Original Article

Comparison of body composition between professional sportswomen and apparently healthy age- and sex-matched controls

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ABSTRACT

Introduction: In view of the relationship between physical activity and nutrition on body composition, we assessed lean and fat mass and BMC (total and regional) in professional Indian sportswomen and compared it with apparently healthy age- and sex-matched females. **Materials and Methods:** This cross-sectional study included 104 sportswomen and an equal number of age-matched normal healthy females (controls). They were evaluated for anthropometry and body composition (fat, lean mass, and bone mineral content (BMC) by DXA. **Results:** Mean age (19.1 ± 1.3 vs. 19.4 ± 1.5 years) and body mass index (21.34 ± 3.02 vs. 21.26 ± 4.05 kg/m^2) were comparable in both groups. Sportswomen had higher intake of energy, macronutrients, calcium, phosphorus and magnesium. Total lean mass (33.67 ± 3.49 vs. 31.14 ± 3.52 kg, $P < 0.0001$), appendicular skeletal muscle index (5.84 ± 0.57 vs. 5.46 ± 0.63 kg/m^2; $P < 0.0001$) and BMC (2.27 ± 0.32 vs. 2.13 ± 0.34 kg, $P < 0.002$) was significantly higher and percentage fat mass was significantly lower (33.1 ± 7.5 vs. 37.0 ± 8.3; $P < 0.0001$) among sportswomen when compared to controls. **Conclusions:** Indian sportswomen have a higher total and regional lean mass, BMC, and lower percentage fat mass when compared with healthy females. Physical activity, energy, protein and calcium intake were positively associated with lean mass and BMC.

Key words: Bone mineral content, fat mass, lean mass, nutrition, physical activity

Introduction

Body composition is not only influenced by genetic and environmental factors, but also by physical activity and nutritional factors.[1] However, there are conflicting reports in the literature.[2,3] Mechanical stress related to physical activity is sensed by osteocytes and stimulates accrual of bone mineral content.[4] Both muscle and fat tissues contribute to this mechanism, by applying stress and load on bones. The absolute mass of both muscle and fat are beneficial for loading on bones.[5]

Lean mass along with fat and bone constitutes body mass index (BMI), which is positively correlated with bone mineral content (BMC) and bone mineral density (BMD).[6,7] Muscle and fat mass increases during adolescence and peaks in the fourth decade.[1,7] Sports activity influences mechanical stress as well-nutritional status of an individual, hence it is likely to affect body composition. However, there are few studies evaluating difference between body compositions of women involved in daily regimented physical activity involving sports as compared to routine activity.[8-11]

Hence, we undertook this study with the objective to assess the effect of physical activity and nutrition on body composition in professional sportswomen and age- and sex-matched healthy controls.

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Materials and Methods

We have retrieved data of body composition (fat, lean and BMC) and its distribution from the records of 104 young sportswomen and 104 healthy age-matched (±1 year) controls from our earlier studies.[6,7] These sportswomen belonged to different colleges affiliated to the University of Delhi. A study subject was defined as a sportswoman, if she represented either her college or the State of Delhi in competitions for either individual or team sports. These were compared with 104 age-matched healthy female controls from our earlier study,[7] who were involved in less than 150 min of physical activity per week. Females with hepatic, renal, neoplastic, gastrointestinal, dermatological and endocrine and systemic infective disorders, steroid intake or alcoholism were excluded. Demographic, anthropometric and clinical data were ascertained and a detailed physical examination conducted. The study was approved by the ethics committee of the Institute of Nuclear Medicine and Allied Sciences and all subjects gave written informed consent.

Nutritional data were available in the records of 90 sportswomen and 52 controls, which were collected using well-established 24-h dietary recall. Dietary assessment of energy, protein, carbohydrate, total fat, dietary fiber, calcium and phosphorous was calculated using nutritive value of Indian foods.[12]

Fasting blood samples were drawn for the estimation of serum 25OHD, intact parathyroid hormone (iPTH), total and ionized calcium, inorganic phosphorus, and alkaline phosphatase (ALP). The normal range for different biochemical parameters are as follows: serum total calcium –2.2-2.55 mmol/L, ionized calcium 1.12-1.32 mmol/L, inorganic phosphorus 0.9-1.5 mmol/L, and alkaline phosphatase <240 U/L. The serum concentrations of 25OHD (reference range: 22.5-94 nmol/L) and PTH (reference range: 10-65 ng/L) were measured by RIA (Diasorin, Stillwater, MN) and electrochemiluminescence assay (Roche diagnostics, GMDH-Manheim, Germany), respectively.

