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Abstract

The aim of this study was to explore the relationships between maximum power and bone variables in a group of young adults. Two hundred and one young adults (53 men and 148 women) whose ages range from 18 to 35 years voluntarily participated in this study. Weight and height were measured, and body mass index (BMI) was calculated. Body composition, bone mineral content (BMC) and bone mineral density (BMD) were determined for each individual by Dual-energy X-ray absorptiometry (DXA). Vertical jump was evaluated using a validated field test (Sargent test). The highest vertical jump was selected. Maximum power (P max, in watts) of the lower limbs was calculated accordingly. In young men, maximum power was positively correlated to whole body (WB) BMC ($r = 0.65$; $p < 0.001$), WB BMD ($r = 0.41$; $p < 0.01$), L1-L4 BMC ($r = 0.54$; $p < 0.001$), total hip (TH) BMC ($r = 0.50$; $p < 0.001$), femoral neck (FN) BMC ($r = 0.35$; $p < 0.01$), FN cross-sectional area (CSA) ($r = 0.33$; $p < 0.05$) and FN cross-sectional moment of inertia (CSMI) ($r = 0.50$; $p < 0.001$). In young women, maximum power was positively correlated to WB BMC ($r = 0.48$; $p < 0.001$), WB BMD ($r = 0.28$; $p < 0.001$), L1-L4 BMC ($r = 0.34$; $p < 0.001$), TH BMC ($r = 0.43$; $p < 0.001$), TH BMD ($r = 0.21$; $p < 0.01$), FN BMC ($r = 0.42$; $p < 0.001$), FN BMD ($r = 0.31$; $p < 0.001$), FN CSA ($r = 0.41$; $p < 0.001$), FN CSMI ($r = 0.40$; $p < 0.001$) and FN Z ($r = 0.41$; $p < 0.01$). The current study suggests that maximum power is a positive determinant of WB BMC, WB BMD, FN CSA and FN CSMI in young men. It also shows that maximum power is a positive determinant of WB BMC, WB BMD, TH BMD, FN BMD, FN CSA, FN CSMI and FN Z in young women.

Keywords: Maximum power; DXA variables; Young adults.

Introduction

Ageing leads to a reduction in lean mass (LM) and bone mineral density (BMD) and an alteration of bone quality (*1*). The World Health Organization (WHO) defined osteoporosis as a systemic skeletal disease characterized by low bone mass and micro-architectural deterioration of bone tissue, leading to an increased bone fragility and susceptibility to fracture risk *(1-3). O*steopenia and osteoporosis represent an important health problem of the ending 20th and the beginning 21st century *(1).* Hip fractures alone are expected to reach 6.3 million per year globally by 2050 *(2).*

Exercise-based interventions are an interesting alternative to medication due to their low cost and their safety (fewer serious side effects), and additional health benefits including improved balance and fall reduction. Furthermore, because osteoporotic fractures happen most frequently at the hip and spine, site-specific interventions to increase BMD are highly desirable. Targeted strengthening of the hip and spine using specific resistance exercises is useful since sufficient skeletal loading stimulates net bone formation at the solicited skeletal sites. A recent meta-analysis recommends the use of multi-component exercises for osteoporotic individuals to improve bone health outcomes *(4)*. Exercise that exerts in high muscular contraction or ground-reaction forces on the skeleton, such as resistance training or structured jump-training, respectively, increase BMD in pre- and post-menopausal women *(4).*

The regular practice of physical activities characterized by significant mechanical stresses stimulates bone formation and improves BMD in the most solicited sites *(5-10).* Indeed, according to Frost theory *(11)* "the mechanostat", the resistance of the bone adapts to the mechanical stresses applied to it. This theory has been supported by numerous studies on animals *(12,13).* In humans, it has been shown that body weight and LM are the best determinants of BMD in both sexes *(14,15).*

Many studies showed that high cardiorespiratory fitness and muscle strength are correlated with higher BMD values at the proximal femur, distal tibia and fibula, lumbar spine and total hip *(16-18).* Although, it is widely accepted that muscle strength is significantly correlated with bone mass, little is known about the relationship between maximum power and BMD. Indeed, muscle mass and bone mass are closely related throughout life, and previous studies have documented the associations of LM with bone mineral content (BMC) and BMD *(19,20).* A positive relationship between bone mass and anaerobic power is reported in professional jumpers *(21).* On the other side, LM as well as anaerobic power are considered as the best predictors of bone mass during growth (*22-25).*

Several studies have shown a significant correlation between BMD and the performances obtained in some physical tests used in current sports practice *(26-29).* A previous study found that vertical jump, maximum power of the lower limbs, and 1-RM half-squat are positively correlated with bone variables in overweight and obese adult women *(30).*

However, the relationship between maximum power and bone variables needs to be more clarified. Therefore, the purpose of this study was to investigate the relationships between maximum power and bone variables in a group of young adults. We hypothesized that maximum power would be significantly associated with bone variables in both sexes. Identification of new determinants of BMC, BMD and hip geometric indices in young adults, would allow screening and early management of future cases of osteopenia and osteoporosis.

