Spring 2016

Factors Affecting Injury History and Their Overall Impact on Athletic Performance in Distance Runners

Trevor Norris
University of Akron, tan19@zips.uakron.edu

Factors Affecting Injury History and Their Overall Impact on Athletic Performance in Distance Runners

Trevor Norris

Abstract

Distance running is a very precise mechanism of many intricate movements and abilities of the body. The amount of miles that a distance runner must run puts a lot of very intense stresses on one's body. These stresses often appear at the bone level and lead to many injuries such as stress reactions and stress fractures but also may play important roles in tissue damages such as strains and pulls. In this study, we used division one college distance runners and examined many intricacies between their level of fitness and overall composition. These include looking at imbalances, dominant traits, and body composition. Our main points of emphasis were injuries, bone mineral density, body fat percentage, and Max VO2. These were investigated by the use of Dexa scanning and the performing of a max VO2 test. Our findings concluded that significant differences were seen between the BMD of men and women collegiate runners (p-value=.0154). Body fat percentage causes a decrease in BMD as it increases and plays a significant role in the amount of injuries one experiences (both p-value's<.001). Lastly, both body fat percentage and BMD play a significant factor in VO2 max (both p-value's<.001).

Introduction

Distance running is a challenging balance of how much stress to put on the body. This stress can be applied to many different areas but for this study that applied to the bones is of interest. Bone mineral density (BMD) is a measure of the density of a bone that provides one with an idea of how dense a particular bone or region is. Such information of BMD can help predict the likelihood of future injury. Dual-energy X-ray absorptiometry (Dexa) scan is a full body scanning tool that is used to find these readings of BMD. Dexa scans provide precise measurements of BMD as well as providing other advantages like short seven-minute scan times, quick easy setup, and a low exposure of radiation. Though Dexa's are good tests of composition for performance, a common technique seen throughout literature is a VO2 max test. A higher score on a max VO2 tests suggests a higher overall aerobic capability of the athlete. This test was selected because our sample being examined were division one college distance runners for the cross country and track teams at the University of Akron.

In an article by Stewart, it is concluded that running indeed causes a gain of bone mineral density and increased bone turnover compared to that of non-runners (Stewart, 2000). This would suggest that runners should be at less risk by the increased activity do to the increased density of their bones. This implies then that there must be a time when the stress applied must not equal the gain of the bone minerals. In the article by MacDougall, they find that with runners of over 20 miles/week the amount of bone density in the lower legs actually decreases but tibia and fibula densities normalized for weight still showed increases (MacDougall, 1192). I believe this article hints at the idea that for each runner there is a point where the stress level trumps that of the gain of density. Research also suggests that BMD can decrease as well. This research suggested that running can overall decrease the amount of BMD seen at the lower vertebratal (Bilanin, 1989).

Furthermore, the amount in which one person possesses imbalances or carries extra weight may apply more stress upon these things. Such suggestions are validated by the paper by Hsu et. al. Fractures were higher for those with an increase in body fat percentage and this had a negative effect on bone density (Hsu, 2006). This makes sense as carrying extra weight can mean more force being applied to your legs when pushing off the ground to run.

The purpose of this paper is to find out more information on why injuries happen as well as implications upon performance of these athletes. By looking at the combination of BMD, body fat percentage, imbalances, and dominant features we hope to better understand the links between these. We would hypothesize based on previous research the following information: a low bone density will result in a greater number of injuries for our sample. These bone densities though will be greater for men than for women. We also hypothesize that one's dominant leg will lead to to higher bone density and that this will lead to seen imbalances between a person's two legs. An increase in body fat percentage will also be correlated to an increase in injuries and one of the reasons investigated will be because of a proposed increase in body fat percentage resulting in a decrease in total bone density. When it comes to performance based upon prior research, we hypothesize that body fat percentage will have a negative effect on performance while one would hypothesize that a higher bone density will provide a higher max VO2.

Methods

Sample
For our sample we were able to contact and arrange testing for the University of Akron Cross Country teams. The study was reviewed and approved by the IRB at The University of Akron. We used both men and women's teams (n=24). Therefore 13 men (n=13) were used and 11 females (n=11). Below are the mean values for the groups.

