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Bone mineral density, lipid profile and body composition: a comparison of swimmers, runners and controls

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Abstract
The aim of this study was to compare bone mineral density, lipid profile and body composition among swimmers, runners and control group. The study was conducted on three groups of individuals, i.e., swimmers (n=14), runners (n=08), and physically active healthy individuals (controls, n=15). Body composition and bone mineral density were evaluated by DXA, and the lipid profile (total cholesterol - TC, HDL - cholesterol, LDL- cholesterol and triglycerides - TG) was analyzed by the automatic spectrophotometric method. Swimmers and runners had a lower percent fat and fat mass and a greater amount of lean mass compared to control ($p<0.05$). Regarding changes in lipid profile, the swimmers had a higher concentrations of HDL-cholesterol, LDL-cholesterol, TC and triglycerides than controls ($p<0.05$), whereas the runners had a lower concentration of HDL-cholesterol and a higher concentration of triglycerides ($p<0.05$). Despite the body benefits, high-performance sport practice causes a factors for cardiovascular diseases.

Keywords: Athletics, body composition, lipid profile, bone mineral density

1. Introduction
Moderate physical exercise has been accepted as a cardiovascular protector [1, 2] and is also known to provide some beneficial adaptations in body composition [3, 4]. Like the cardiovascular adaptations, body composition adapts according to the stimulus received; for instance, intensity and specificity are determinant factors for sport performance [5].
In this respect, the best performances are observed in individuals with the most favorable characteristics for the sport in question, with the appropriate anthropometric characteristics being considered to be determinant factors for which sport performances [6]. Compartmental anthropometric evaluation implies the quantitation of the major components of the body such as fat, muscles, bones, and visceral mass [7]. In high-performance athletes, the evaluation of body composition by means of simpler methods and especially by the body mass index (BMI) may lead to controversial results since muscle mass is denser and weighs more than fat [8].
Several studies have shown the benefit of sport practice regarding body aspects [9, 10, 11], showing an increase in muscle mass quantity and a decrease in body fat. Also, regarding bone mineral density (BMD), studies have stated that sports involving activities with ground impact or epiphyseal torque due to muscle activity promote increase bone density [12, 13].
Considering the modifications associated with physical exercise, it seems reasonable to ask whether the practice of intense and sustained physical exercise such as that performed by elite athletes can lead to an increase in oxidative stress, provoking an increased risk of cardiovascular diseases since reactive oxygen species (ROS) resulting from excessive effort may contribute to the onset and progression of atherosclerotic lesions, favoring the infiltration and accumulation of lipids in the subendothelial space [14]. On this basis, the objective of the present study was to compare bone mineral density, lipid profile and body composition among swimmers, runners and control group.

2. Materials and methods

The participants included in the study were 14 swimmers (experts in tests of 50 to 400 meters) of the swimming team of the University of Ribeirão Preto – UNAERP, Ribeirão Preto – SP, Brazil, 08 runners (experts in tests of 100 to 400 meters) of the track team of Ribeirão Preto – SP, and 15 healthy individuals practicing physical activity in a recreational manner, students of the Physical Education Course of the School of Physical Education and sports of Ribeirão Preto – USP. All participants were males. The individuals gave written informed consent to participate in the study and were submitted to the procedures included in the proposed protocol.

Inclusion criteria were: at least four years of uninterrupted high-performance sport practice and being classified for the State and/or National Championship of their respective modalities.

Prospective volunteers with obvious gait abnormalities or musculoskeletal disorders were excluded from the study.

The anthropometric characteristics evaluated were body weight (Wt) and height (Ht), determined with a Filizola Electronic ID 1500 precision platform scale (São Paulo, SP: Brazil) with 0.1 g precision and a stadiometer with 0.5 cm precision. BMI was calculated by the formula: BMI= Wt (kg)/Ht (m) [2].

Body composition and BMD were evaluated by DXA (Hologic QDR 4500 W®; Bedford, MA, USA) with whole body scanning and exposure to different levels of energy, i.e., 70 and 140 kilovolts. The apparatus was calibrated daily using a standard object for bone mass and another object for the soft parts.

The X-ray photons passed through the body segments and were analyzed with a software. The results of the exam provided data regarding body fat and lean mass (muscles and viscera) and which were used to obtain total body weight in grams and percent fat mass.

For the exam, the participants wore light clothing and were asked to remove metal artifacts. When this was not possible, the “artifact” tool of the software was used to isolate the area of the device.

The participants was positioned in dorsal decubitus by the technician in charge and centered on the table of the scanner, with the central line of the table being used as reference, and with the lower limbs tied together with Velcro tape.

The hands of the individuals were supposed to be opened with the palms resting on the examining table and with the arms stretched along the body and lying within the lines of the scanning area on the cushion of the table.

The reading arm slid in a straight line along the individual’s body at a distance of 80 cm scanning the participants from head to feet. The detector captured the information associated with the attenuation of the photon beams after passage through the body of the participants and fed it to a microcomputer for analysis with a specific software. The entire procedure was carried out according to manufacturer recommendations.