Materials and Methods

Subjects and Study Design

Two hundred and one young adults whose ages ranged from 18 to 35 years voluntarily participated in the present study. They were divided into two groups: 53 young men and 148 young women. All participants were nonsmokers and had no history of major orthopedic problems or other disorders known to affect bone metabolism or physical tests of the study. Pregnant women, amenorrheic, and those taking medications that may affect bone and calcium metabolism (corticosteroid or anticonvulsant therapy) were excluded from the study. All participants completed an interview about medical history including menstrual history and medication use. The work described has been carried out in accordance with the declaration of Helsinki (regarding human experimentation developed for the medical community by the World Medical Association). Other inclusion criteria included no diagnosis of comorbidities and no history of fracture. An informed written consent was obtained from the participants. The current study was approved by the University of Balamand Ethics Committee.

Anthropometrics

Height (in centimeters) was measured in the upright position to the nearest 1mm with a standard stadiometer. Body weight (in kilograms) was measured on a mechanic scale with a precision of 100 g. Subjects were weighed wearing only underclothes. Body mass index (BMI) was calculated as body weight divided by height squared (in kilograms per square meter) *(31).* Body composition including LM (Kg) and fat mass (FM; %, Kg) was evaluated by dual-energy X-ray absorptiometry (DXA; GE Healthcare, Madison, WI).

Bone Variables

BMC (in grams) and BMD (in grams per square centimeter) were determined for each individual by DXA at whole body (WB), lumbar spine (L1-L4), total hip (TH), and femoral neck (FN; GE Healthcare). FN cross-sectional area (CSA), strength index (SI), buckling ratio (BR), FN section modulus (Z), cross-sectional moment of inertia (CSMI) and L1-L4 TBS were also evaluated by DXA *(32-34).* The TBS is derived from the texture of the DXA image and has been shown to be related to bone microarchitecture and fracture risk. The TBS score can assist the healthcare professional in assessing fracture risk *(33,34).* In our laboratory, the coefficients of variation were less than 1% for BMC and BMD and less than 3% for FN CSA *(17,35-37).* The same certified technician performed all analyses using the same technique for all measurements.

Maximum power

The vertical jump was evaluated using a field test (Sargent test). Two main parameters were retained: vertical jump performance (cm) and power (w). The subjects performed three jumps with 2 minutes of recovery between jumps. The highest vertical jump was selected. Maximum power (P max, in watts) of the lower limbs was calculated *(38). P max (w) = √g/2 * body weight (kg) * √H * 9.81; g is equal to 9.81 and H is vertical jump height in meters.*

Statistical Analysis

The means and standard deviations were calculated for all clinical data and for the bone measurements. Intersex differences were specified by Student's t-test. Associations between maximum power and bone variables were given as Pearson correlation coefficients and r values were reported. Multiple linear regression analysis models were used to test the relationship of maximum power and LM with bone variables, and R^2 values were reported.

Statistical analyses were performed using the SigmaStat 3.1 Program (Jandel Corp., San Rafael, CA). A level of significance of $p < 0.05$ was used.

Results

Clinical Characteristics and Bone Data of the Study Population

Mean values of age, weight, height, BMI, LM, FM, FM percentage, bone variables, vertical jump and maximum power are displayed in Table 1. Age, L1-L4 BMD, L1-L4 TBS, BR and FN SI were not significantly different between men and women. Weight, fat mass, height, BMI, LM, WB BMC, WB BMD, L1-L4 BMC, TH BMC, TH BMD, FN BMC, FN BMD, FN CSA, FN CSMI, FN Z, vertical jump and maximum power were significantly higher in men than in women. Fat mass percentage was significantly higher in women compared to men.

