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Multiple-of-bodyweight axial bone loading using novel exercise intervention with and without bisphosphonate use for osteogenic adaptation

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Abstract:
Aim: To determine bone density adaptation from multiple-of-bodyweight (MOB) compressive force with exercise apparatus designed for osteogenic loading.
Methods: Osteogenic Loading (OL) apparatus was used to isolate optimal ranges of motion allowing for axial bone loading at levels that could be MOB (force/loading measured by load cells within the OL apparatus). Optimal positions for OL were verified by analysis of force production maximization [1]. Volunteer subjects, mean age of 62.5(+/-8.2 SD), (n=14) performed 4 specific multi-joint movements on the OL apparatus, each lasting 5 seconds. Sessions were repeated once per week.
Results: **Mean peak force/loading for subjects was 9.18(+/-2.63 SD) MOB (hip/legs) and 3.13(+/-0.79 SD) MOB (spine)**. Since different hospitals and radiology offices were used to gather DXA data, not all subjects had both hip and spine T-scores, and weeks/sessions of using OL were not uniform, the results are presented in a case report format, depicting pre and post DXA of hip and spine.
Conclusions: This MOB level of axial force has been seen to improve BMD [2, 3, 4], however has been commonly affiliated with injury. BMD improvement outcomes were observed in all subjects for one or both test sites with no instances of injury or discomfort, at levels of MOB reaching 9.18(+/-2.63 SD) MOB (hip/legs) and 3.13 (+/-0.79 SD) MOB (spine). These results suggest a larger more controlled study be done to further examine the OL stimulus and adaptation.

Sbj	Gnd	Wt. lbs.	Age at end	Bisphos -phonate	Weeks/# OL session	PRE T-score HIP	POST T-score HIP	PRE T-score SPINE	POST T-score SPINE	BMD gain
1	M	160	60	N	52	-1.5	-1.0	-0.3	0.3	Y
2	M	158	66	N	72	-2.3	-1.9	NA	NA	Y
3	M	183	58	N	52	-2.4	-1.7	-3.6	-1.3	Y
4	F	125	59	N	28	-1.3	-1.4	-2.4	-2.0	Y
5	F	170	59	N	73	-0.7	-0.9	-0.7	-0.4	Y
6	F	177	71	N	80	-1.3	-1.2	-2.4	-2.1	Y
7	F	120	63	N	52	-1.3	-1.0	-2.6	-2.0	Y
8	F	139	62	N	26	-1.6	-1.7	-2.6	-2.4	Y
9	F	135	63	N	26	-0.4	0.3	NA	NA	Y
10	F	128	57	N	52	-1.5	-1.0	-2.1	-0.8	Y
11	F	122	50	N	52	-1.1	-0.4	NA	NA	Y
12	F	134	66	N	52	-2.5	-2.3	-2.6	-2.4	Y
13	F	122	57	N	52	-0.6	-0.2	-0.7	-0.7	Y
14	F	115	85	Y	73	-3.1	-3.1	-2.9	-2.7	Y

Keyword: Exercise, Multiple of bodyweight
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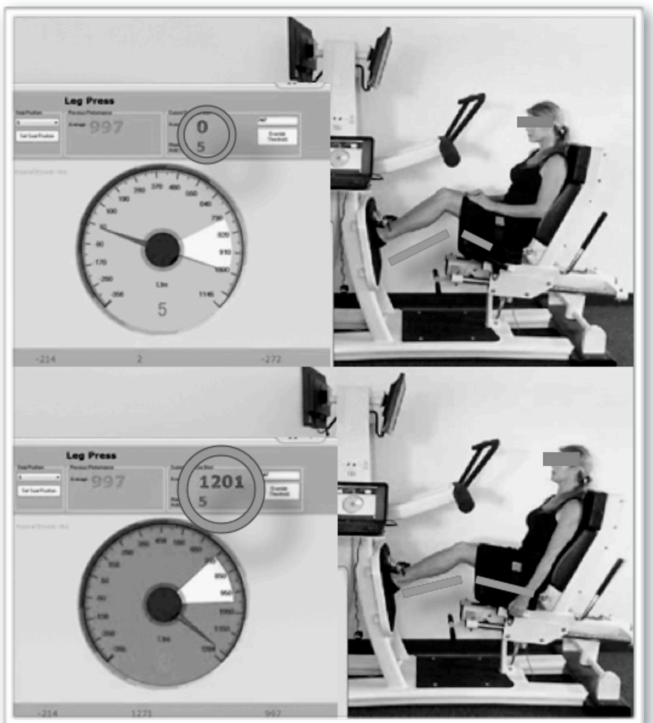
Aim: To determine bone density adaptation from multiple-of-bodyweight (MOB) compressive force with exercise apparatus designed for osteogenic loading.

Introduction: Forces that briefly bend or compress bone stimulate an adaptive response of BMD growth in accordance with Wolff's Law [3]. A novel apparatus that allows for these compressive forces to the level required to potentially have effect on osteoblastic function has been developed.