	Sample Size	Age	Weight (lbs.)	Height (cm)	Body Fat (%)	Max VO2 (ml/(kg*min)	BMD (g/cm2)	Number of injuries
Men Athletes	13	20	150.65	179.275	8.692	69.469	1.258	2.1538
Women Athletes	11	20	119.17	167.1	21.009	52.267	1.179	0.9

Table 1: Shows the means for each group in the respective men and women athlete groups.

Survey
Each participant when arriving took a survey that stated their dominant side as well as their injury history.

Dexa Scan
Dual-energy X-ray absorptiometry (Dexa) scan is a full body scanning tool. Participants were weighed in kilograms. They then preceded to have the Dexa scan done over a period of seven minutes. The Dexa Scan relies on the use of two x-ray beams of different energy levels. One of these beams is high energy while the other is low. The x-rays of each beam pass through the bone and vary based upon the thickness of the bone. Based upon the difference between the two

beams the bone density can be measured. The Dexa scan also provides body fat percentage readings. This is obtained by measuring the amount of fat tissue (lbs.) and dividing it by the amount of tissue (lbs.).

<u>VO2 Max Test</u>

Participants were set up with a heart rate monitor and a VO2 mask. Participants warmed-up for a stage of four minutes at 7.5 mph and then began the testing protocol that consisted of incremental stages at a consistent speed of 8.9 mph at 0% grade and increasing by 2% in grade every two-minutes. The subjects were verbally encouraged to give a maximal effort and the test was terminated once volitional fatigue was achieved. Subjects wore a Korr face mask (Korr VO2 mask, Korr Medical Technologies, Inc., Salt Lake City, Utah) to continuously analyze pulmonary gas exchange variables throughout the test using a metabolic cart (ParvoMedics TruOne 2400, WebWorx Technology, Sandy, Utah) as well as a heart rate monitor (Polar FT1 Heart Rate Monitor, Polar Electro Inc., Lake Success, New York). The tester asked participants during the test how they are feeling on a scale of 1-10 and are asked to answer via their fingers. This allows us to maintain some idea of where each participant is effort wise. Meanwhile data is being recorded on the computer for heart rate, VO2, RER, etc. Once the participant feels they have reached a maximum effort they are told to grab on to the handle of the treadmill. We then disconnect the mask from the participant and they preceded to cool down for their four minutes.

<u>Data Analysis</u>

Data analysis was done by the compiling of the data from the Dexa machine, the survey, and metabolic chart. Running of various statistical evaluations of the data and presenting them in the following graphs followed. Two sample t-tests were used for the analyzing of differences between differing variables such as BMD, Body Fat Percentage, Max Vo2, and Gender. A chi-square statistical analysis was done between the groups of dominant side and whether that side was denser than that other leg. P-values were considered significant when $p<.05$.

Results

The first part of the results will be focused on the link between bone density and injuries. Each separate part of the results will be devoted to by the underlining, italicizing, and bolding of the section.

Bone Density and Injuries

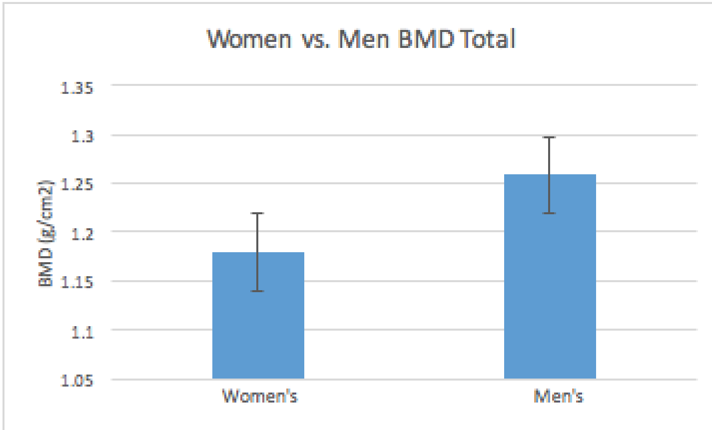

Figure 1: Men's and Women's total BMD is shown above.

