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Relationship between bone mineral values and leg anaerobic power in professional wrestlers.

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Abstract

This study aimed to determine the relationship between bone mineral values and anaerobic power in professional wrestlers. A cross-sectional study was performed on 14 male wrestlers (22.9 ± 3.4 years) and 11 untrained men (24.5 ± 1.6 years; controls). Bone Mineral Content (BMC), Bone Mineral Density (BMD) and body composition were examined using dual-energy X-ray absorptiometry. Peak Power (PP) and Mean Power (MP) were measured by Wingate Anaerobic Test. The research showed that the wrestlers had greater leg lean mass, BMC and BMD, as well as MP expressed in absolute terms (W), and relative to body mass (W•kg^{-1}) compared with controls. MP (W) was correlated with leg lean mass in both groups. PP (W) and MP (W) were notably associated with BMC and BMD in both wrestlers and untrained men ($r=0.608$, $p<0.021$ and $r=0.717$, $p<0.004$) respectively, although less significant in controls. PP (W•kg^{-1}) and MP (W•kg^{-1}) were associated with BMD in wrestlers ($r=0.616$, $p<0.05$; $r=0.641$, $p<0.05$, respectively), but not in controls. In the total subject population, PP (W) and MP (W) correlated with leg lean mass, BMC and BMD. In conclusion, bone mineral values, especially BMD were significantly associated with anaerobic power in both the absolute and relative measures in wrestlers.

Keywords: Bone mineral content, Bone mineral density, Mean power, Peak power, Professional wrestler.

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Introduction

Competitive wrestling activity is extremely dynamic in nature, encompassing repeated explosive movements at a high intensity which alternates with sub-maximal work. Good anaerobic and aerobic capacity, upper and lower body strength, power, agility, flexibility and body composition are the most important factors needed to achieve good results in wrestling competitions [1,2]. Furthermore, a significant effect of wrestling on femur Bone Mineral Density (BMD) is also observed compared with femurs of sedentary subjects and subjects following different disciplines [3,4]. Wrestling and its sport-specific training involve high strain rates in versatile movements and high peak forces [5], which is more effective in bone formation than training with a large number of low-force repetitions [6].

The associations among lean mass, bone mass and anaerobic power are intriguing, and they are probably related to each other. In men and women, the absolute lean mass of the lower extremities was linearly related to the peak and mean Wingate Test power output [7]. On the other hand, muscle mass and bone mass are closely related throughout life, and previous studies have documented the associations of lean mass with bone mineral content (BMC) or BMD [8-20].

A positive relationship between bone mass and anaerobic power (using Sargent jump) is reported in professional jumpers [21]. On the other hand, lean mass as well as leg anaerobic power are considered as the best predictors of bone mass during growth [16-19,22,23]. In wrestling, anaerobic power and capacity are particularly important because of the short-duration and high intensity performance requested by this discipline. Wingate Test can be used to reflect the maximum ability of wrestlers to generate power [1]. However, little is known about the relationship between anaerobic power and bone mineral values in professional wrestlers. Therefore, the purpose of this study was to investigate this relationship in wrestlers compared with untrained men. We hypothesized that bone mineral values would be associated with anaerobic power in professional wrestlers.

Materials and Methods

Subjects

The subject recruitment and screening procedures have been previously described [24]. Briefly, twenty-five male subjects, fourteen professional wrestlers and eleven untrained healthy controls aged from 19 to 28 years, were enrolled for this study. The selected wrestlers were at a national performance level and in similar training status. The selected untrained subjects underwent less than two hours of sporting activities per week. Informed consent was obtained from all participants prior to the measurements. This study was conducted according to the Declaration of Helsinki and was approved by the Ethics Committee of our university (Case No. GS20110058) on August 10, 2011.

Anthropometrics

Height (cm) and weight (kg) were measured using a stadiometer (to the nearest 0.5 cm) and a beam balance platform scale, respectively.

Body composition and bone mineral measurements

A total body scan was performed using DXA (QDR-Explorer, Hologic, USA) to determine total and regional body composition (arms, legs and trunk). Fat percentage (F%), lean mass, BMC and BMD were assessed. Participants were scanned in light clothing, while lying flat on their backs with arms at their sides. The same experienced investigator completed and analyzed all scans using standard analysis protocols. Phantom measurements were used for quality control during the study period. In our laboratory, the coefficient of variation was <1%.

