Spring 2016

Total and Regional BMD Comparison of Collegiate Male and Female Athletes

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Honors Research Project: Final Paper

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Introduction

Bone mineral density (BMD) is a measure of density of bone that provides researchers with an idea of how dense a particular bone, region, or skeleton is relative to a sample size or to a standardized population[4]. Certain tests that measure the density of bone are clinically important for determination of osteoporosis or other bone degenerative diseases. For researchers, it can help identify risk factors or preventions for bone loss. Dual-energy X-ray absorptiometry (DEXA or DXA) scan is a full body device that passes low dose X-rays through the entire body[4]. These scans can be used to identify patients that have a potential risk of fracture, to monitor treatment progression, to determine if patients have osteoporosis or other bone degenerative diseases[4]. DEXA is a more precise measurement of BMD than other techniques, including advantages like short scan times, low radiation dose, rapid patient setup, and stable calibration[4]. BMD increases during childhood until peak mass is achieved[2], generally peaking somewhere around midlife or the age of thirty [10].Therefore, maximizing bone mass throughout early development is an important prevention of osteoporosis later in life[2]. Wolff's law describes how bone adapts through loads or stresses that it is placed under[1] and the theory of minimum effective strain stimulus (MESS) describes a minimum level of mechanical loading required to produce a significant increase in BMD[2]. Both of these theories are the basic ideas and foundation on which bone acquisition occurs. In addition, mouse models have shown that high impact, irregular loads in multiple planes and slower rest cycles are more effective at increasing bone mass than low impact, regular, one dimensional loads[1]. These types of loads are typically found in ball sports (soccer, basketball, volleyball) where high impact, irregular, multiplanar forces are included whereas endurance sports (running and cycling) produce regular, repetitious, lower impact forces[1,8].

Shown in previous studies, runners and swimmers can have lower BMDs than athletes in ball sports or inactive controls[1]. Swimmers experience less load forces and don't stimulate the bone enough to trigger bone mineral acquisition[1]. Even though runners have a more repetitious and regular pattern of forces runners, still see increased BMD in their legs than inactive controls[1]. The purpose of this research is to add to and replicate previous studies on BMD in athletes to better understand how certain sport specific exercise promotes bone acquisition. This is key into understanding how to prevent osteoporosis later in life. Based on previous research, we hypothesize that soccer players will have the highest total body BMD followed by running and swimming. Additionally, soccer will have the highest BMD in the lower regions (legs and pelvis) followed by running and swimming having the lowest.

Methods

Subjects:

Athletes were recruited from the University of Akron main campus via word of mouth and email. The athletes ranged from 18-25 years old with 15 male (n=15) and 36 female (n=36) athletes. Total sample size was 51 athletes (n=51). Other athletes were scanned from sports including weight lifting, basketball, and track and field, but sample size from those sports were too low to be included in this study. Inclusion criteria for a group consisted of having a sample size of at least 10 athletes in that group. Athletes in endurance running, soccer, and swimming were on the University of Akron's cross country, soccer, and swimming teams (NCAA Division I). The endurance runners were scanned in the month of January during the indoor track season and all runners were distance athletes also on the cross country team. The soccer team was scanned during the months of February and March in their offseason. The swim team was scanned in March just after their tournament postseason. All athletes were scanned based on convenience and did not have scientific relevance to the timing of the scan. The subjects were asked to sign an informed consent and were allowed to stop the scan or revoke their participation in the study at any time. All subjects volunteered for the study and did not receive compensation. This study was approved by The University of Akron IRB.

DEXA (Dual-Energy X-ray absorptiometry):

DEXA (Lunar Prodigy, Madison, WI) was used to measure bone density. DEXA uses low energy X-rays to view bone density. The radiation dose is low (1/10th of a typical X-ray and much less than a CAT scan) and risks associated are the same as any other X-ray device. The athletes were instructed to wear proper clothing during the scan, such as sweatpants, athletic shorts, and a t-shirt. All metal and jewelry were requested to be removed. Age and gender were self-reported by the participants, all other data was generated from the DEXA scan. The scan was performed by a State of Ohio GXMO licensed professional. Total and Regional BMD data were collected from the DEXA output. Trunk and rib regional data was not reported because the trunk isn't a useful average of other regions for this study and the ribs are not a load bearing structure of the skeleton.

Statistics:

Data was collected from the output of the DEXA machine, only age and gender were self-reported. Results are reported as mean and standard deviation. One-way ANOVA was used to analyze differences between groups in total and regional BMD and Tukey post hoc testing completed (Minitab 17, Stage College, PA, Minitab Inc.). Significance was considered when $p < .05$ and Tukey's post hoc comparison of 95% confidence intervals did not contain zero.

Results:

Average descriptive characteristics of the athletes are summarized in Table 1. Total sample size was 51 athletes (n=51) broken down into 4 groups as shown in Table 1. The average age for all of the sports was approximately 20 years old.