For the determinations of total cholesterol (TC), HDL-cholesterol (HDL-C) and triglycerides (TG), the participants were asked to fast for 12 hours and blood samples were collected into a dry tube and subjected to the automatic spectrophotometric method with an Integra 400 instrument in the Laboratory of Nutrition of the University Hospital of Ribeirão Preto.

The procedures and analytical methods used in the study were approved by the Research Ethcis Committee of the University Hospital, Faculty of Medicine of Ribeirão Preto - USP (nº1609/2011).

Data are reported as arithmetic means ± SD. Statistical analysis was carried out by ANOVA using the SAS® software, version 9.0 (2002) (Cary, NC, USA). The level of significance adopted was 5% ($p<0.05$).

3. Results & Discussion

The anthropometric characteristics and the age of the three groups are listed in Table 1. Data are reported as mean ± SD.

The distribution of body composition is presented in Table 2, which shows that the swimmers had a greater amount of lean mass (g) in all segments evaluated compared to the control group ($p<0.05$), as well as a reduction of percent fat and fat mass (g) at all sites evaluated ($p<0.05$), whereas no significant differences in BMD were observed (Table 3).

The runners presented a higher lean mass (g) in the upper limbs (UL), lower limbs (LL) and in the subtotal amount ($p<0.05$), as well as a decrease of percent fat and fat mass (g) at all sites evaluated ($p<0.05$). Curiously, analysis of the BMD of runners showed a lower in the arms ($p<0.05$) and a higher the hips ($p<0.05$) (Table 3).

The main differences between groups were detected in the lean mass of the LL ($p<0.05$), which was greater in runners compared to swimmers, and in percent fat of the trunk and subtotal percent fat ($p<0.05$), in addition to a greater fat mass in the UL and trunk ($p<0.05$).

Of the groups studied (Table 4) showed that the swimmers had higher HDL-cholesterol ($p<0.05$), LDL–cholesterol ($p<0.05$) and TC ($p<0.05$) values, while the runners showed a lower of HDL-cholesterol ($p<0.05$). The athletes differed only regarding TC ($p<0.05$), with swimmers showing greater concentrations.

Competitive sports practice involves great adaptations on the part of the athlete, with those related to anthropometric parameters being most easily visualized. Several studies have evaluated the distribution of this body composition.

In the present study we observed that the athletes had a higher lean mass than controls and a lower of percent fat and fat mass compared to the control group, in agreement with previous studies [9, 10, 15], although the distribution of body composition varies according to the sport practiced. The swimmers presented a higher lean mass in all segments evaluated, in contrast to the runners, who only showed a lower in the UL and LL which generated an increase in the subtotal amount of lean mass. This better distribution of lean mass through the body of the swimmers may have been due to the fact that swimming is characterized by movements of the entire body, with the arms accounting for most of the swimmer’s propulsion, while the trunk must perform rotation movements in order to improve the sliding of the swimmer, and the legs are mainly characterized by providing support to the athlete [16]. This overall movement can favor a higher lean mass in all body segments.

In the runners there was a higher the amount of lean mass in the UL and LL, also when compared to the swimmers, as also reported in a previous study [10]. This higher lean mass in the LL was expected since the LL are the only segments responsible for the locomotion of these athletes. However, we also observed a higher the amount of lean mass in the UL of the runners, which leads us to hypothesize that this higher was due to the physical training with weights. In addition to promoting the body balance necessary during a race [17], the arms may help the athlete to achieve greater velocity, with improved performance during training and in competitions.

The remaining body adaptations observed concerned adipose tissue and BMD. As a result of the high energy expenditure during training, we noted a reduction of percent fat and fat mass (g) in the athletes of both sports, in agreement with previous reports [9, 10]. As also observed in previous studies [10, 18], we detected a higher BMD in athletes involved in activities requiring impact on the ground. However, this higher occurred only in the segments subjected to impact, i.e., the improved bone density due to exercise mainly occurs in the segments involved in the sports gesture.

In order to generate the body adaptations observed here, these athletes were submitted to intensive training programs which may promote metabolic changes. Evaluation of the lipid profile may detect possible changes in lipid metabolism that may determine possible cardiovascular injuries.

In the present study we noted that, even though the swimmers had the highest concentrations of parameters related to cardiovascular protection (HDL-cholesterol), curiously they also presented higher concentrations of LDL-cholesterol, TG and TC, which are risk factors for cardiovascular diseases. In contrast, the runners did not present a lower concentration of HDL-cholesterol, but they also presented higher concentrations of LDL-cholesterol. Some of our results agree with studies in which a higher HDL-cholesterol was reported as a result of regular physical exercise [14, 19]. However, as also observed in previous studies, the swimmers showed greater risk factors that may have been associated with the ROS resulting from intense training [5, 14]. ROS are normally produced by body metabolism and may be intensified by physical exercise, which also promotes muscle injuries and inflammation [20]. ROS are able to remove electrons from other cell compounds and to provoke lipid peroxidation and oxidative injuries in various molecules, a fact that leads to a total loss of cell function [20, 21].