Correlations Between Clinical Characteristics and Bone Variables in young men

Maximum power was positively correlated to WB BMC ($r = 0.65$; $p < 0.001$), WB BMD ($r = 0.41$; $p < 0.01$), L1-L4 BMC ($r = 0.54$; $p < 0.001$), TH BMC ($r = 0.50$; $p < 0.001$), FN BMC ($r = 0.35$; $p < 0.01$), FN CSA ($r = 0.33$; $p < 0.05$) and FN CSMI ($r = 0.50$; $p < 0.001$). Vertical jump was positively correlated to WB BMC ($r = 0.31$; $p < 0.05$), L1-L4 BMC ($r = 0.40$; $p < 0.01$) and FN CSMI ($r = 0.29$; $p < 0.05$). FM was positively correlated to WB BMC ($r = 0.29$; $p < 0.05$). FM was negatively correlated to L1-L4 TBS ($r = -0.37$; $p < 0.01$) and FN SI ($r = -0.45$; $p < 0.001$). LM was positively correlated to WB BMC ($r = 0.57$; $p < 0.001$), WB BMD ($r = 0.42$; $p < 0.01$), L1-L4 BMC ($r = 0.27$; $p < 0.05$), TH BMC ($r = 0.47$; $p < 0.001$), FN BMC ($r = 0.38$; $p < 0.01$), FN CSA ($r = 0.40$; $p < 0.01$), FN CSMI ($r = 0.52$; $p < 0.001$) and FN Z ($r = 0.48$; $p = 0.05$) (Table 2).

Correlations Between Clinical Characteristics and Bone Variables in young women

Maximum power was positively correlated to WB BMC ($r = 0.48$; $p < 0.001$), WB BMD ($r = 0.28$; $p < 0.001$), L1-L4 BMC ($r = 0.34$; $p < 0.001$), TH BMC ($r = 0.43$; $p < 0.001$), TH BMD ($r = 0.21$; $p < 0.01$), FN BMC ($r = 0.42$; $p < 0.001$), FN BMD ($r = 0.31$; $p < 0.001$), FN CSA ($r = 0.41$; $p < 0.001$), FN CSMI ($r = 0.40$; $p < 0.001$) and FN Z ($r = 0.41$; $p < 0.01$). Vertical jump was positively correlated to FN SI ($r = 0.17$; $p < 0.05$). FM was positively correlated to WB BMC ($r = 0.33$; $p < 0.001$), WB BMD ($r = 0.39$; $p < 0.001$), L1-L4 BMC ($r = 0.17$; $p < 0.05$), L1-L4 TBS ($r = 0.18$; $p < 0.05$), TH BMC ($r = 0.31$; $p < 0.001$), TH BMD ($r = 0.27$; $p < 0.001$), FN BMC ($r = 0.30$; $p < 0.001$), FN BMD ($r = 0.32$; $p < 0.001$), FN CSA ($r = 0.34$; $p < 0.001$), FN CSMI ($r = 0.25$; $p < 0.01$) and FN Z ($r = 0.44$; $p < 0.001$). FM was negatively correlated to FN SI ($r = -0.33$; $p < 0.001$). LM was positively correlated to WB BMC ($r = 0.79$; $p < 0.001$), WB BMD ($r = 0.58$; $p < 0.001$), L1-L4 BMC ($r = 0.59$; $p < 0.001$), L1-L4 BMD ($r = 0.30$; $p < 0.001$), TH BMC ($r = 0.75$; $p < 0.001$), TH BMD ($r = 0.45$; $p < 0.001$), FN BMC ($r = 0.63$; $p < 0.001$), FN BMD ($r = 0.52$; $p < 0.001$), FN CSA ($r = 0.72$; $p < 0.001$), FN CSMI ($r = 0.71$; $p < 0.001$) and FN Z ($r = 0.73$; $p < 0.001$). LM was negatively correlated to BR ($r = -0.26$; $p < 0.05$) (Table 3).

Multiple Linear Regressions in men

After adjusting for LM, maximum power remained positively correlated to WB BMC ($p < 0.001$), L1-L4 BMC ($p < 0.001$), TH BMC ($p = 0.013$) and FN CSMI ($p = 0.021$). Maximum power was a stronger positive determinant of WB BMC and TH BMC than LM. LM was a stronger positive determinant of FN CSMI than maximum power. After adjusting for maximum power, LM remained positively correlated to WB BMC ($p = 0.009$), TH BMC ($p = 0.039$), FN CSA ($p = 0.041$) and FN CSMI ($p = 0.011$) (Table 4).

Multiple Linear Regressions in women

The correlations between maximum power and bone variables disappeared after adjusting for LM. LM remained positively correlated to WB BMC ($p < 0.001$), WB BMD ($p < 0.001$), L1-L4 BMC ($p < 0.001$), L1-L4 BMD ($p < 0.001$), TH BMC ($p < 0.001$), TH BMD ($p < 0.001$), FN BMC ($p < 0.001$), FN BMD ($p < 0.001$), FN CSA ($p < 0.001$), FN CSMI ($p < 0.001$) and FN Z ($p < 0.001$) after adjusting for maximum power. LM remained negatively correlated to BR ($p = 0.01$) after adjusting for maximum power (Table 5).