Table 1 Descriptive Characteristics of Athletes						
Main Sport	Sample Size	Age	Weight (lbs.)	Height (cm)	Lean Mass (lbs.)	% Body Fat
Men's Endurance Running	15	20 ± 1.30	149.70 ± 16.16	179.8 ± 5.90	128.78 ± 14.91	9.4 ± 3.8
Women's Endurance Running	11	20 ± 1.21	119.15 ± 8.57	167.2 ± 4.62	89.73 ± 7.33	21.8 ± 3.1
Women's Soccer	11	20 ± 1.21	142.66 ± 9.25	170.3 ± 3.66	90.31 ± 25.31	28.54 ± 4.7
Women's Swimming	14	20 ± 1.28	138.75 ± 12.76	168.2 ± 7.88	103.83 ± 9.75	23 ± 3.6

Table 1, Descriptive characteristics of athletes, values are reported as a mean ± standard deviation.

Table 2 shows the total and regional BMD for each sport. Regional BMD included the arms, legs, pelvis, spine, and head. The values for arms and legs are averages of the left arm and right arm, and left leg and right leg computed by the DEXA. Men’s endurance running (1.256 g/cm^2, 0.948 g/cm^2, and 1.529 g/cm^2) was significantly higher than women’s endurance running (1.187 g/cm^2, 0.828 g/cm^2, and 1.351 g/cm^2) in total BMD, arms, and legs. Also, men’s endurance running (1.529 g/cm^2) had significantly higher BMD in the legs than women’s soccer (1.427 g/cm^2) and women’s swimming (1.293 g/cm^2). Women’s swimming (0.912 g/cm^2) was found to have higher BMD in the arms than women’s endurance running (.828 g/cm^2). Women’s soccer (1.427 g/cm^2 and 1.356 g/cm^2) had a higher BMD in the legs and pelvis than the women swimmers (1.293 g/cm^2 and 1.228 g/cm^2) and higher pelvis than the women’s endurance runners (1.221 g/cm^2). No significant difference was found between any of the sports for spine and head regional BMD.

Table 2 Total and Regional BMD						
Main Sport	Total BMD	Arms	Legs	Pelvis	Spine	Head
Women's Swimming	1.187 ± .066	.912 ± .961†	1.293 ± .051*□	1.228 ±.103□	1.094 ± .089	2.176 ± .259
Women's Endurance Running	1.187 ± .031*	.828 ± .029*	1.351 ± .029*	1.221 ± .074□	1.041 ± .045	2.187 ± .199
Men's Endurance Running	1.256 ± .088	.948 ± .081	1.529 ± .113	1.282 ± .117	1.037 ± .084	1.974 ± .283
Women's Soccer	1.246 ± .062	.888 ± .058	1.427 ± .059*	1.356 ± .128	1.124 ± .130	2.220 ± .240

Table 2, Total and Regional BMD, data is the mean ± standard deviation. All BMD values are g/cm^2.

* Significantly different from men's endurance running

†Significantly different from women's endurance running

□ Significantly different from women's soccer

Discussion:

The purpose of this to study was to replicate and add to previous research on BMD in athletes. Our findings demonstrate that there is no significant difference in total body BMD in women's endurance running, swimming, or soccer. Men's endurance running did show a significant difference compared to the women, but men have a larger total body BMD than women[9].Women's swimming was found to have significantly higher arm BMD than women's running. This finding was interesting because there was no difference between total body BMD between the runners and swimmers. This finding was not supported in any other research. It is possible that the increase could be from the specific training that the swimmers could be doing. It is important to note that none of the swimmers scanned in this study were also divers which could skew the arm data; all were specific to swimming. Additionally, there is no significant difference between the legs of the women's endurance running and women's swimming group. Women's soccer was found to have a significantly higher leg BMD than women's swimming, supporting previous research that shows that soccer has a positive effect on BMD[3] .Women's soccer was also found to have significantly higher BMD in the pelvis than women's running and swimming. These findings show that soccer and soccer specific training may be beneficial to the BMD of the pelvis and legs. There was no significant difference between any of the groups in the area of the spine and head. The head region is known to be used as a control in other studies because across sports there is no statistical difference in BMD as supported here[2].

In comparison to other studies done in this field, the total body BMD from the men's endurance running group was slightly higher than a study done by Fredericson et al. 2007 with the same sample size(n) and same age group. The data from women's endurance running group showed higher total BMD and higher leg BMD than a study from Mudd et al. 2007, but that study had a larger sample size. In the soccer and swimming group this study showed higher total and regional BMD values than the Mudd et al. 2007 study with a larger sample size (n) in this study. Compared to the Narasi et al. 2015 study, the men's endurance running group seemed to have higher total BMD and higher regional BMD in the legs and arms than their sedentary controls. In the Narasi et al. 2015 study, they used different men for their test subjects and sedentary controls. The women's endurance running and swimming group seemed to show no difference in total BMD than sedentary controls from the Fredericson et al. 2007 study; no regional data was available from this study. Previous studies have stated that running confers no benefit to BMD, this study may show that there may be a slight benefit for males running due to BMD being higher in the male endurance athletes than the sedentary controls from other studies [6]. The data for the women support other studies that show that the sports of running and swimming show no benefit to BMD[6].