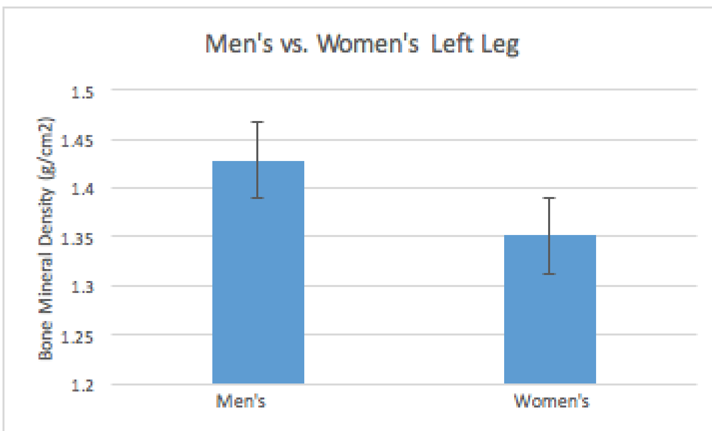

Figure 2: Men's vs. women's left leg bone mineral density was compared.

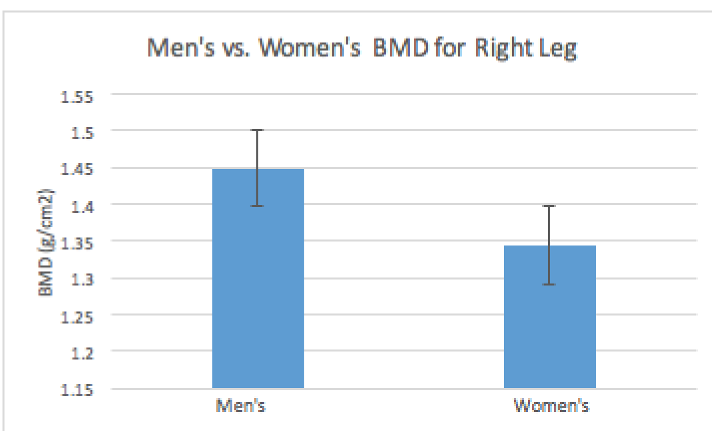

Figure 3: Men’s and Women’s Right legs were compared.

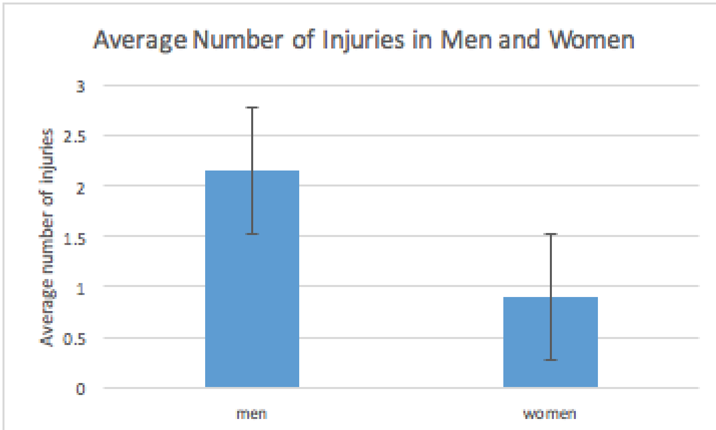

Figure 4: The relationship between men and women and injuries is explored above.

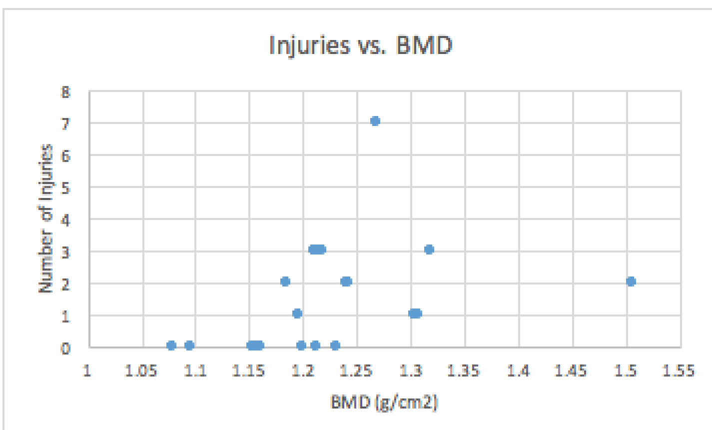

Figure 5: Above shows the relationship between injuries and BMD.

