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Olympic Lifting is Superior to Power Lifting in Improving Bone Mineral Density

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Olympic Lifting is Superior to Power Lifting in Improving Bone Mineral Density

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Abstract

Olympic Lifting is Superior to Power Lifting in Improving Bone Mineral Density

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Purpose The aim of this study was to analyze the relationship between anthropometrics, sport-specific training history, and bone mineral density (BMD) in female Olympic weightlifters (OL) (n=8), power lifters (PL) (n=8), soccer players (SP) (n=10), and recreationally active participants (RA) (n=11).

Methods Certain anthropometrics and BMD in the femoral neck, lumbar, and total body were measured by dual-energy x-ray absorptiometry and other standard methods. BMD measurements, anthropometrics, and training history were compared using one-way ANOVA. Significance for ANOVA was set at $p < 0.05$.

Results OL had significantly denser L2 ($p = 0.013$), L3 ($p = 0.006$), L4 ($p = 0.002$), and L1-L4 ($p = 0.004$) vertebrae than RA. PL also showed a significantly higher L4 BMD than RA ($p = 0.025$). All three athletic groups were significantly denser than RA ($p < 0.01$) in total body BMD. OL were also shown to be significantly denser than PL ($p = 0.021$) in total body BMD, but there was no significant difference between OL and SP. At the

femoral neck, both OL ($p = 0.03$) and SP ($p < 0.001$) were shown to have a significantly higher BMD than RA.

Conclusion All three sports will improve total body BMD. However, Olympic weightlifting is clearly superior to power lifting in building BMD in the lumbar spine, femoral neck, and the total body. Power lifting also provides limited significant improvement in the lumbar spine as well. Soccer also has great benefits for the femoral neck, but not the lumbar spine.

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Introduction

Bone mineral density (BMD) is an indicator of bone strength [1-3]. It is widely measured by dual-energy x-ray absorptiometry (DXA). DXA is used to identify osteoporosis, see whether a patient may be at risk of fracture, and measure exact BMD [2]. People with osteoporosis/osteopenia suffer from having a low BMD, putting them at a greater risk for bone fracture compared to healthy young adults [4].

The main problem with diagnosis is that osteoporosis can exist in someone without them knowing. This leads to the under-treatment of osteoporotic symptoms for many potential patients [5]. All too often it is a fracture that will tell someone whether they have osteoporosis. Fractures usually occur at the femoral neck, lumbar spine, and the radius [4]. The objective of all treatment is to prevent fractures, the biggest cause of which are falls.

Sadly, among all fall-related deaths, adults over 65 years of age have the most fatalities [6]. Currently, osteoporotic fractures cost the U.S. 19 billion dollars annually [7], and if left unchecked costs will rise to 25.3 billion by 2025 [8]. Osteoporosis is more prevalent in women, but men suffer from osteoporotic fractures as well. In the year 2000, 61% of 54 million osteoporotic fractures worldwide were in women, while men suffered from 22.4 million fractures [9]. Studies indicate that 1 in 3 women and 1 in 5 men over 50 years of age worldwide will experience an osteoporotic fracture [10].

Prevention of hip fractures is essential. Hip fracture patients find it very hard to begin a rehabilitation program due to perceived environmental barriers. One study found that even after a year of rehabilitation, elderly patients still saw many things like stairs, lighting fixtures, floor surfaces, street conditions, hilly terrain, long distances and lack of adequate outdoor resting places as major obstacles affecting their quality of life [11].

Exercise both before [12] and after puberty [13] has been shown to carry its effects into old age. Exercise makes bone adaptations in the parts of the body that have been exercised most frequently. For example, young female tennis and squash players' dominant arms that they hit the ball with gained significantly more bone density in their proximal humerus and distal radius than their non-dominant arm [14]. It was observed that playing at least two years before menarche doubles the benefits on their bone mineral content when compared to women who started after menarche [14]. Thus, emphasis must be placed on building bone density while young to prevent osteoporosis and fractures that are prevalent with the onset of old age.

Weight-bearing exercises have been shown to be superior to non-impact exercises when it comes to significantly improving BMD [15]. It is also known that power and strength exercises have a very different impact on bones. Postmenopausal women have been shown to respond better to the same exercise when performed with as much acceleration and velocity that they can put into it [16]. In other words, when two groups of participants did the same exercises (leg press, leg curls, bench press, rowing, leg adduction and abduction, abdominal flexion, back extensions, lat pull-downs, hyperextension, leg extension, shoulder raises, and hip flexion, including running, jumping, and aerobics), the group doing them with more speed had a significantly better lumbar spine BMD ($p < 0.05$) [17]. For these reasons, our study compared the two competitive forms of weightlifting: power lifting and Olympic weightlifting.