Obtaining and maintaining peak bone mass is important in the prevention of osteoporosis later in life[2]. Maintaining optimal bone mass throughout a person's lifetime through adequate bone loading activities can prevent osteoporosis and other bone degenerative diseases[2]. Based on the results from this study, as well as other studies it would seem that soccer players show to have the highest BMD in total as well as regional in the legs. For these areas soccer may be an optimal sport and activity to prevent bone loss later in life or to gain BMD. The actions in the sport must meet the MESS law[2] and Wolff's law[1] in order to observe bone acquisition.

Further study into the activities best suited for older patients who may be at risk for osteoporosis is needed in order to intitate exercise protocols for them. These studies should consider nutritional, hormonal, and genetic influences into the factors for exercise prescription as well as a large sample size. In conclusion, this study replicates and adds to research previously completed. We showed that running may have a slight benefit in men's BMD, but not in women's and that running and swimming have similar BMDs to that of sedentary control groups from other studies, supporting previous work done.

Limitations

Limitations in this study are extensive due to the level and nature of this research. There is possible selection bias to those genetically predisposed to have higher bone density for their sport and may be more likely to be athletes. In addition the findings in the sample athletes may not be able to be generalized to athletes of all competition levels such as recreational athletes. For the females involved in this study contraception information, cycling information, hormonal data, and nutritional data was not obtained. Likewise for the men, nutritional and hormonal data were not obtained. These factors may affect the BMD that was found in these athletes. The sample size was limited to the sports reported in this study due to time constraints and scheduling constraints for both the licensed scanners and the athletes. Training schedules for the athletes were unable to be obtained from the coaches of the athletes due to non-communication from the coaches on this subject. BMD may not be the best predictor of bone health as recent research states, bone quality may be a better indicator which includes parameters like tissue architecture, turnover, microfracture, and mineralization[5]. As of now, bone quality studies are too invasive to be done on humans[5].The DEXA was not programmed to scan for more specific regions of the body such as specific bone sites (tibia, femur, calcaneus, etc.), this would provide more accurate reflection of where the highest BMD is at and truly which sport is most effective at bone acquisition in certain bones.

Acknowledgements:

I would like to thank Dr. Otterstetter for being my research mentor, scanning athletes, and being a reader for this project; Rachele Kappler for scanning athletes and being a reader; Dr. Holda for sponsoring this project and offering useful input; The Williams Honors College for the opportunities of the honors projects.

References:

1. Scofield, K. L., & Hecht, S. (2012). Bone health in endurance athletes: runners, cyclists, and swimmers. Current Sports Medicine Reports, 11(6), 328-334. doi:10.1249/JSR.0b013e3182779193
2. Morel, J., Combe, B., Francisco, J., & Bernard, J. (2001). Bone mineral density of 704 amateur sportsmen involved in different physical activities. Osteoporosis International: A Journal Established As Result Of Cooperation Between The European Foundation For Osteoporosis And The National Osteoporosis Foundation Of The USA, 12(2), 152-157.
3. Fredericson, M., Chew, K., Ngo, J., Cleek, T., Kiratli, J., & Cobb, K. (2007). Regional bone mineral density in male athletes: a comparison of soccer players, runners and controls. British Journal Of Sports Medicine, 41(10), 664-668.

4. Blake, G. M., & Fogelman, I. (2007). The role of DXA bone density scans in the diagnosis and treatment of osteoporosis. Postgraduate Medical Journal, 83(982), 509-517.
5. Huang, T., Chang, M., Chen, K., S., S., & Yang, R. (2011). The Effects of Endurance Running Training on Young Adult Bone: Densitometry vs. Biomaterial Properties. Biomaterials - Physics and Chemistry.
6. Nasri, R., Hassen Zrour, S., Rebai, H., Neffeti, F., Najjar, M. F., Bergaoui, N., & ... Tabka, Z. (2015). Combat sports practice favors bone mineral density among adolescent male athletes. Journal Of Clinical Densitometry: The Official Journal Of The International Society For Clinical Densitometry, 18(1), 54-59. doi:10.1016/j.jocd.2013.09.012
7. Mudd, L. M., Fornetti, W., & Pivarnik, J. M. (2007). Bone Mineral Density in Collegiate Female Athletes: Comparisons Among Sports. Journal of Athletic Training, 42(3), 403–408.
8. Nebigh, A., Rebai, H., Elloumi, M., Bahlous, A., Zouch, M., Zaouali, M., & ... Tabka, Z. (2009). Bone mineral density of young boy soccer players at different pubertal stages: relationships with hormonal concentration. Joint, Bone, Spine: Revue Du Rhumatisme, 76(1), 63-69. doi:10.1016/j.jbspin.2008.03.002
9. Nieves, J. W., Formica, C., Ruffing, J., Zion, M., Garrett, P., Lindsay, R., & Cosman, F. (2005). Males have larger skeletal size and bone mass than females, despite comparable body size. Journal Of Bone And Mineral Research: The Official Journal Of The American Society For Bone And Mineral Research, 20(3), 529-535.
10. Kenney, W. L., Wilmore, J. H., Costill, D. L., & Wilmore, J. H. (2012). Physiology of Sport and Exercise. Champaign, IL: Human Kinetics, (17), 428.