (cm)	163.4 ± 3.3	159.5 ± 3.9	.050*
Weight (kg)	72.2 ± 19.5	69.3 ± 13.6	.739
BMD (g/cm^2)			
Lumbar Spine	1.193 ± .132	1.243 ± .175	.523
Left Femoral Neck	1.060 ± .102	1.122 ± .205	.437
Left Total Hip	1.024 ± .079	1.117 ± .164	.157
Left Radius	.892 ± .094	.875 ± .063	.688

** Significant difference between 1-REP and 2-REP groups*

Effects of BioDensity Training on BMD

With and without adjusting for height, mixed measure ANOVA showed that no significant time, group, or time x group interaction effects in BMD after 12-week bioDensity training, However,

large effect size of time (η^2 = .214, *p* = .083) at lumbar spine BMD was observed after adjusting for height. Percent change of BMD during the 12-week was calculated based on the baseline and post DXA measurements and reported in Table 2. Despite the effect sizes between groups were large, no significant differences were found in the percent change of BMD.

Table 2. Percent Change of BMD in BioDensity Training (Mean ± SD)

%Change BMD	1-REP (n=9)	2-REP (n=7)	95% CI	*p*-Value	Effect Size
Lumbar Spine	.23 ± 2.95	.81 ± 2.53	(-3.53, 2.41)	.682	2.78
Left Femoral Neck	-.31 ± 1.10	-.68 ± 1.66	(-1.10, 1.85)	.594	1.37
Left Total Hip	.10 ± 2.19	-.03 ± 1.61	(-1.98, 2.25)	.893	1.96
Left Radius	.16 ± 3.13	-.18 ± 3.23	(-3.09, 3.78)	.832	3.18

Effect size was reported in Cohen's d.

Effects of BioDensity on Serum Sclerostin

Mixed measure ANCOVA showed that the 12-week bioDensity training had no significant effects of time, intervention, or time x intervention interaction on the serum sclerostin levels (Figure 1). There is a moderate trend of decline from baseline to post-training in both 1-REP (.386 ± .090 vs. .364 ± .094 ng/mL) and 2-REP (.386 ± .099 vs. .363 ± .162 ng/mL) groups with a medium effect size of time (η^2 = .108).

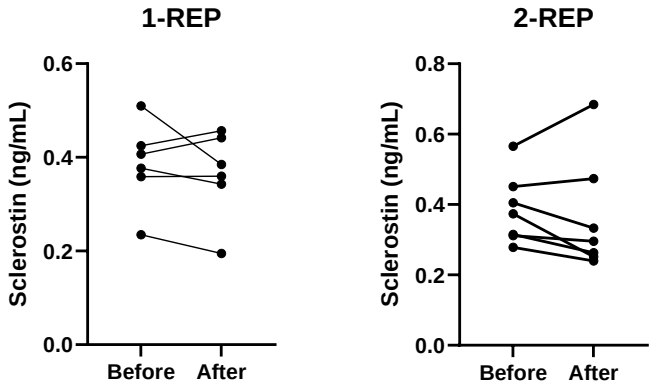

Figure 1. Serum Sclerostin Before and After BioDensity Training in 1-REP and 2-REP Groups

DISCUSSION

To date, there are limited research on the bioDensity exercise and most of the studies have been conducted on older men or women, which might be in part because of the rapid decline in bone density after 50 years old. It's worthy to note that it's also important for younger adults to develop high peak bone mass in their 20s to prevent osteopenia and osteoporosis at an older age. Harding et al. (2020) found that 8-month bioDensity training, twice a week, significantly improved the lumbar spine BMD in middle-aged and older men with osteopenia and osteoporosis, while the traditional high intensity resistance training improved BMD at multiple sites at a larger extent in comparison. Although there were no significant changes in BMD and sclerostin in our young female participants, we found large effect size of time at lumbar spine BMD after adjusting for height (η^2 = .214), and medium effect size of time for serum sclerostin (η^2 = .108), suggesting a potential training effect. In addition, the large effect size of percent change of BMD suggesting an intervention effect between 1-repetition and 2-repetition protocol. There are several limitations of this study. The sample size is small, and the results are underpowered. This explains why we observed medium to large effect size of time or group, but no statistically significant differences were detected. Due to the duration and involvement of the study, we were not able to recruit a large group of participants and randomly assign them to a control or intervention group. The lack of randomized control design limits the interpretation of our results. Lastly, bone adaptation is a slow process which requires longer intervention. Our training intervention was limited to 12 weeks because of our academic schedule.

CONCLUSION

In conclusion, we found the supervised bioDensity exercise is feasible and well tolerated in young women. Although no statistical changes of BMD and sclerostin were observed, our preliminary results suggest a potential training effect. Future study should increase the sample size and duration of the intervention, target individuals with low bone mass, or add other biomarkers to examine the training effectiveness.

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