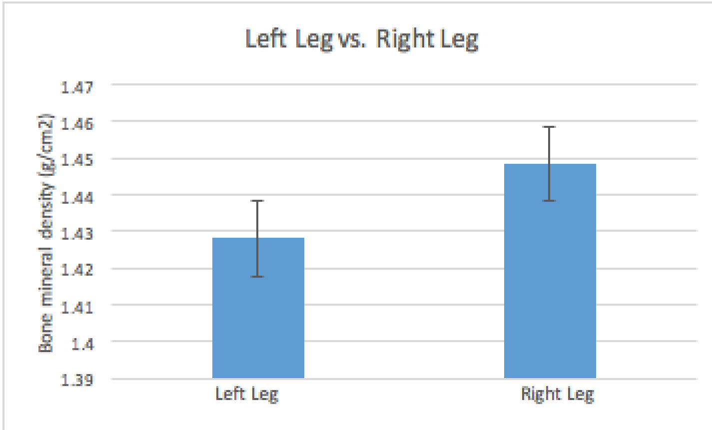

Figure 6: Left vs. right leg bone mineral density for the whole group are shown above.

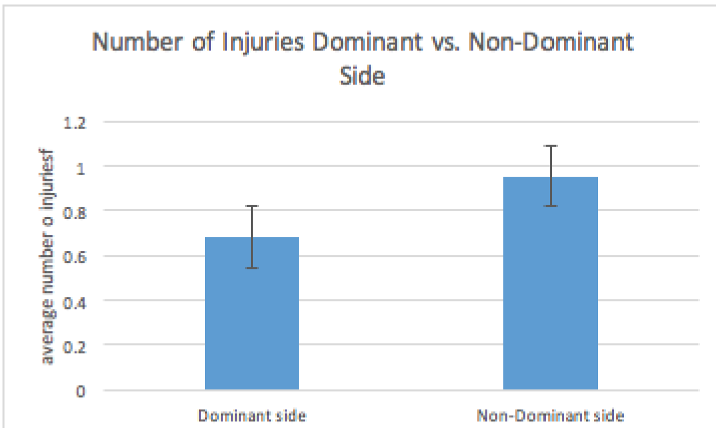

Figure 7: Above investigates the relationship between Dominant side injuries vs. Non-Dominant side injuries.

Observed			
	right	left	total
Non-dominant higher	11	2	13
dominant higher	8	1	9
total	19	3	22

Expected			
	right	left	total
Non-dominant higher	10.777	2.2557	13.0327
Dominant higher	8.225	0.8147	9.0397
total	19.002	3.0704	22.0724

Table 2: The above tables are data for the comparison between the dominant leg and whether the dominant leg is higher in BMD.

<u>Link Between BMD and Body Fat</u>

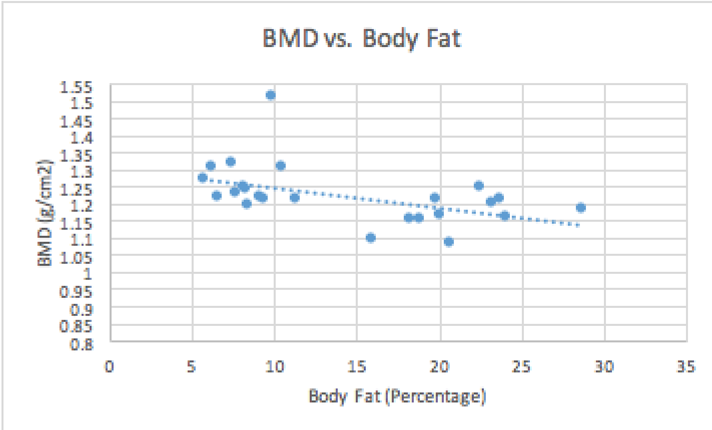

Figure 8: The above shows BMD vs. Body Fat for the whole sample together.

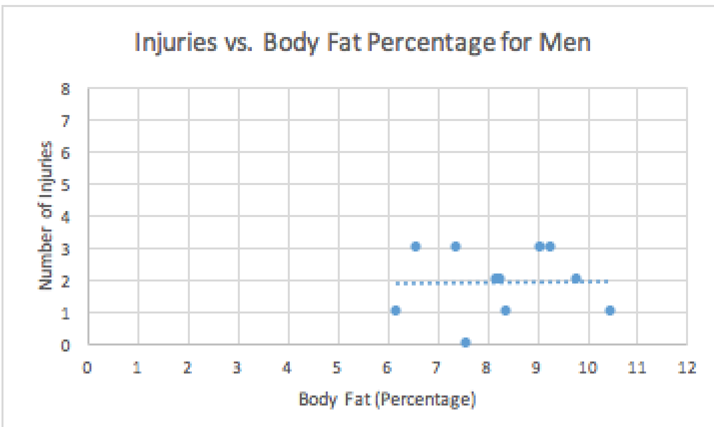

Figure 9: The relationship between injuries and body fat percentage is shown above for men.