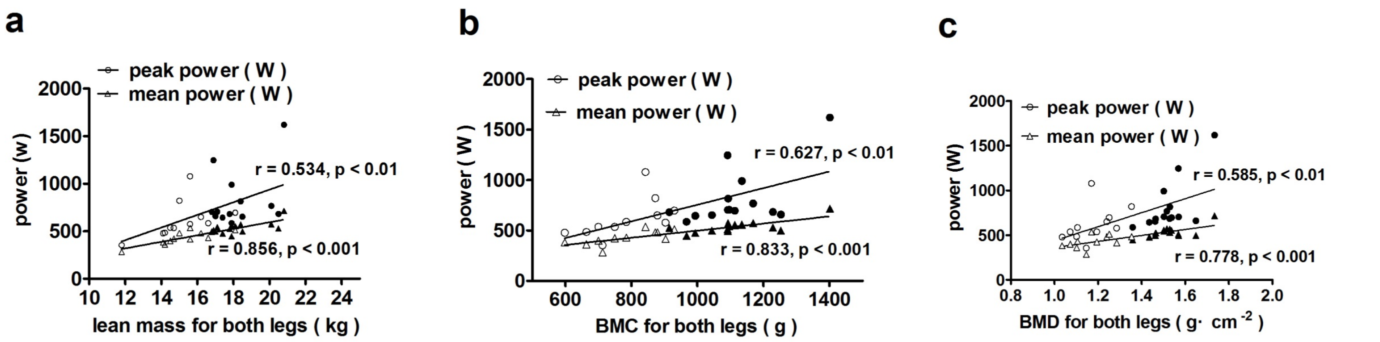

Figure 1. Anaerobic power is correlated with leg lean mass and bone mineral values in the total subject population. (a) Correlation between anaerobic power and leg lean mass. Peak power for professional wrestlers: closed circles; Peak power for untrained men: open circles; Mean power for professional wrestlers: closed triangles; Mean power for untrained men: open triangles. (b) Correlation between anaerobic power and leg BMC. Peak power for professional wrestlers: closed circles; Peak power for untrained men: open circles; Mean power for professional wrestlers: closed triangles; Mean power for untrained men: open triangles. (c) Correlation between anaerobic power and leg BMD. Peak power for professional wrestlers: closed circles; Peak power for untrained men: open circles; Mean power for professional wrestlers: closed triangles; Mean power for untrained men: open triangles. BMC: bone mineral content; BMD: bone mineral density.

30-s wingate anaerobic test (WAnT)

The WAnT was performed on a friction-loaded cycle ergometer (Monark 894E, Stockholm, Sweden) interfaced with a computer. The saddle height was adjusted to obtain the optimal fit for each participant, who warmed up by pedaling for 3-5 min at sub-maximal speed. During the warm-up period, participants were asked to perform three "all-out" 5-second cycle sprints under the experimenter's command. After completing the warm-up, subjects dismounted the cycle ergometer and rested quietly for 5 min. Next, participants started a 10 second unloaded pedaling before the start of the test. Subsequently, the participants were instructed to accelerate maximally against no load under the command of the experimenter. A predetermined resistance was then added after 3 second of maximal acceleration. The test resistance was set at 7.5% of the subject's body weight within a 0.1 kg resolution of resistance range. Participants were instructed to remain seated for the entire duration of the test and were requested to pedal as fast as possible to maintain maximal pedaling speed until the end of the 30 second test period. Strong verbal encouragement was given to participants during the whole test. Peak power (PP) and mean power (MP) were calculated using computerized software. PP represented the highest mechanical power output in the test, whereas MP was calculated as the average power attained throughout the entire test. PP and MP were expressed in absolute terms (W), and relative to body mass (W•kg^{-1}).

Table 1. Descriptive characteristics of professional wrestlers and untrained men.

	Untrained men (n=11)	Professional wrestlers (n=14)
Age (yr)	24.4 ± 1.6	22.9 ± 3.4
Height (m)	1.70 ± 0.04	1.67 ± 0.04
Weight (kg)	61.0 ± 7.0	64.9 ± 5.0
Values are expressed as mean ± SD.		

Statistical analysis

Analyses were performed using SPSS 17.0 for Windows. Independent sample t-tests were used to compare the differences between the groups of professional wrestlers and untrained men. Pearson's correlation was calculated to explore the association between anaerobic power and bone mineral values as well as lean mass for both legs (lean mass and BMC for left and right leg were summed; BMD was averaged for left and right leg). Correlation coefficients interpretation was as follows: r ≤ 0.49 weak relationship; 0.50 ≤ r ≤ 0.74 moderate relationship; and r ≥ 0.75 strong relationship [25]. Values are reported as means and SD. A P value <0.05 was considered statistically significant.