Since Olympic lifting requires a greater velocity and rate of loading to complete than power lifting [18], we assumed that the benefits on the skeleton would be increased in the femoral neck and total body. SP have already been shown to have excellent femoral neck BMD [3], and we thought because of the explosiveness needed at the hips during Olympic lifting that the same would be true of OL. PL and OL have already been shown to have higher lumbar BMD than controls [19, 20]. We also observed that the lumbar spine receives more compressive stress during power or Olympic lifting than in soccer. Therefore, we hypothesized that OL, PL, and SP would have significantly higher total BMDs than RA. We also surmised that both OL and SP would have a significantly greater femoral neck BMD than PL and RA. Finally, we believed that OL and PL would also have significantly greater lumbar BMD than SP and RA.

Materials and Methods

PARTICIPANTS

Forty-six premenopausal women who were 18 years and older participated in this study. Of these, only 37 of the participants' data were able to be used for this study. 11 women comprised the recreationally active control group, 10 were PL, 8 were OL, and 8 were SP. This study's method was approved by The University of Texas at Austin's Institutional Review Board. All participants were informed of all testing procedures and signed the formal consent for participation in research form. Athletes were recruited from local gyms and athletic clubs, as well as several exercise classes offered at The University of Texas at Austin.

All the women were healthy, and without any preexisting conditions that would inhibit them from exercise or cause their BMD to be negatively affected. Any women who reported taking medication whose side effects were known to affect BMD were excluded from the study. Those who were or may have been pregnant were excluded from the study as well.

The questionnaire covered injuries, medical conditions that affect bone health or the ability to be physically active, pregnancy, breastfeeding status, amenorrhea, birth control use, surgeries, medications, and competitive status. It also determined how much training the participant did by having the participant recall and write their average weekly exercise schedule. Competitive athletes had to have been training at least 9 months prior to the DXA scan in their specific sport.

A participant would be disqualified if they were breastfeeding because of postpartum effects on BMD [21, 22]. We did not exclude anyone for amenorrhea or for taking birth control. These variables have been included in BMD studies without affecting results [19]. Only 5 had amenorrhea, and of those 4 were included in the study. 18 participants were also on birth control, and of those 17 were included in the study.

RA could not have previously participated in any high-impact, or odd-impact sports either competitively or for more than 6 months from the age of 14 to the present [3]. If RA participants answered that they had been competitive in any sport or had competed in any of the sports in the study, then they were excluded from the study. RA were also to have no history of heavy training in any of the sports aforementioned. Four of the RA were excluded for having been athletes at some point from the age of 14 up, and 1 was excluded for having an eating disorder. Two people of an unknown group were excluded because they chose not to complete the questionnaire, one of which chose not to sign the consent form (she did not participate in the study). 1 of the PL was excluded for having an eating disorder, and another was excluded for being on a medication known to negatively impact BMD.

OL were significantly older than every other group ($p < 0.01$) (Table 1). SP were also significantly taller than RA and PL, but not OL ($p < 0.01$) (Table 1). None of the groups showed any significant difference in weight. All three competitive groups were also significantly leaner than RA with no significant differences between them ($p < 0.01$) (Table 1). SP by far had trained the longest since age 14, whereas the lifting groups usually were not active in their sport until they were closer to being adults ($p < 0.01$) (Table 1).

DXA SCANS

Participants had their height and weight measured with accepted methods in comfortable, athletic clothes with shoes removed. All measures of BMD and body composition were conducted using DXA with a GE Lunar iDXA (GE Healthcare, Chicago, IL with enCore^{TM} Software version 15). The DXA was also used to assess the participants' lean body mass, fat mass, and bone mineral content. Three scans were performed for each participant. A scan of their whole body, femoral neck, and lumbar spine. The participant chose their dominant hip which would be scanned [3]. The lumbar spine scan measured L1-L4.

STATISTICAL ANALYSIS

Anthropometrics, as well as total, femoral neck, and lumbar BMD were compared using one-way analysis of variance (ANOVA) with Tukey's post-hoc analysis. Weight was considered for use as a covariate, which can positively affect BMD [19]. In this study however, weight was not significantly correlated with BMD, therefore the decision was made to use ANOVA instead of ANCOVA. SPSS 22.0 (SPSS Inc., Chicago, IL) was used for all statistical analysis with an alpha level significance of $p < 0.05$ set a-priori. All data is presented as a mean ± standard deviation (SD) in the text.