Discussion

The present study conducted in a group of young adults mainly shows that maximum power is positively correlated to WB BMC, WB BMD, FN CSA and FN CSMI in young men. This study also shows a positive correlation between maximum power and WB BMC, WB BMD, TH BMD, FN BMD, FN CSA, FN CSMI and FN Z in young women. The strengths of the associations between maximum power and bone variables were poor to moderate in both sexes.

After adjusting for LM, maximum power remained significantly correlated to WB BMC, L1-L4 BMC, TH BMC and FN CSMI in young men, whereas the correlation between maximum power and bone variables disappeared after adjusting for LM in young women. Accordingly, the relationships between maximum power and bone variables in young adults seem to be influenced by gender. These relationships seem to be stronger in men compared to women in our cohort. FM percentage is known to be higher in women compared to men. Our results are consistent with those of two previous studies conducted on young adults. El Khoury et al. *(39)* showed that maximum power was positively correlated to WB BMC, WB BMD, L1-L4 BMD, TH BMD, and FN Z in a group of young overweight and obese men. These correlations disappeared after adjusting for LM. Another previous study found a positive correlation between maximum power and BMD in both young women and men *(40).* A recent study has shown that maximum power is a positive determinant of many bone variables in a group of young overweight and obese women *(30)*.

Our results showed that vertical jump is positively correlated to WB BMC, L1-L4 BMC, and FN CSMI in young men, whereas vertical jump is positively correlated only to FN SI in young women. Accordingly, the relationships between vertical jump and bone variables in young adults seem to be influenced by gender. These relationships seem to be stronger in men compared to women in our cohort. Our results are in accordance with those of a previous study conducted on young adults that has shown that vertical jump was positively correlated to WB BMC and BMD in young women. In contrary, it did not find any correlation between vertical jump and bone variables in young men *(40).* The relationships between vertical jump performance and bone variables may be influenced by the weight status of the studied population *(40)*. However, a more recent study has shown that vertical jump was the best predictor of TH and FN BMD in a group of young overweight and obese women *(30).*

The current study shows that, in young men, FM is positively correlated only to WB BMC, whereas FM is negatively correlated to L1-L4 TBS and FN SI. It also shows that, in young women, FM is positively correlated to WB BMC, L1-L4 TBS, WB BMD, TH BMD, FN BMD, FN CSA, FN CSMI and FN Z, whereas FM is negatively correlated to FN SI. Based on our results, the relationships between FM and bone variables are sex-dependent and seem to be stronger in women compared to men. The latter may partially explain the sex-specificity regarding the relationships between vertical jump/maximum power and bone variables obtained in our study. Janicka et al. *(41)* conducted a study on three hundred healthy sexually mature adolescents and young adults (150 men and 150 women) between 13 and 21 years old. They found positive correlations between FM and DXA and computed tomography (CT) bone variables in women, whereas these correlations were weaker or nonexistent in men *(41)*. Accordingly, these authors suggested that adipose tissue is not beneficial to bone structure in young men *(41).* In line with these results, a recent study conducted on a group of young overweight and obese men did not find any positive correlation between FM and bone variables *(39).*

The type of FM may differently affect bone tissue. The relation between visceral adipose tissue (VAT) and bone has been previously documented in many studies. A study conducted on young women suggests that VAT was negatively correlated with BMD, while subcutaneous adipose tissue (SAT) was positively correlated with BMD *(42).* Similarly, another study conducted by Choi et al. *(43)* showed that VAT was negatively correlated with BMD, while SAT was positively correlated with BMD in Korean men and women, after adjusting for body weight. In addition, Yamaguchi et al. *(44)* confirmed that SAT was positively correlated with BMD in men with type 2 diabetes.

Our study shows that LM is positively correlated to WB BMC, WB BMD, FN CSA, FN CSMI and FN Z in young men. Regarding women, our results also show that LM is positively correlated to WB BMC, WB BMD, FN CSA, FN CSMI and FN Z. LM remained positively correlated to WB BMC, TH BMC, FN CSA and FN CSMI after adjusting for maximum power in young men, whereas LM remained positively correlated to WB BMC, WB BMD, FN CSA, FN CSMI and FN Z, after adjusting for maximum power in young women. Our results are in accordance with those of many previous studies *(18-25)*. A study conducted on a group of young overweight and obese men found a positive correlation between LM and several bone variables such as