Table 2. Anaerobic power, bone mineral values and body composition measurements in the professional wrestlers and untrained men.

	Untrained men (n=11)	Professional wrestlers (n=14)
WAnT measurements		
PP (W)	617.6 ± 195.9	817.5 ± 287.0
PP (W•kg^{-1})	10.1 ± 3.2	12.6 ± 4.1
MP (W)	427.0 ± 72.4	534.5 ± 63.7**
MP (W•kg^{-1})	7.0 ± 1.0	8.2 ± 0.7**
Bone mineral values		
Left leg BMC (g)	392.0 ± 52.0	549.9 ± 64.7***
Right leg BMC (g)	393.2 ± 59.0	563.8 ± 62.9***
Left leg BMD (g•cm^{-2})	1.18 ± 0.11	1.51 ± 0.10***
Right leg BMD (g•cm^{-2})	1.18 ± 0.09	1.54 ± 0.10***
Total body BMC (g)	2163.4 ± 215.5	3089.2 ± 347.6***
Total body BMD (g•cm^{-2})	1.10 ± 0.05	1.43 ± 0.10***
Body composition		
Left leg LM (kg)	7.6 ± 0.8	9.2 ± 0.8***
Right leg LM (kg)	7.6 ± 0.9	9.0 ± 0.7***
Total body LM (kg)	44.7 ± 4.3	55.3 ± 4.5***
Total body F%	20.8 ± 5.7	11.2 ± 2.4***

Values are expressed as mean ± SD. **p<0.01, ***p<0.001 vs. untrained men. BMC: Bone Mineral Content; F%: Fat Percentage; LM: Lean Mass; MP: Mean Power; PP: Peak Power.

Results

The descriptive characteristics, whole body composition and bone mineral values of professional wrestlers and untrained men have been already described in details [24]. No statistically significant difference was found in height, age and weight between wrestlers and control subjects (Table 1). The professional wrestlers showed higher BMI, leg lean mass, total body BMC and BMD as well as lower body F% compared with the untrained men (Tables 1 and 2). Left and right leg lean mass, left and right leg BMC and BMD values in the wrestlers were higher than the untrained men (all p<0.001, Table 2). The MP (W and W•kg^{-1}) in the wrestlers were also higher than the untrained men (both p<0.01, Table 2). Furthermore, a similar trend on PP (W and W•kg^{-1}) was observed in both groups but did not reach the significant level (p=0.06 and 0.11, respectively). When participants of both groups were examined as a whole, a positive relationship was obtained between PP (W) and lean mass; MP (W) and lean mass; PP (W) and BMC; MP (W) and BMC; PP (W) and BMD; MP (W) and BMD. Among them, MP (W) was more strongly related to lean mass and bone mineral values than PP (W) (Figure 1).

Furthermore, the two groups were examined separately (Table 3). In the wrestlers, PP (W) was positively correlated with BMC and BMD for both legs (r=0.608, p<0.05; r=0.681, p<0.01, respectively), but not associated with lean mass for both legs. In untrained men, the association between PP (W) and lean mass approached the borderline of significance (r=0.538, p=0.088), and the positive relationship between PP (W) and BMC showed a reliable trend (r=0.586, p=0.058). MP (W) was associated with lean mass for both legs in both wrestlers and control group (r=0.649, p<0.05 and r=0.832, p<0.01) respectively (Table 3). However the correlation in the control group was higher. MP (W) was especially positively associated with both BMC and BMD for both legs in the wrestlers (r=0.717, p<0.01; r=0.698, p<0.01, respectively). In contrast, MP (W) was correlated with BMC but not BMD in the control group (r=0.709, p<0.05 and r=0.498, p>0.05, respectively). PP (W•kg^{-1}) and MP (W•kg^{-1}) were associated with leg BMD in the wrestlers (r=0.616, p<0.05; r=0.641, p<0.05, respectively), but not in the control group (Table 3). The positive relationship between PP and MP (W•kg^{-1}) variables and leg BMC exhibited a reliable trend in the wrestlers (r=0.490, p=0.075; r=0.500, p=0.069, respectively).

Table 3. Pearson correlation coefficient summary for leg LM, BMC and BMD vs. anaerobic power in the professional wrestlers and untrained men.

	Untrained men (n=11)			Professional wrestlers (n=14)		
	LM	BMC	BMD	LM	BMC	BMD
PP (W)	0.538	0.586	0.435	0.348	0.608*	0.681**
MP (W)	0.832**	0.709*	0.498	0.649*	0.717**	0.698**
PP (W•kg^{-1})	-	0.412	0.31	-	0.49	0.616*
MP (W•kg^{-1})	-	0.405	0.306	-	0.5	0.641*

*p<0.05, **p<0.01 vs. anaerobic power. BMC: Bone Mineral Content; BMD: Bone Mineral Density; F%: Fat Percentage; LM: Lean Mass; MP: Mean Power; PP: Peak Power.