Results

OL had significantly denser L2 ($p = 0.013$), L3 ($p = 0.006$), and L4 ($p = 0.004$) vertebrae than RA. When L1-L4 are averaged together, OL are the only group significantly denser than RA ($p = 0.004$). PL also had some significance in the lumbar area with L4 being denser than RA ($p = 0.025$). With total BMD, all 3 athletic groups were significantly denser ($p < 0.01$) than RA. OL were also shown to be significantly denser than PL ($p = 0.021$) in total body BMD as well. At the femoral neck, both OL and SP were shown to have a significantly higher BMD than RA ($p = 0.03$ and $p < 0.001$, respectively) (Fig. 1). Means with SD of each measured site's BMD are listed in Table 2. The BMD differences between each group are shown in Fig. 1.

Discussion

Our results showed that female Olympic weightlifters have higher BMD than power lifters for the total body, femoral neck, and lumbar spine. Also, every training group had a greater total BMD than RA. Both OL and SP were shown to have a denser femoral neck than RA. Therefore, our hypothesis was supported. However, there were no inter-group differences between the athletic groups, except where OL were denser than PL in total body BMD. PL also only showed limited significance in the lumbar spine, with only L4 being denser than RA.

Power lifting consists of the squat, deadlift, and bench press exercises, which are performed more slowly than Olympic lifts which will be described hereafter [18]. The proper types of exercise will load the desired parts of the skeleton and improve BMD at that specific site [23]. However, not all exercises are created equal. It all depends on where and how much load is applied. For instance, power lifting can improve lumbar and whole-body BMD [20], but it has not shown a significant effect on BMD at the neck of the femur [3, 20]. This could be due to power lifting providing compressive stress, but not enough odd-impact or high-impact forces. Soccer players, for example perform odd-impact maneuvers (rapidly changing directions, with quick starts and stops) and have significantly higher femoral neck BMD than controls. High-impact athletes also have great femoral neck BMD. High-impact examples would include sports like high-jumping and triple-jumping [3].

Odd-impact and high-impact sports may be superior to power lifting for a few reasons. First, the lifts are performed more slowly relative to odd and high-impact sports. Second, the rate of loading is much higher in odd and high-impact sports due to the higher velocities at which they are played [3]. In two studies involving postmenopausal women, power training was defined as doing basic resistance exercises more quickly (as fast as possible) during the concentric phase than a strength group which performed the concentric phase more slowly (4 sec.). The power group attenuated their bone loss significantly more effectively than the strength group [16-17]. This goes to further illustrate that doing lower body exercises with higher velocity increases the rate of loading. This is better for the femoral neck than slow, heavy power lifting.

Olympic lifts require speed and explosiveness that are seen in both ‘odd-impact’ and ‘high-impact’ sports [3]. Therefore, it may be postulated that Olympic lifting may provide significant improvements in femoral neck BMD. The lifts (the snatch and the clean and jerk) are very powerful, dynamic movements that involve taking a barbell from the ground to up above the head in a few seconds. This requires a very quick and explosive movement (seen in high-impact and odd-impact sports) to pull the weight up while simultaneously dropping the hips to catch the weight in a squat. Power is greater in Olympic lifting when compared to power lifting [18]. The rate of loading is also greater in Olympic lifting. This happens naturally with the increase in speed needed to complete the lift [3, 17].

OL have been shown to achieve greater performance than PL after just 4 weeks of training. A division three American football team was split into OL and PL that had to train for 4 weeks to see if there were any measurable differences. OL had a significantly greater vertical jump height performance ($p < 0.05$) than PL [18]. OL use more power and speed in their training which would help to explain this result. The lifts themselves are also very similar to jumping with weight. Indeed, some OL get both feet off the ground as they pull the bar up to get under the weight and catch it. Therefore, it could be argued that Olympic lifting is more power based and power lifting is less so.

