Journal of Clinical Densitometry: Assessment & Management of Musculoskeletal Health, vol. 17, no. 2, 320–324, 2014

1094-6950/17:320–324/$36.00
http://dx.doi.org/10.1016/j.jocd.2014.01.008

Original Article

Maximal Oxygen Consumption and Bone Mineral Density in a Group of Young Lebanese Adults

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Abstract

The aim of this study was to explore the relationship between maximal oxygen consumption (VO_2 max) and bone mineral density (BMD) in a group of young Lebanese adults. Twenty women and 37 men whose ages range from 18 to 32 yr participated in this study. Informed written consent was obtained from the participants. Body weight and height were measured, and body mass index was calculated. VO_2 max was determined by direct measurement while exercising on a bicycle ergometer (Siemens-Elema RE 820; Rodby Elektronik AB, Enhorna, Sweden). Whole body bone mineral content (WB BMC), whole body bone mineral density (WB BMD), lumbar spine BMD (L1–L4 BMD), total hip BMD (TH BMD), and femoral neck BMD (FN BMD) were measured by dual-energy X-ray absorptiometry. In women, VO_2 max (expressed as L/mn) was positively correlated to WB BMC ($r = 0.82$; $p < 0.001$), WB BMD ($r = 0.80$; $p < 0.001$), L1–L4 BMD ($r = 0.73$; $p < 0.001$), TH BMD ($r = 0.80$; $p < 0.001$), and FN BMD ($r = 0.85$; $p < 0.001$). In men, VO_2 max (expressed as L/mn) was positively correlated to WB BMC ($r = 0.57$; $p < 0.001$), WB BMD ($r = 0.53$; $p < 0.001$), L1–L4 BMD ($r = 0.50$; $p < 0.001$), TH BMD ($r = 0.38$; $p < 0.01$), and FN BMD ($r = 0.30$; $p < 0.05$). In both sexes, the positive associations between VO_2 max and bone variables (BMC and BMD) remained significant after adjustment for age ($p < 0.001$). This study suggests that VO_2 max (L/mn) is a positive determinant of BMC and BMD in young adults. Aerobic power seems to be a determinant of BMC and BMD in young adults.

Key Words: Aerobic performance; osteoporosis prevention; peak bone mass.

Introduction

Peak bone mineral density (BMD) attained at the third decade of life is considered as one of the strongest predictors of fracture risk later in life *(1–11)*. Although several studies have shown associations between anaerobic power and BMD *(1–3)*, little is known concerning the relation between aerobic power and BMD in young adults *(4–6)*. Maximal oxygen uptake (VO_2 max) is the maximum rate of oxygen consumption as measured during incremental exercise *(4–6)*. VO_2 max is widely accepted as the single best measure of cardiovascular fitness and maximal aerobic power *(4–6)*. VO_2 max is expressed either as an absolute rate (L/min) or as a relative rate (mL/mn/kg) *(4–6)*. The aim of this study was to explore the relation between maximal oxygen consumption (VO_2 max) and bone variables (bone mineral content [BMC] and BMD) in a group of young Lebanese adults.

Received 12/04/13; Revised 12/23/13; Accepted 01/17/14.

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Materials and Methods

Subjects and Study Design

Twenty women and 37 men whose ages range from 18 to 32 yr participated in this study. The 57 participants were

recruited from 2 private universities located in North Lebanon. All participants were nonsmokers and had no history of major orthopedic problems or other disorders known to affect bone metabolism. Other inclusion criteria included no diagnosis of comorbidities and no history of fracture. Moreover, women participating in this study were not pregnant and had not taken hormonal contraceptives for the past 6 mo. This study did not include extremely obese (body mass index [BMI] >40 kg/m^2) subjects or extremely lean (BMI <16 kg/m^2) subjects. An informed written consent was obtained from the participants. This study was approved by the University of Balamand Ethics Committee.