Discussion

The main findings of the present study were the following: the professional wrestlers' anaerobic power was positively associated with bone mineral values, especially BMD; and this association is maintained with BMD relative values. Our previous reports showed that professional wrestlers had lower body F% and higher bone mineral values in the total body as well as lumbar spine [24]. In the present study, we found that professional wrestlers possessed higher bone mineral values in both legs. Our results were in accordance with the data from Platen [26] and Hinrich [4]. Indeed, these studies demonstrated that long term wrestling training resulted in a greater accrual of bone mass. The wrestlers are characterized by higher anaerobic capacity, as demonstrated by PP and MP of our wrestlers that were close to that of other wrestlers in previous studies [27-29].

There is a relationship between lean mass and anaerobic power. Blimkie [30] examined arm anaerobic power in teenage boys and girls and its relationship to lean tissue using WAnT, and they found that both absolute peak power and mean power of the arms are highly correlated with lean tissue volume. Witzke and Snow [24] showed highly positive associations between bone-free lean body mass and leg maximal power (absolute measure) in adolescent girls. Fat Free Mass (FFM) is usually calculated as the sum of lean mass, soft tissue and bone mineral content. In general, FFM is used to estimate the total skeletal muscle [31]. Vardar [29] reported that total FFM was related with leg peak power in male but not female wrestlers, and FFM was significantly correlated with mean power in both female and male wrestlers. Moreover, changes in mean power (absolute measure) are primarily related with FFM in young male wrestlers [32,33]. In the present study, we did not find any association between lean mass and peak power in male professional wrestlers ($r=0.348$, $p>0.05$). Nonetheless, the association between leg lean mass and peak power in the control group approached the borderline of significance ($r=0.538$, $p=0.088$). In accordance with previous studies, mean power was significantly associated with lean mass in both groups, and this association was notably strong in the control group. Thus, the association between mean power and FFM or lean mass in the wrestlers is more reliable than peak power [32,33].

A novel feature of this study was the relationship between bone mineral values, especially BMD, and anaerobic power in their absolute and relative values in the wrestlers. Although the relationship between FFM or lean mass and anaerobic power, as well as lean mass and bone mineral values has been examined in many populations, there is a paucity of data analyzing the relationship between bone mineral values and anaerobic power in athletes. To maintain or increase power output, muscle and bone works as a unit. The role of the Golgi tendon organ is to protect the bones onto which such muscles are attached. A muscle can contract with such force that its tendon is pulled from the bone, taking part of the bone with it. When a muscle contracts, the tendons binding this muscle to the adjacent bone are being stretched. The Golgi organ's function is to monitor the tensile stress in the tendons of contracting muscle, and if the tension becomes too high, to initiate a reflex arc that terminates with the muscle unit being relaxed and the antagonist muscle contracting instead. Activation of the Golgi organ then leads to a lessening of the pull of the muscle's tendon on the bone to which it is anchored [34]. After exercise training, bigger muscles develop greater force, inducing more intense mechanical stimulation of the bones to which they are attached and consequently, the muscular strength increases may parallel changes in bone mineral values [12,35]. These relations can be explained by the mechanostat theory, which asserts that bone strength is regulated by modeling and remodeling processes depending on the forces acting on the bone [8,36-38]. Thus, sports activities which involve tensile, compressive, shear, bending, and torsional stresses on bones can elicit mechanostat-related mechanisms [38,39].

The absolute leg maximal anaerobic power was associated with BMC and BMD at different sites in the adolescent girls [23]. A study conducted by Haydari [21] showed a positive relationship between femoral neck and trochanter BMC, as well as BMD variables and anaerobic power (Sargent jump test) in professional jumpers. Vicente-Rodriguez [16] reported that 300 m running speed (as anaerobic capacity estimation) correlated with BMC and BMD variables in young female handball players. Hence, our data provided an additional support, and further contributed to existing observations showing that the wrestlers exhibited positive correlations between BMD and anaerobic power related to their relative values. One limitation of the current study was that we could not evaluate any cause-and-effect association between bone mineral values and anaerobic power using the cross-sectional approach. Furthermore, the results are limited to young male wrestlers.

Conclusion

Our study indicated that the professional wrestlers' bone mineral values, especially BMD, were significantly associated with anaerobic power in their absolute and relative values.

Acknowledgments

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