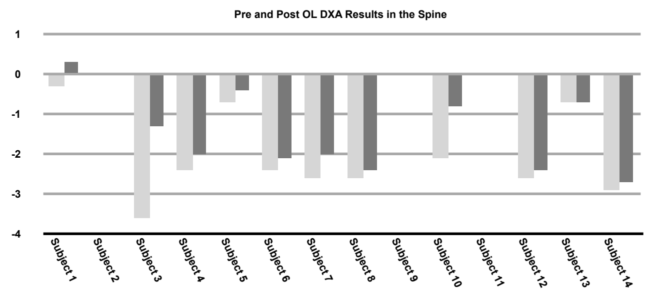
Methods: Osteogenic Loading (OL) apparatus was used to isolate optimal ranges of motion allowing for axial bone loading at levels that could be MOB (force/loading measured by load cells within the OL apparatus) seen right. Force-production-increase adaptations of 550 test subjects of both genders was previously analyzed. Gains in force production had been found averaging 6.1% for females and 5.1% for males, per weekly session, after learning effect was discounted in beginning sessions [5]. Optimal positions for OL were verified by analysis of force production maximization and electron myography [1]. For this study, volunteer subjects, mean age of 62.5 (+/-8.2 SD), (n=14) performed 4 specific multi-joint movements on the OL apparatus, each lasting 5 seconds. Subjects were told to perform OL movements with the greatest amount of force possible, while still maintaining comfort. Sessions were repeated once per week. DXA scans were repeated at differing intervals determined by the subject's physicians. Duration of OL therapy between scans was 1.02 years (+/-.34 SD). Patients approved use of their de-identified DXA scans with their physicians.

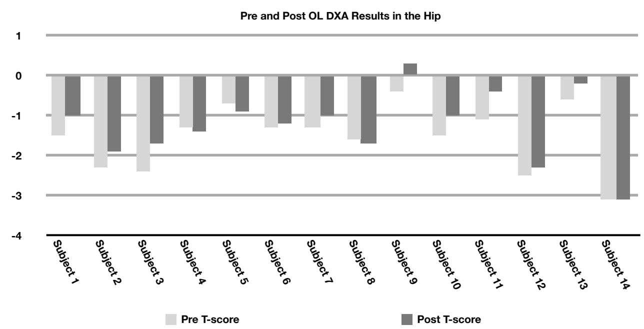
Results: Mean peak force/loading for subjects was 9.18(+/-2.63 SD) MOB (hip/legs) and 3.13(+/-0.79 SD) MOB (spine). Since different hospitals and radiology offices were used to gather DXA data, not all subjects had both hip and spine T-scores, and weeks/sessions of using OL were not uniform, the results are presented in a case report format, depicting pre and post DXA of hip and spine. **The BMD (g/cm2) measures in the subjects increased an average of 7.02% in the hip and 7.73% in the spine.** The BMD increases that occurred reached statistical significance from pre to post DXA scans ANOVA ($P < 0.001$).



Above, a post-menopausal female subject is achieving leg/hip loading of 1200lbs./545kg. This is 10 multiples of her bodyweight. In the movement, the seat fixture does not move, nor does the foot plate. The movement seen is from compression.

Discussion: The forces applied in the MOB loading that this OL intervention can allow, are beyond those seen in conventional exercise or activity. The therapy provided with OL shows not only high forces, but indicates how users respond to the forces based on comfort as the limiting factor. This loading can be seen as a measure of bone performance, for example an individual who can comfortably produce 10 MOB in the lower extremities on the OL apparatus could potentially posses a greater ability to absorb impact forces in a fall over an individual who can only produce 3 MOB. More research is needed to determine quantifications of bone performance. Bisphosphonate intervention primarily affects the cortical layer in bone. A protocol that combines therapy with OL in conjunction with bisphosohonates could potentially affect both cortical and trabecular bone mass and provide a more complete





BMD reconditioning. The variance of T-score and BMD results varied with specifically subject 3 having results above the normal distribution from the other subjects. It is important to point out that this is an exercise intervention, and results seen with any exercise depend heavily on the individual's commitment to the activity.

Conclusions:

- This MOB level of axial force has been seen to improve BMD [3, 4], but has been commonly affiliated with injury. No instances of injury were reported with these subjects.
- Statistically significant BMD increase outcomes were observed in all subjects for one or both test sites.
- BMD increased in both the subjects who where not taking bisphosphonates and the single subject who was.
- A larger more controlled study with respect to duration and sample size, is required to further examine the OL stimulus and adaptation.

Conflict of Interest Disclosure: *Author has ownership/financial interest in Performance Health Systems, LLC., a corporation that manufactures and distributes the OL apparatus used in this analysis. Subject data was shared by physicians whose patients were using the OL apparatus and whose pre and post patient DXA scans fell within the usage parameters (use of OL once weekly or bi-monthly, and pre and post DXA fell within the prescription of 25 to 75 weeks).

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