Previous studies have shown that swimmers may produce a larger amount of ROS compared to other sports mainly due to swimming training which consists of the execution of aerobic and anaerobic exercises that induce a high level of stress during training in high-performance athletes [14].

On this basis, changes in the lipid profile of athletes can occur due to the intensity and duration of training, causing an increase in the risk factors for cardiovascular diseases.

Table 1: Anthropometric characteristics in participants

	Swimmers	Runners	Control Group
Age (years)	20.38 ± 2.6	23.6 ± 4.3	20.6 ± 3.5
Body Mass (kg)	74.95 ± 4.9	76.3 ± 4.3	74.1 ± 9.6
Height (cm)	1.80 ± 0.0	1.85 ± 0.0	1.78 ± 0.0
BMI (kg/cm^2)	23.22 ± 1.5	22.3 ± 2.1	23.4 ± 2.6

Table 2: Comparison of body composition in participants

	Control Group	Runners	Swimmers
Lean Mass UL (kg)[a.b.]	3.22 ± 7.53	3.54 ± 0.64	3.55 ± 0.21
Lean Mass Trunk (kg) [a.]	24.56 ± 3.27	27.12 ± 2.88	27.33 ± 1.56
Lean Mass LL (kg)[a.b.c]	9.08 ± 9.76	11.17 ± 1.54	9.94 ± 0.53
Subtotal Lean Mass (kg)[a.b]	49.61 ± 6.30	57.20 ± 6.87	54.65 ± 2.67
% Fat UL[a.b]	21.1 ± 3.3	13.3 ± 1.7	15.6 ± 3.5
% Fat Trunk[.b.c]	22.0 ± 3.0	13.2 ± 1.9	16.5 ± 3.7
% Fat of the LL[a.b]	25.2 ± 3.2	14.2 ± 2.4	19.0 ± 5.5
Subtotal % Fat[.b.c]	23.4 ± 3.0	13.4 ± 1.8	17.2 ± 4.2
Fat Mass UL (kg)[a.b.c]	0.90 ± 2.47	0.57 ± 0.10	0.69 ± 0.17
Fat Mass Trunk (kg)[a.b.c]	7.21 ± 1.61	4.28 ± 0.89	5.59 ± 1.52
Fat Mass LL (kg)[a.b]	3.29 ± 0.69	1.97 ± 0.49	2.55 ± 0.89
Subtotal Fat Mass (kg)[a.b]	15.74 ± 3.35	9.26 ± 1.93	11.94 ± 3.43

[a] *p*<0.05 Swimmers Vs. Control Group; [b] *p*<0.05 Runners Vs. Control Group; [c] *p*<0.05 Swimmers Vs. Runners

Table 3: Comparison of bone mineral density in participants Control Group Runners Swimmers

BMD Forearm 1/3 (g/cm^2)[b]	**0.775 ± 0.03**	**0.747 ± 0.05**	**0.785 ± 0.04**
BMD Total Spine(L1-L4) (g/cm^2)	1.05 ± 0.14	1.12 ± 0.11	1.04 ± 0.07
BMD total Hip (g/cm^2)[b, c]	1.063 ± 0.14	1.245 ± 0.10	1.102 ± 0.12
BMD Femoral Head[c] (g/cm^2)	1.027 ± 0.13	1.144 ± 0.13	1.027 ± 0.12
Subtotal (BMD g/cm^2)	1.170 ± 0.08	1.268 ± 0.13	1.216 ± 0.08

[a] *p*<0.05 Swimmers Vs. Control Group; [b] *p*<0.05 Runners Vs. Control Group;
[c] *p*<0.05 Swimmers Vs. Runners

Table 4: Comparison of lipid profile of the groups evaluated

	Swimmers	Runners	Control Group
HDL - cholesterol (mmol/l) [a, b]	46.4 ± 6.5	41.0 ± 7.2	45.6 ± 7.5
LDL - cholesterol (mmol/l) [a]	120.5 ± 27.1	100.5 ± 32.5	92.6 ± 18.39
Total cholesterol (mmol/l) [a, c]	181.43 ± 31.1	152.63 ± 37.5	151.6 ± 22.3
Triglycerides (mmo/l)	72.2 ± 28.88	56.3 ± 9.33	67.4 ± 29.55

[a] *p*<0.05 Swimmers vs. Control Group
[b] *p*<0.05 Runners vs. Control Group
[c] *p*<0.05 Swimmers vs. Runners

4. Conclusion

The present study demonstrated that the anthropometric benefits associated with sport practice are enormous, although each sport has its own pattern related to the sport gesture. Athletes of both sport modalities presented a reduction of percent fat and fat mass; however, regarding lean mass, the swimmers presented a higher and better distribution throughout the body, while the runners presented a higher mainly in the LL and UL, which are responsible for a good sport performance. However, changes in lipid profile were found, showing that, despite the bodily benefits, high-performance sports practice may lead to metabolic change due to the intense stress suffered during training and competitions, thus causing a higher of the risk factors for cardiovascular diseases.

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