Elite junior male OL who begin training at around 13-15 years of age have shown greater femoral neck and lumbar BMD than age-matched controls ($p \leq 0.05$) and an adult reference group ($p \leq 0.05$) [1]. Weightlifting at a young age may not totally prevent osteoporosis, but it certainly increases BMD and could possibly help prevent osteoporosis in the future [1]. Even retired, male OL from the ages of 27-54 maintained their BMD benefits that they gained from their earlier days of intense weightlifting. The retired OL had significantly higher BMD than their age-matched controls in lumbar ($p < 0.01$), total body ($p < 0.01$), and femoral neck ($p < 0.01$) regions. They included 19 retired OL and 26 controls [24]. Our results match these. Still, these studies were all studying men, and should be redone to show their effects on women as well. However, our study still clearly shows that when compared to female PL, female OL are going to have better results for the total body, lumbar spine, and femoral neck.

The increased power and loading rate have a direct effect on increasing BMD, and our study supports this observation as well. Our finding has not always been supported in female OL [19]. Still, another study like ours has shown female OL with significantly higher BMD than non-athletic controls. Studies indicate that females in both odd-impact and high-impact sports have higher mean BMD at the femoral neck than OL, but with no actual significant difference between them [19, 25]. The novelty of this study lies in showing that OL are superior to PL in regard to BMD.

Any exercise that employs the back extensors and the core enables the strengthened muscles to take pressure off the back and alleviate discomfort in osteoporotic patients who have had vertebral fracture(s) [26]. This reduction in pain could be due to the strengthened back and core muscles providing straighter posture, allowing the back pain to be reduced as it is better positioned to handle spinal compression and stress [26]. Power training has been shown to not increase and in some cases even decrease back pain in postmenopausal women [16-17]. Therefore, Olympic lifting or a doctor-recommended variation may be a good option to improve lumbar BMD and possibly relieve back pain in patients seeking relief.

To prevent hip fractures, odd-impact and/or high impact exercises should be part of the exercise intervention as well. Olympic lifting in combination with such exercises should be further examined to determine its viability in improving BMD in the postmenopausal population. It is never too late to improve BMD, even post-menopause [27]. Lifting programs have been shown to significantly improve BMD in postmenopausal women with and without hormone replacement therapy (HRT). However, the significant improvements were found in lumbar and femoral neck regions only with HRT [27]. Future interventions should focus on combining Olympic lifting and soccer-style exercises, with some postmenopausal participants on HRT and some that are not.

We must address certain limitations in this study. Firstly, no strength tests to compare the participants were used in this study. However, it seems to be type of loading rather than the amount of loading that seems more indicative of increased femoral neck BMD [3, 25]. For example, swimmers have been shown to put in tremendous work hours per week (19.9) with no significant BMD differences from the control group. Soccer and squash players who averaged 9.3 hours per week had significantly higher BMD in the lumbar spine and femoral neck than controls. This was because the type of loading in the two sports were very different, and swimming could not provide the necessary impact to improve BMD at those sites. [3].

In addition to the lumbar spine and femoral neck, future studies should also look at differences in the radius. This is because is another weak point that can break easily with the onset of osteoporosis [4]. OL have been shown to have significantly higher radial strength and BMD than controls [19, 28]. This probably is a function of the bending of the forearm that occurs during the catch phase and the summary push and balance of the weight above the head during the snatch and clean and jerk [28].

Tracking hours spent training and how many sessions were done per week would have also provided better insight into just how much training is needed to affect BMD [25]. However, training more hours alone does not clearly indicate a better BMD response. If bone is not properly stimulated, then it will not increase in BMD [3, 25]. Also, had we had more participants we could have possibly shown that weight, age, and height do correlate significantly with BMD and should act as covariates [3, 19].

In conclusion, Olympic weightlifting should be considered a superior alternative to power lifting to improve BMD for the total body, femoral neck, and the lumbar spine. To our knowledge, this is the first study to directly compare competitive PL's and OL's BMDs in the lumbar spine, femoral neck, and the total body. However, Olympic lifting does not have to be the only exercise used if the femoral neck is to be strengthened, as SP were not significantly different from OL. Odd-impact activities that involve cutting, sprinting, and frequent starts and stops with high acceleration such as soccer should be included to improve femoral neck BMD.

Tables

Table 1
Characteristics of the athletic groups (PL, OL, and SP) and the control group (RA) (mean and S.D).