Lean and fat mass (total and regional distribution) and BMC at leg, arm, trunk and total body was measured using the Prodigy Oracle (GE Lunar Corp., Madison, WI) according to standard protocol. Quality control procedures were carried out in accordance with the manufacturer's recommendations. Instrument variation was determined regularly using a phantom supplied by the manufacturer and mean coefficient of variation was <0.5%. For *in vivo* measurements, mean coefficients of variation for all sites were <1%. Appendicular skeletal muscle mass index (ASMI) was calculated by lean mass at arms and leg in kilogram divided by square of height in meters.

Statistical analysis was carried out using SPSS Version 20.0 (SPSS Inc., Chicago, IL, USA). Data were presented as mean ± SD or number (%) unless specified. Significance levels were analyzed by Student's *t*-test. If Bartlett's Chi-square test for equality of population variances was <0.05, then Kruskal–Wallis test was applied. Pearson correlation coefficient was used to assess relationship between BMC, fat and lean mass. A $P < 0.05$ was considered statistically significant.

Results

This study included 104 sportswomen (18-21 years), with mean age and BMI of 19.1 ± 1.3 years and 21.34 ± 3.02 kg/m^2 and 104 age-matched healthy females (controls) [Table 1]. Sportswomen had higher serum 25OHD and lower PTH and ALP levels when compared to controls. Dietary intake of energy, macronutrients, calcium, phosphorus and magnesium was higher in sportswomen when compared to controls [Table 2].

In sportswomen, total and regional lean mass and BMC were higher, while total and regional fat mass were not significantly different from controls. However, total and regional percent fat mass were significantly lower in sportswomen than controls [Table 3]. Total and regional lean mass and ASMI remained significantly higher among sportswomen after adjustment for age, height, 25OHD, PTH and ALP when compared to controls except in arm. The difference between fat mass and percent fat mass disappeared when adjusted for age, height, 25OHD, PTH and ALP. Only leg BMC was higher in sportswomen when adjusted for above-mentioned parameters. Total BMC was higher in sportswomen even after adjustment for total lean and fat mass when compared to controls (2.24 vs. 2.16, $P = 0.022$).

Table 1: Basic characteristics of sportswomen and normal healthy controls

	Sportswomen (*N*=104)	Normal controls(*N*=104)	*P* value
Age (years)	19.1±1.3	19.4±1.5	0.098
Weight (Kg)	53.8±8.9	52.9±10.1	0.464
Height (m)	1.59±0.06	1.58±0.05	0.244
BMI (Kg/m^2)	21.34±3.02	21.26±4.05	0.870
S 25OHD (ng/ml)	21.6±7.5	9.1±4.3	<0.0001
iPTH (pg/ml)	34.8±17.5	47.8±26.0	<0.0001
ALP	193±51	251±67	<0.0001

*BMI: Body mass index, S 25OHD-serum 25 dihydroxy vitamin D, iPTH: Intact parathyroid hormone, ALP: Alkaline phosphatase

Table 2: Dietary intake of nutrients among sportswomen and normal healthy controls

	Sportswomen (*N* = 90)	Normal controls(*N* = 52)	*P* value
Energy (Kcal)	2020±579	1450±277	<0.0001
Protein (gm)	56.9±18.4	39.6±11.4	<0.0001
Carbohydrate (gm)	297.4±82.7	215.7±52.6	<0.0001
Fat (gm)	62.54±7.1	47.4±8.7	<0.0001
Fibers (gm)	8.1±2.6	4.7±1.3	<0.0001
Calcium (mg)	784±327	172±80	<0.0001
Phosphosporus (mg)	1181±414	958±218	<0.0001
Magnesium (mg)	390±143	276±72	<0.0001
Vitamin D (ng)	0.16±0.23	0.19±0.26	0.517