Anthropometrics

Height (cm) was measured in the upright position to the nearest 1 mm with a standard stadiometer. Body weight (kg) was measured on a mechanic scale with a precision of 100 g. The subjects were weighed wearing only underclothes. BMI was calculated as body weight divided by height squared (kg/m^2). Body composition was evaluated by dual-energy X-ray absorptiometry (DXA) (GE Healthcare; Madison, WI).

Bone Variables

BMC (g) and BMD (g/cm^2) were determined for each individual by DXA at whole body (WB), lumbar spine (L1−L4), total hip (TH), and femoral neck (FN) (GE Healthcare, Madison, WI). FN cross-sectional area (CSA), FN section modulus, and FN strain index were also evaluated by DXA. In our laboratory, the coefficients of variation were $<1\%$ for BMC and BMD *(12)*. The same certified technician performed all analyses using the same technique for all measurements.

Daily Protein Intake

The estimation of the daily protein intake (DPI) was based on a frequency questionnaire *(13)*.

Daily Calcium Intake

The estimation of the daily calcium intake (DCI) was based on a frequency questionnaire *(14)*. Selection of items was based on the food composition diet, frequency of use, and relative importance of food items as a calcium source. The total number of foods was 30 items. The questionnaire included the following food items: milk and dairy products, including calcium-enriched items such as yogurt, cheese, and chocolate. Items such as eggs, meat, fish, cereals, bread, vegetables, and fruits were also included. Adequacy of calcium in the subjects was assessed using the adequate intake guidelines of 1000 mg of calcium *(14)*.

Sleep Quality

The estimation of the sleep quality index was evaluated using a self-reported questionnaire *(15)*.

Physical Activity

The duration of physical activity (h/wk) was evaluated using a validated questionnaire *(16)*.

VO_2 Max Testing

We directly assessed VO_2 max of the participants using a Cosmed Fitmate pro device (version 2.20) while exercising on a bicycle ergometer (Siemens-Elema RE 820; Rodby Elektronik AB, Enhorna, Sweden). A progressive 2-min step protocol (20−30 W/step) was used as previously described *(17,18)*.

Blood Samples

Serum 25-hydroxyvitamin D level was measured by the Nichols Advantage competitive binding chemiluminescence immunoassay. Serum intact parathyroid hormone (PTH) was measured using the Nichols Advantage 2-site chemiluminescence immunoassay.

Statistical Analysis

The means and standard deviations were calculated for all clinical data and for the bone measurements. Comparisons between the 2 groups (males and females) were made after checking for Gaussian distribution. If Gaussian distribution was found, parametric unpaired t tests were used. In other cases, Mann-Whitney U-tests were used. Associations between clinical characteristics and bone data were given as Pearson correlation coefficients. Multiple linear regression analysis models were used to test the relationship of DXA variables with lean mass and VO_2 max, and with VO_2 max and age, and r^2 were reported. Data were analyzed with Number Cruncher Statistical System (NCSS; Kaysville, UT). A level of significance of $p < 0.05$ was used.

Results

Clinical Characteristics and Bone Variables of the Study Population

Age, morphological characteristics, dietary intakes, serum vitamin D, serum PTH, physical activity (h/wk), VO_2 max, Pittsburgh Sleep Quality Index, and bone variables (BMC, BMD, and geometric indices of hip bone strength) of the study population are listed in Table 1. There were significant differences between the 2 groups (males and females) regarding morphological characteristics, DCI, DPI, physical activity (h/wk), VO_2 max, and some bone variables (Table 1).

Correlations Between VO_2 Max (L/mn) and Anthropometrical Characteristics

In men, VO_2 max (L/mn) was positively correlated to weight ($r = 0.62$; $p < 0.001$) and lean mass ($r = 0.76$; $p < 0.001$). In women, VO_2 max (L/mn) was positively correlated to weight ($r = 0.55$; $p < 0.05$) and lean mass ($r = 0.81$; $p < 0.001$).

Correlations Between Clinical Characteristics and Bone Variables in Men

Weight, BMI, lean mass, and VO_2 max (L/mn) were positively correlated to WB BMC, WB BMD, L1−L4 BMD, TH BMD, FN BMD, CSA, cross-sectional moment of inertia, and