WB BMC, WB BMD, FN CSA and FN Z *(45).* Zakhem et al. showed that LM was positively correlated to WB BMC and WB BMD in both young women and men *(40).* Several previous studies have shown that LM was a strong determinant of bone variables *(39, 46-54).* Accordingly, LM is a positive determinant of bone variables in young adults and this relation is valid in both sexes. El Hage et al. conducted a study on a group of adolescent girls and boys (35 girls and 65 boys). In boys, they showed that LM was strongly correlated to WB BMD and L1–L4 BMD and that FM was not positively correlated to BMD and was negatively correlated to WB bone mineral apparent density. In girls, they found that LM and FM were positively correlated to WB BMD, while only FM was correlated to L1-L4 BMD. They suggested that LM is a strong determinant of WB BMD and L1-L4 BMD in boys, and that FM is a stronger determinant of WB BMD than LM in girls *(55).*

Our study had some limitations. First, the cross-sectional nature of the present study is a limitation because it cannot evaluate the confounding variables. The second limitation is the 2-dimensional nature of DXA *(56,57).* The third limitation is the low number of subjects especially in the male group. Finally, maximum power was not directly measured but indirectly calculated using a formula after performing a vertical jump test. However, to our knowledge, the present study is one of few studies that aimed at exploring the relationships between maximum power and many bone variables such as BMD, BMC, and hip geometric indices in young adults. Vertical jump and maximum power are easily calculated when performing a simple physical test. Interestingly, our results showed that the relationships between maximal power and bone variables in young adults are sex-dependent and seem to be stronger in men compared to women.

In conclusion, the current study suggests that maximum power is a positive determinant of BMC, WB BMD, FN CSA and FN CSMI in young men. It also suggests that maximum power is a positive determinant of WB BMC, WB BMD, TH BMD, FN BMD, FN CSA, FN CSMI and FN Z in young women. In addition, our study shows that maximum power is an independent determinant of WB BMC and L1-L4 BMC in young men. Our study is one of very few studies that demonstrated positive correlations between maximum power and bone variables in young adults. Thus, implementing strategies to increase maximum power of the lower limbs in young adults may be useful for preventing osteoporosis later in life. Finally, our study may be useful for the prevention and early detection of osteoporosis and osteopenia.

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Conflict of Interest

None of the authors reported a conflict of interest related to the study.

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Table 1: Physical Characteristics of the Study Population

Characteristics	Men (n = 53)	Women (n = 148)
	Mean ± SD	Mean ± SD
Age (yr)	24.3 ± 4.9	24.1 ± 3.9
Weight (kg)	84.9 ± 20.0 ***	67.0 ± 13.7
Height (m)	1.73 ± 0.08 ***	1.62 ± 0.07
BMI (kg/m^2)	27.9 ± 5.3 **	25.3 ± 4.8
Lean Mass (kg)	55.306 ± 12.02 ***	39.751 ± 8.646
Fat Mass (kg)	26.646 ± 14.881	25.191 ± 8.638
Fat Mass %	27.4 ± 9.4 ***	36.4 ± 6.9
WB BMC (g)	2919 ± 394 ***	2309 ± 397
WB BMD (g/cm^2)	1.207 ± 0.097 ***	1.101 ± 0.106
L1-L4 BMC (g)	70.4 ± 12.3 ***	60.7 ± 11.9
L1-L4 BMD (g/cm^2)	1.170 ± 0.126	1.152 ± 0.131
L1-L4 TBS	1.409 ± 0.106	1.427 ± 0.106
TH BMC (g)	39.1 ± 6.4 ***	29.5 ± 6.1
TH BMD (g/cm^2)	1.106 ± 0.132 ***	0.988 ± 0.125
FN BMC (g)	5.90 ± 0.88 ***	4.62 ± 0.99

FN BMD (g/cm^2)	1.104 ± 0.146 ***	0.973 ± 0.139
FN CSA (mm^2)	186.6 ± 27.0 ***	150.2 ± 28.3
FN CSMI $(mm^2)^2$	16040 ± 3675 ***	10485 ± 3863
FN Z (mm^3)	898 ± 207 ***	635 ± 194
BR	5.73 ± 2.35	6.604 ± 3.142
FN SI	1.592 ± 0.468	1.633 ± 0.433
Vertical jump (m)	0.326 ± 0.227 ***	0.167 ± 0.085
Maximum power (w)	1011 ± 401 ***	568 ± 167

BMI, body mass index; WB, whole body; BMC, bone mineral content; BMD, bone mineral density; TBS, trabecular bone score; TH, total hip; FN, femoral neck; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia; Z, section modulus; BR, buckling ratio; SI, strength index; SD, standard deviation. *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Table 2: Correlations Between Clinical Characteristics and Bone Variables in Young Men