	Recreationally Active (n=11)	Power Lifter (n=10)	Olympic Lifter (n=8)	Soccer Player (n=8)	P value (F)
Age (years)	22.09 (4.48)^{c}	23.70 (5.60)^{c}	33.13 (11.12)^{a,b,d}	20.25 (3.01)^{c}	0.002 (6.312)
Height (cm)	158.31 (4.51)^{c,d}	161.06 (5.53)^{d}	165.71 (4.97)^{a}	170.04 (5.37)^{a,b}	<0.001 (9.452)
Weight (kg)	58.96 (10.96)	68.58 (32.74)	69.75 (13.31)	65.10 (8.19)	0.607 (0.620)
Body fat (%)	35.07 (6.03)^{b,c,d}	26.63 (3.89)^{a}	26.63 (4.21)^{a}	27.01 (3.10)^{a}	<0.001 (8.535)
Sport-specific training since age 14 (years)	0 (0)^{c,d}	2.38 (1.27)^{d}	3.91 (2.93)^{a,d}	8.25 (3.01)^{a,b,c}	<0.001 (26.041)

Superscripts indicate a significant ($p < 0.05$) mean difference between groups as follows:
^{a}Significantly different from RA
^{b}Significantly different from PL
^{c}Significantly different from OL
^{d}Significantly different from SP

Table 2
BMD of the athletic groups (PL, OL, and SP) and the control group (RA) (mean and S.D).

Site of measurement	Bone Mineral Density (g/cm^2)			
	Recreationally Active (n=11)	Power Lifter (n=10)	Olympic Lifter (n=8)	Soccer Player (n=8)
Lumbar spine (L1-L4)	1.16 (0.08)	1.30 (0.13)	1.37 (0.11)	1.30 (0.16)
L1	1.10 (0.09)	1.20 (0.16)	1.26 (0.11)	1.21 (0.17)
L2	1.16 (0.08)	1.29 (0.17)	1.36 (0.10)	1.30 (0.17)
L3	1.24 (0.10)	1.36 (0.12)	1.45 (0.11)	1.37 (0.17)
L4	1.15 (0.09)	1.33 (0.14)	1.40 (0.15)	1.30 (0.17)
Total BMD	1.07 (0.07)	1.19 (0.08)	1.30 (0.07)	1.23 (0.07)
Femoral neck	0.97 (0.97)	1.09 (0.16)	1.12 (0.09)	1.21 (0.10)

Figures

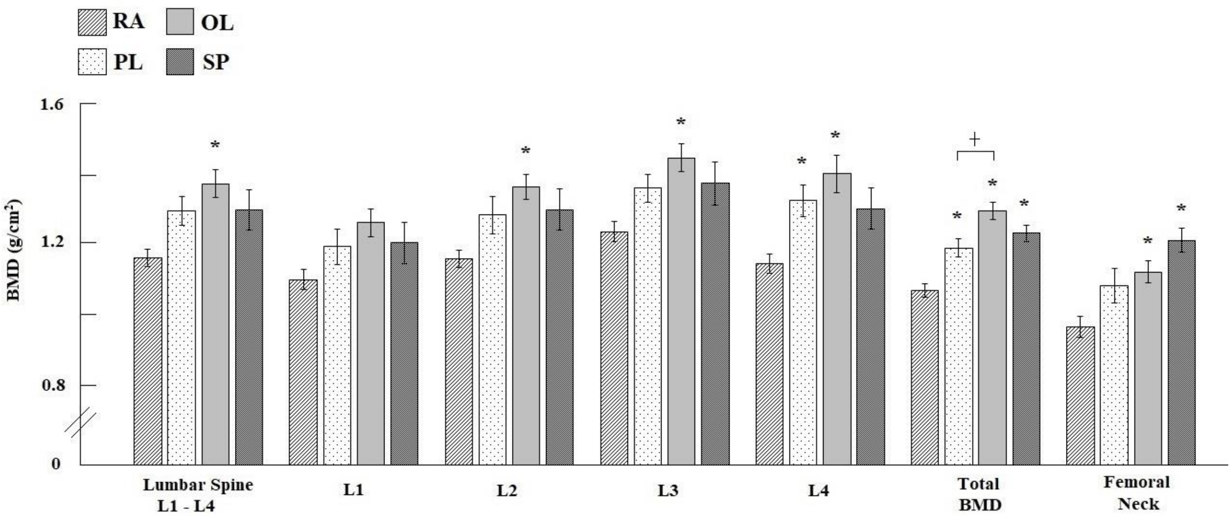

Fig. 1 Actual BMD values of the competitive athlete groups (PL, OL, and SP) and from the control group (RA). * indicates the group had greater BMD than RA ($p < 0.05$). ┼ indicates that OL had greater BMD than PL ($p < 0.05$)

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