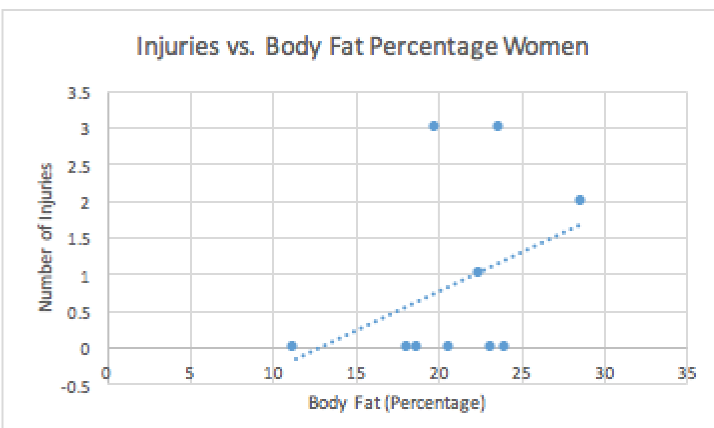

Figure 10: This shows the relationship between body fat percentage and injuries in women.

Implications upon Performance

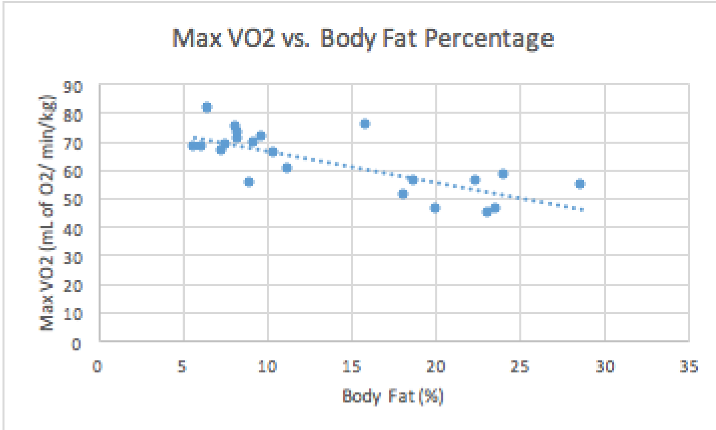

Figure 11: Body Fat Percentage effect is investigated in regards to Max VO2 testing.

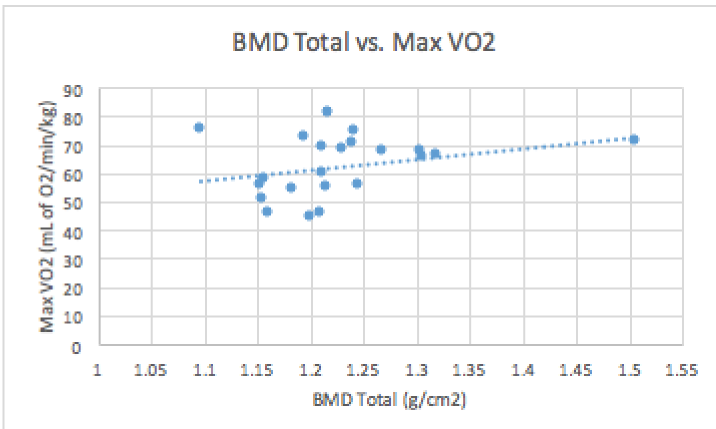

Figure 12: BMD total was investigated vs. Max VO2.

Discussion

The idea that injuries can be prevented as well as performance can be dictated by certain traits is very influential in the general scheme of a sport. In this paper we started at BMD. In doing so we first took a further look into our sample.