N = 53	WB BMC (g)	WB BMD (g/cm^2)	L1-L4 BMC (g)	L1-L4 BMD (g/cm^2)	L1-L4 TBS	TH BMC (g)	TH BMD (g/cm^2)	FN BMC (g)	FN BMD (g/cm^2)	FN CSA (mm^2)	FN CSMI (mm^2)^2	FN Z (mm^3)	BR	FN SI
Age (yr)	-0.03	-0.10	0.01	-0.12	-0.26	-0.22	-0.27 *	-0.28 *	-0.28 *	-0.28 *	-0.16	-0.14	-0.44 *	-0.12
Weight (kg)	0.63 ***	0.41 **	0.31 *	0.12	-0.25	0.49 ***	0.24	0.31 *	0.19	0.34 *	0.42 **	0.45 *	0.24	-0.57 ***
Height (m)	0.77 ***	0.40 **	0.57 ***	0.18	-0.25	0.61 ***	0.26	0.45 ***	0.24	0.49 ***	0.60 ***	0.54 **	-0.18	-0.12
BMI (kg/m^2)	0.37 **	0.30 *	0.07	0.04	-0.17	0.29 *	0.16	0.16	0.12	0.17	0.21	0.31	0.43 *	-0.62 ***

FM (kg)	0.29 *	0.19	0.15	0.08	-0.37 **	0.22	0.16	0.10	0.10	0.14	0.16	0.18	0.20	-0.45 ***
FM %	0.01	0.08	-0.10	-0.06	-0.24	-0.11	-0.08	-0.19	-0.09	-0.14	-0.20	-0.37	0.45 *	-0.64 ***
LM (Kg)	0.57 ***	0.42 **	0.27 *	0.13	-0.08	0.47 ***	0.18	0.38 **	0.25	0.40 **	0.52 ***	0.48 *	-0.15	-0.17
VJ (m)	0.31 *	0.17	0.40 **	0.18	0.16	0.22	0.01	0.17	-0.01	0.12	0.29 *	0.10	-0.27	0.08
MP (w)	0.65 ***	0.41 **	0.54 ***	0.24	-0.01	0.50 ***	0.19	0.35 **	0.12	0.33 *	0.50 ***	0.41	-0.06	-0.25

BMI, body mass index; FM, fat mass; LM, lean mass; VJ, vertical jump; MP, maximum power; WB, whole body; BMC, bone mineral content; BMD, bone mineral density; TBS, trabecular bone score; TH, total hip; FN, femoral neck; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia; Z, section modulus; BR, buckling ratio; SI, strength index. *$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

Table 3: Correlations Between Clinical Characteristics and Bone Variables in Young Women

N = 148	WB BMC (g)	WB BMD (g/cm^2)	L1-L4 BMC (g)	L1-L4 BMD (g/cm^2)	L1-L4 TBS	TH BMC (g)	TH BMD (g/cm^2)	FN BMC (g)	FN BMD (g/cm^2)	FN CSA (mm^2)	FN CSMI (mm^2)^2	FN Z (mm^3)	BR	FN SI
Age (yr)	0.06	0.08	0.15	0.10	0.018	0.07	0.00	0.02	0.01	0.03	0.05	-0.07	0.11	-0.12
Weight (kg)	0.64 ***	0.55 ***	0.42 ***	0.24 **	0.19 *	0.60 ***	0.40 ***	0.54 ***	0.48 ***	0.62 ***	0.56 ***	0.68 ***	-0.11	-0.31 ***
Height (m)	0.56 ***	0.22 **	0.36 ***	0.02	-0.24 **	0.42 ***	0.13	0.41 ***	0.28 ***	0.42 ***	0.46 ***	0.50 ***	-0.32 *	-0.17 *
BMI (kg/m^2)	0.40 ***	0.47 ***	0.26 **	0.24 **	0.33 ***	0.42 ***	0.36 ***	0.37 ***	0.37 ***	0.44 ***	0.36 ***	0.57 ***	-0.00	-0.24 **

FM (kg)	0.33 ***	0.39 ***	0.17 *	0.13	0.18 *	0.31 ***	0.27 ***	0.30 ***	0.32 ***	0.34 ***	0.25 **	0.44 ***	0.00	-0.33 ***
FM %	-0.18 *	-0.00	-0.17 *	-0.02	0.14	-0.14	-0.00	-0.08	-0.00	-0.09	-0.18 *	-0.21	0.32	-0.25 **
LM (Kg)	0.79 ***	0.58 ***	0.59 ***	0.30 ***	0.09	0.75 ***	0.45 ***	0.63 ***	0.52 ***	0.72 ***	0.71 ***	0.73 ***	-0.26 *	-0.14
VJ (m)	-0.03	-0.12	0.00	-0.04	-0.15	-0.05	-0.09	0.00	-0.05	-0.05	-0.02	-0.21	0.17	0.17 *
MP (w)	0.48 ***	0.28 ***	0.34 ***	0.12	-0.05	0.43 ***	0.21 **	0.42 ***	0.31 ***	0.41 ***	0.40 ***	0.41 **	0.02	-0.13

BMI, body mass index; FM, fat mass; LM, lean mass; VJ, vertical jump; MP, maximum power; WB, whole body; BMC, bone mineral content; BMD, bone mineral density; TBS, trabecular bone score; TH, total hip; FN, femoral neck; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia; Z, section modulus; BR, buckling ratio; SI, strength index. *p < 0.05. **p < 0.01. ***p < 0.001.