Table 3: Body composition of sportswomen and normal healthy controls

	Sportswomen (*N*=104)	Normal controls(*N*=104)	*P* value
Total lean mass (Kg)	33.67±3.49	31.14±3.52	<0.0001
Trunk lean mass (Kg)	16.04±1.81	14.68±1.67	<0.0001
Leg lean mass (Kg)	11.41±1.44	10.52±1.39	<0.0001
Arm lean mass (Kg)	3.33±0.53	3.08±0.55	<0.0001
ASMI (kg/m^2)	5.84±0.57	5.46±0.63	<0.0001
Total fat mass (Kg)	17.3±6.8	19.3±7.7	0.053
Trunk fat mass (Kg)	8.5±3.6	9.5±4.3	0.093
Leg fat mass (Kg)	6.9±2.6	7.5±2.6	0.034
Arm fat mass (Kg)	1.5±0.7	1.7±0.8	0.080
Total fat percent	33.1±7.5	37.0±8.3	<0.0001
Trunk fat percent	33.6±8.4	37.4±9.6	0.003
Leg fat percent	36.0±7.3	40.4±7.6	<0.0001
Arm fat percent	30.2±7.8	33.9±9.0	0.002
Total BMC (Kg)	2.27±0.32	2.13±0.34	0.002
Trunk BMC (Kg)	0.74±0.14	0.68±0.16	0.008
Leg BMC (Kg)	0.83±0.13	0.76±0.13	<0.0001
Arm BMC (Kg)	0.26±0.04	0.24±0.04	<0.0001

*ASMI: Appendicular skeletal muscle mass index, BMC: Bone mineral content

Total and leg BMC were more related to total (sportswomen: r = 0.595, $P < 0.0001$; controls: r = 707, $P < 0.0001$) and regional lean mass (sportswomen–arm: r = 0.801, $P < 0.0001$; leg: r = 0.732, $P < 0.0001$) than total (sportswomen: r = 0.493, $P < 0.0001$; controls: r = 0.680, $P < 0.0001$) and regional fat mass (sportswomen–arm: r = 0.491, $P < 0.0001$; leg: r = 0.539, $P < 0.0001$) in both groups. Trunk BMC correlated more with total (sportswomen: r = 0.680, $P < 0.0001$; controls: r = 0.765, $P < 0.0001$) and regional fat mass in both groups. Arm BMC showed no relationship with total or regional fat or lean mass in control groups (total fat mass: r = 0.010, $P = 0.921$; total lean mass: r = 0.011, $P = 0.011$), whereas it showed strong correlation with total and regional lean mass among sportswomen (total fat mass: r = 0.491, $P < 0.0001$; total lean mass: r = 0.801, $P < 0.0001$).

Discussion

Since nutrition and physical activity influence development of body composition,[1] we decided to estimate lean and fat mass in women involved in daily regimented physical activity involving sports as compared to age- and sex-matched controls. As reported in other populations, sportswomen in the present study had significantly higher total and regional lean mass, and ASMI compared with age-matched healthy controls.[1,9] A similar study among young girls (8-10 years) also showed positive effect of physical activity on lean mass.[9] However, the influence of physical activity and nutrition on sarcopenia in the elderly is inconsistent.[2] This suggests that the major effect of these influences occurs in early life when peak muscle and bone mass is being acquired.

Sportswomen had higher BMC (total and regional) when compared to controls. A study reported 12-19% more BMC in physically active young girls (8-10 years),[8] as compared to a difference of 6-9% between the two groups in the present study. This may reflect difference in age and intensity of physical activity in two studies. The skeleton's sensitivity to mechanical loading diminishes with age[11] and physical activity influences the bone to a greater extent before puberty than after puberty,[1] which may also explain the difference in the two studies. Moreover, total cortical area is correlated with the lean mass,[13] which was higher in sportswomen.

Sportswomen had significantly higher intake of energy and macronutrients when compared to controls. These findings are in agreement with other studies reporting nutrient intake in sportswomen as compared to their sedentary counterparts.[1,14,15] The higher protein intake of sportswomen may be a factor responsible for higher lean mass in these subjects as also reported by other investigators.[16,17] A higher daily intake of calcium and magnesium in sportswomen in contrast to controls in present study was consistent with the observations made by other investigators regarding association of calcium and magnesium intake and lean mass in females.[18,19]

It has been suggested that, it is the absolute mass of muscle as well as fat that is beneficial for mechanical loading on bones and that relative proportion of fat and lean mass may not be so relevant in terms of loading impact on bones.[5,8,10] In the present study, though no significant difference in total and regional fat mass was observed between the two groups, significantly lower percentage of fat mass in sportswomen suggested relatively higher lean and bone mass. This difference in BMC between the sportswomen and controls could have possibly been contributed by higher lean mass than fat mass as a result of regular physical activity and good nutrition.

The main limitation of the study was the absence of data on muscle strength and physical performance, which prevented us from reporting data on prevalence of sarcopenia.

Conclusions

Indian sportswomen have a higher total and regional lean mass and BMC, but comparable fat mass than healthy females. Physical activity and good nutrition had positive impact on lean and bone mass.

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