As can be seen in the above graph (Figure 1), the women's average was 1.179 g/cm2 while the average for the men is 1.2582 g/cm2. This led to a significant difference between the two groups (p-value=.0154). For our study, it was found that men had a significantly higher bone mineral density than that of females. One would hypothesize that this difference is caused by increased body fat percentage as indicated in this study in figure 8. This is one of probably many reasons that should be further explored. Others that could be further looked into rely on that of hormone production as well as bone repair mechanisms.

To confirm the prior report of men and women differences in BMD, we compared both right and left leg BMD readings between men and women. The result (Figure 2 and 3) provided us with further proof that our hypothesis was true. In figure 2, the average of the men was 1.4281 and for women was 1.3510, g/cm2 respectively. The difference between these two groups was significantly different (p-value=.0042). In figure 3 these were further represented by the men's average of 1.4485 g/cm2 and the female's of 1.3439 g/cm2. There was evidence of these two groups being significantly different (p-value=.00008) as well. This proves part of the hypothesis that women have indeed lower bone density than that of men. This falls in line with previous research done (Lane, 1986).

Male injury numbers vs. female injury numbers (Figure 4) were investigated do to the significant difference seen in the BMD between men and women (Figure 1). When examine though data resulted in no significant difference (p-value=.066). Our hypothesis of women having more injuries came back false in this data set and almost at a significant difference level (p-value=.066). For this when looking at the data one would strongly recommend this to be re-explored using a much larger data set as many of the women used in this study had very few injuries to record. This doesn't really line up with other results found in this study and therefore if given more time and participants one would look in greater detail.

Injuries and BMD were examined again to determine what if any role the BMD played in injuries (Figure 5). This testing resulted in no significant difference between the two groups (p-value=.3514). Although the results came back as insignificant one would again advise the use of a larger population as the women population could be troublesome for this investigation.

A source of injuries can be imbalances. Imbalances were thus examined as a probable cause of injuries (Figure 6). We examined if there was an imbalance between that of the left leg vs. that of the right leg since runners were indeed the sample and many of their injuries occur in this area. The average of the group was 1.4281 and 1.4485 g/cm2 for the left and right leg, respectfully. This data was not significant between the two groups (p-value=.5968). Further analysis of left vs. right legs were broken down within the sample for men and women. Both groups resulted in p-values that represented an insignificant difference within each group. When comparing the difference in legs no significant difference was found.

The idea of Dominant sides (what side is favored or best used by the participant) was then investigated in relation to both injuries and BMD. This was investigated due to further expand on the idea of different legs maybe playing a role in each situation physiologically. The first step of this was to compare that of the number of injuries experienced on the dominant leg compared to that of the non-dominant one (Figure 7). This came back as no significant difference between the two amounts of injury (p-value=.40). The idea was then explored that although there was no difference in injuries, we wondered if possible favoring of a dominant leg would cause an increase in BMD. When explored using a chi square test the result came back as no significant difference (Table 2) between the two groups (p-value=.774). Therefore, there is no significant difference between the dominant side of the body and having a higher BMD on that side.

Runners and athletes alike are always curious about their body fat percentage. Thus, body fat percentage was tested against that of BMD (Figure 8). A significant difference was seen between the two variables (p-value<.0001). Along with this the trend line displayed on the graph helps to show the relationship between the two variables. As the body fat percentage increases the BMD decreases. These relationships were then further looked into within the subpopulations of men and women. The same relationship held true and both groupings resulted in significant differences (men’s p-value<.0001 and females p-value<.0001). A difference was found between the groups with the general trend showing that increasing body fat percentage decreased BMD. This holds true with what previous reports suggested (Hsu, 2006). When looking closely at the data the difference is more apparent in females. This is hypothesized to be do to the cause of the increase in estrogen production from adipose tissue in females (Felson, 1993).

Since the trend was examined we were curious how many injuries were seen in comparison to body fat percentage levels. In figure 9 and 10, we see the results for this comparison for the subpopulations of men and women. In figure 9, There was a significant difference between the two groups (p-value<.01). The general trend shows slightly that as you increase body fat there is an increase in the number of injuries. In figure 10, There was a significant difference observed between the two groups for women (p-value<.01). The general trend of the relationship shows that as body fat percentage increases the number of injuries increases. This is hypothesized to be because of the increase pounding on the legs caused by the carrying of more weight and fat tissue. These trends may become more apparent if the sample size could again be enlarged.