Table 4: Multiple Linear Regressions in Men

Men (n = 53)	Coefficient ± SE	*t* value	*p* value
Dependent variable: WB BMC (R^2 = 0.711)			
Constant	1857.263 ± 184.878	10.046	<0.001
Maximum Power (w)	0.481 ± 0.115	4.173	<0.001
Lean Mass (kg)	10.399 ± 3.854	2.698	0.009
Dependent variable: WB BMD (R^2 = 0.481)			
Constant	1.016 ± 0.0567	17.939	<0.001
Maximum Power (w)	0.0000658 ± 0.0000354	1.861	0.069
Lean Mass (kg)	0.00224 ± 0.00118	1.897	0.064
Dependent variable: L1-L4 BMC (R^2 = 0.543)			
Constant	54.162 ± 6.947	7.797	<0.001
Maximum Power (w)	0.017 ± 0.00435	3.901	<0.001
Lean Mass (kg)	-0.0178 ± 0.145	-0.124	0.902

Dependent variable: L1-L4 BMD (R^2 = 0.248)			
Constant	1.087 ± 0.081	13.416	<0.001
Maximum Power (w)	0.0000759 ± 0.0000505	1.502	0.139
Lean Mass (kg)	0.000112 ± 0.00169	0.0664	0.947
Dependent variable: L1-L4 TBS (R^2 = 0.0924)			
Constant	1.449 ± 0.0705	20.557	<0.001
Maximum Power (w)	0.0000124 ± 0.000044	0.283	0.779
Lean Mass (kg)	-0.000958 ± 0.00147	-0.652	0.517
Dependent variable: TH BMC (R^2 = 0.565)			
Constant	24.629 ± 3.569	6.902	<0.001
Maximum Power (w)	0.00572 ± 0.00223	2.568	0.013
Lean Mass (kg)	0.158 ± 0.0744	2.119	0.039
Dependent variable: TH BMD (R^2 = 0.220)			
Constant	0.99 ± 0.0856	11.563	<0.001

Maximum Power (w)	0.0000436 ± 0.0000534	0.816	0.418
Lean Mass (kg)	0.0013 ± 0.00178	0.729	0.469
Dependent variable: FN BMC (R^2 = 0.423)			
Constant	4.319 ± 0.533	8.1	<0.001
Maximum Power (w)	0.000451 ± 0.000333	1.356	0.181
Lean Mass (kg)	0.0204 ± 0.0111	1.833	0.073
Dependent variable: FN BMD (R^2 = 0.256)			
Constant	0.933 ± 0.094	9.918	<0.001
Maximum Power (w)	-0.00000433 ± 0.0000587	-0.0738	0.942
Lean Mass (kg)	0.00318 ± 0.00196	1.625	0.111
Dependent variable: FN CSA (R^2 = 0.431)			
Constant	135.835 ± 16.231	8.369	<0.001
Maximum Power (w)	0.0116 ± 0.0101	1.143	0.258
Lean Mass (kg)	0.708 ± 0.338	2.092	0.041

Dependent variable: FN CSMI (R^2 = 0.592)			
Constant	7049.766 ± 1971.804	3.575	<0.001
Maximum Power (w)	2.931 ± 1.23	2.382	0.021
Lean Mass (kg)	108.954 ± 41.103	2.651	0.011
Dependent variable: FN Z (R^2 = 0.550)			
Constant	412.049 ± 169.309	2.434	0.024
Maximum Power (w)	0.176 ± 0.123	1.43	0.168
Lean Mass (kg)	5.69 ± 2.919	1.949	0.065
Dependent variable: BR (R^2 = 0.159)			
Constant	7.166 ± 2.265	3.164	0.005
Maximum Power (w)	-0.0000561 ± 0.00165	-0.0341	0.973
Lean Mass (kg)	-0.026 ± 0.039	-0.666	0.513
Dependent variable: FN SI (R^2 = 0.258)			
Constant	1.973 ± 0.301	6.558	<0.001

Maximum Power (w)	-0.000263 ± 0.000188	-1.401	0.168
Lean Mass (kg)	-0.00207 ± 0.00627	-0.33	0.743

WB, whole body; BMC, bone mineral content; BMD, bone mineral density; TBS, trabecular bone score; TH, total hip; FN, femoral neck; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia; Z, section modulus; BR, buckling ratio; SI, strength index.

Table 5: Multiple Linear Regressions in Women

Women (n = 148)	Coefficient ± SE	*t* value	*p* value
Dependent variable: WB BMC (R^2 = 0.795)			
Constant	834.234 ± 96.659	8.631	<0.001
Maximum Power (w)	0.175 ± 0.143	1.228	0.222
Lean Mass (kg)	34.61 ± 2.763	12.527	<0.001
Dependent variable: WB BMD (R^2 = 0.586)			
Constant	0.823 ± 0.0344	23.94	<0.001
Maximum Power (w)	-0.0000345 ± 0.0000508	-0.68	0.498
Lean Mass (kg)	0.00751 ± 0.000982	7.643	<0.001
Dependent variable: L1-L4 BMC (R^2 = 0.592)			
Constant	27.291 ± 3.94	6.927	<0.001
Maximum Power (w)	0.00341 ± 0.00572	0.596	0.552
Lean Mass (kg)	0.797 ± 0.111	7.194	<0.001

Dependent variable: L1-L4 BMD (R^2 = 0.309)			
Constant	0.975 ± 0.05	19.505	<0.001
Maximum Power (w)	-0.0000464 ± 0.0000739	-0.628	0.531
Lean Mass (kg)	0.00512 ± 0.00143	3.582	<0.001
Dependent variable: L1-L4 TBS (R^2 = 0.150)			
Constant	1.396 ± 0.0421	33.172	<0.001
Maximum Power (w)	-0.0000901 ± 0.0000622	-1.449	0.15
Lean Mass (kg)	0.00207 ± 0.0012	1.717	0.088
Dependent variable: TH BMC (R^2 = 0.755)			
Constant	8.122 ± 1.612	5.04	<0.001
Maximum Power (w)	0.00116 ± 0.00238	0.487	0.627
Lean Mass (kg)	0.523 ± 0.0461	11.346	<0.001
Dependent variable: TH BMD (R^2 = 0.451)			
Constant	0.734 ± 0.0446	16.44	<0.001

Maximum Power (w)	-0.0000297 ± 0.000066	-0.45	0.654
Lean Mass (kg)	0.00682 ± 0.00128	5.341	<0.001
Dependent variable: FN BMC (R^2 = 0.642)			
Constant	1.621 ± 0.305	5.312	<0.001
Maximum Power (w)	0.000708 ± 0.000451	1.569	0.119
Lean Mass (kg)	0.0654 ± 0.00872	7.492	<0.001
Dependent variable: FN BMD (R^2 = 0.526)			
Constant	0.632 ± 0.0475	13.318	<0.001
Maximum Power (w)	0.0000294 ± 0.0000702	0.419	0.676
Lean Mass (kg)	0.00815 ± 0.00136	6.011	<0.001
Dependent variable: FN CSA (R^2 = 0.725)			
Constant	55.11 ± 7.826	7.042	<0.001
Maximum Power (w)	0.00516 ± 0.0116	0.446	0.656
Lean Mass (kg)	2.319 ± 0.224	10.367	<0.001

Dependent variable: FN CSMI (R^2 = 0.716)			
Constant	-2287.192 ± 1080.394	-2.117	0.036
Maximum Power (w)	0.356 ± 1.597	0.223	0.824
Lean Mass (kg)	316.221 ± 30.882	10.24	<0.001
Dependent variable: FN Z (R^2 = 0.733)			
Constant	122.028 ± 76.25	1.6	0.115
Maximum Power (w)	-0.00768 ± 0.128	-0.06	0.952
Lean Mass (kg)	12.987 ± 2.013	6.452	<0.001
Dependent variable: BR (R^2 = 0.345)			
Constant	8.314 ± 1.698	4.895	<0.001
Maximum Power (w)	0.00485 ± 0.00285	1.7	0.095
Lean Mass (kg)	-0.119 ± 0.0448	-2.664	0.01
Dependent variable: FN SI (R^2 = 0.158)			
Constant	1.946 ± 0.171	11.37	<0.001

Maximum Power (w)	-0.00022 ± 0.000253	-0.872	0.385
Lean Mass (kg)	-0.00471 ± 0.00489	-0.964	0.337

WB, whole body; BMC, bone mineral content; BMD, bone mineral density; TBS, trabecular bone score; TH, total hip; FN, femoral neck; CSA, cross-sectional area; CSMI, cross-sectional moment of inertia; Z, section modulus; BR, buckling ratio; SI, strength index.