The most important thing for athletes is their ability to perform though. Thus, both BMD and body fat percentage were explored for links to performance. In BMD, a significant difference was seen (Figure 12). The above graph is for the whole sample. With this, the general trend was as BMD was increased an increase in VO2 max performance was seen. A significant difference was recorded (p-value<.0001). The same difference was seen for both the men and women results as well. The general trend shows that as bone density is increased Max VO2 is increased as well. One would hypothesize that this would be the case because with increased BMD you are less susceptible to injuries. This would lead to increased training and an ability to consistently build without having to take long periods of time off where one's fitness level would go down. With body fat percentage (Figure 11) a significant difference was also seen. The results showed a significant difference for the whole sample (p-value<0.0001). The subpopulations examined separately for both men and women both again showed difference (p-value<.0001). The general trend as seen above by the line held true for both the men and women. The general trend for this relationship was as body fat percentage increased your VO2 max decreased. This is further exemplified where in basic training in the army the aerobic output during basic training is 3.7% and 10.5% increased with lower body fat percentages (Patton, 1980). This means that as body fat is decreased the aerobic performance increases.

<u>Conclusion</u>

Therefore, one would conclude that there are many important interrelationships between body fat percentage, BMD, injuries, and VO2 max. Our findings concluded that significant differences were seen between the BMD of men and women collegiate runners (p-value=.0154). Body fat percentage causes a decrease in BMD as it increases and plays a significant role in the amount of injuries one experiences (both p-value’s<.001). Lastly, both body fat percentage and BMD play a significant factor in VO2 max (both p-value’s<.001).

Limitations

Limitations for this study have various points of study. First we must acknowledge the overall genetic predisposition that some may have for overall higher bone density. Nutritional habits as well as hormonal levels for each participant may also be variable. All these above could effect BMD. For the VO2 max testing, these athlete's previous days of activity were not recorded or looking into. Therefore, their level of maximal effort could be different depending on the level of training heading up to the events. The masks could also serve as a limiting factor of the tests because of its uncomfortable nature compared to what each participant is used to when running normally. The number of people in the study was specifically limiting and talked about previously inside of the discussion. A larger sample may help with the injury set of data specifically in the women section.

Acknowledgements

One would like to thank all the readers of this paper specifically Dr. Otterstetter, J.T. Olson, Dr. Pinheiro, and Marissa Baranauskas. The experience spent running these tests presented a great opportunity to not only learn but explore areas that were at the time outside my comfort zone in research. Each served and instrumental role and I can't thank them enough. So to them and everyone else I didn't mention Thank You.

References

Bilanin, Jo Ellen, M. Suzette Blanchard, and Estelle Russek-Cohen. "Lower Vertebral Bone Density in Male Long Distance Runners." Medicine & Science in Sports & Exercise 21.1 (1989): 66-70. Web.

Felson, David T., Yuqing Zhang, and Marrian Hannan. "Effects of Weight and Body Mass Index on Bone Mineral Density in Men and Women: The Framingham Study." Journal of Bone and Mineral Research 8.3 (1993): 567-73. Web.

Hsu, Yi-Hsiang, Scott Venners, and Henry Terwedow. "Relation of Body Composition, Fat Mass, and Serum Lipids to Osteoporotic Fractures and Bone Mineral Density in Chinese Men and Women." The American Journal of Clinical Nutrition 83.1 (2006): 146-54. Web.

Lane, N. E., M.D., and Daniel Blotch, PhD. "Long-distance Running, Bone Density, and Osteoarthritis." JAMA: The Journal of the American Medical Association 255.9 (1986): 1147-151. Web.

MacDougall, J.D., C.E. Webber, and J. Martin. "Relationship among Running Mileage, Bone Density, and Serum Testosterone in Male Runners."Journal of Applied Physiology 73.3 (1992): 1165-170. Web.

Patton, JF, WL Daniels, and JA Vogel. "Aerobic Power and Body Fat of Men and Women during Army Basic Training." Aviation, Space, and Environmental Medicine 51.5 (1980): 492-96. Web.

Stewart, Arthur D., and James Hannan. "Total and Regional Bone Density in Male Runners, Cyclists, and Controls." Medicine & Science in Sports & Exercise 32.8 (2000): 1373-377. Web.

Suominen, Harri. "Bone Mineral Density and Long Term Exercise." Sports Medicine 16.5 (1993): 316-30. Web.