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Original Article

Diet, Body Composition, and Bone Mass in Well-Trained Cyclists

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Abstract

Cycling is believed to be associated with low bone mass. In this study, we investigate food intake, body composition, and bone mass in well-trained young adult cyclists compared with those in sedentary controls. Four-day estimated diet records were used to study dietary intake in 31 cyclists and 28 sedentary controls (all male, 24 yr old on average), together with maximal oxygen uptake (VO_{2max}), body composition, and bone mass measurements (dual-energy X-ray absorptiometry). The VO_{2max} values were twice as high as those in the cyclists, whereas no significant difference in bone mass was observed between cyclists and controls. A total of 10 cyclists and 9 controls had low bone mass. Total-body lean mass and appendicular skeletal muscle mass were higher in cyclists ($p < 0.001$), whereas percentage of body fat was lower ($p < 0.001$) compared with that of the controls. Energy and macro- and micronutrient intake was higher in the cyclists than in the controls ($p < 0.01$). Energy consumption was considered adequate in the cyclists, whereas lipid and protein intake was higher than the American College of Sports Medicine recommendation. Lipid consumption negatively correlated with bone mass in the athletes. Our results demonstrate that cycling was associated with greater aerobic conditioning and lean mass without significant association with bone mass compared with sedentary controls.

Key Words: Body composition; bone mass measurements; nutrition and cycling.

Introduction

Sport has a significant impact on the athletes' body composition, and this effect varies according to the type of sport. Cycling is mainly an endurance modality, and cyclists usually have reduced percentage of body fat, increased skeletal muscle mass, and higher maximal oxygen uptake (VO_{2max}) when compared with those in healthy sedentary individuals (1–3).

Several studies have demonstrated that athletes have higher bone mineral density (BMD) compared with that in nonathletes (4–7). Moreover, it has been demonstrated that BMD is associated more with body lean mass than with fat mass (8). Strength and VO_{2max} are also associated with higher bone mass (5). Different from other sports, cycling does not seem to benefit bone health, and this is probably related to the fact that cycling is not a weight-bearing or impact-loading activity. Some authors have not found significant difference in bone mass between cyclists and controls. Lower BMD and higher risk for osteoporosis have been observed in male master cyclists (9–12). On the other hand, recent analysis on master cyclists suggested that competition-based cycling and the associated training regime is beneficial in preserving average or above-average bone strength surrogates into old age in men (13).

Nutritional status is especially relevant for bone mass acquisition and maintenance as well as for achieving the best performance in sports (14,15). Micro- and macronutrients have an important role in bone health. Calcium, phosphorus, and magnesium have an important role in bone mineralization. Among the macronutrients, protein seems to be the most relevant element for bone status. Protein excess is associated with higher renal excretion of calcium and higher bone resorption (16–19). The association between protein intake and bone health is not as straightforward as it would suggest.

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It has been demonstrated that the reason for the increased renal excretion of calcium on a high-protein diet is the result of increased calcium absorption (20). It is still not known whether the lack of positive effect of cycling on bone mass is because of the type of exercise itself and its relative absence of loading or because of other confounding factors, such as dietary habits.

In the present study, we compare BMD, body composition, and food intake between well-trained young adult cyclists and sedentary controls. We were interested in investigating the potential correlations between diet, body composition, and bone mass in this particular population.

Experimental Methods

Participants

Participants were all male and included a total of 31 cyclists and 28 sedentary controls. Cyclists were 20−30 yr old, euthrophic (body mass index [BMI] = 18.5−24.9 kg/m^2) (21), regularly subscribed to the Brazilian Cycling Confederation, and had participated in competitions in the last 12 mo. All cyclists were out of season. Cyclists were selected randomly from the CEMAFE—Center of Studies in Medicine of the Physical Activity and the Sport, Federal University of São Paulo, São Paulo, and all had VO_{2max} higher than 50 mL/kg/min, but that was not a selection criterion for the study. Controls were also 20−30 yr old, had VO_{2max} lower than 45 mL/kg/min (22), and had been sedentary for at least the last 12 mo. Sedentary controls were age-matched to cyclists and were also euthrophic (BMI = 18.5−24.9 kg/m^2).

Individuals practicing other type of sport or training including high-impact activities were excluded from the study. Use of medication that affected bone mass (anabolic steroids, glucocorticoid, diuretics, bisphosphonates, calcitonin, and sodium fluorite) was also an exclusion criterion. Individuals using nutritional supplements were not excluded. As most of the athletes had training regimes that included resistance exercises (weight lifting), this kind of activity was not excluded from the study. The time spent for resistance exercises (weight lifting workout) in the last 12 mo was recorded and used as a covariate in the analyses.

This study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures involving human subjects were approved by the Universidade Federal de São Paulo's Ethics Committee. Written informed consent was obtained from all subjects.

Evaluation Protocol

All participants answered structured questionnaires detailing information on the athletes' career and time of sedentarism (for the controls), previous fracture, and family history of fracture, comorbidities, medication use, smoking, and alcohol consumption. The structured questionnaire included details concerning aspects of lifestyle (alcohol consumption, smoking, and physical activity), diet (current and past consumption of dairy products on a food frequency basis), drug use (diuretics, glucocorticosteroids, bisphosphonates, sodium fluoride, calcitonin, and anabolic steroids), and individual health perception and has been validated in our population and culture (23).

Body weight was measured using a balance beam scale, and height was measured using a stadiometer (Filizola, São Paulo, Brazil). BMI was calculated as BMI = weight (kg)/height^2 (m^2) (24,25). Body composition (lean mass, kg; fat mass, kg; and percentage of fat mass, %) and BMD measurements at the spine (L1−L4), femur (femoral neck, trochanter, and total hip), and whole body were performed in all participants using dual-energy X-ray absorptiometry (DXA and software GE-Lunar version 6.7; GE-Lunar Radiation Corporation, MD plus 73595, Madison, WI). Root mean squared coefficients of variation were 3% and 2%, respectively, for the femoral neck and lumbar spine/whole-body BMD measurements (26). The 2004 Osteoporosis Diagnosis Criteria proposed by the International Society of Clinical Densitometry (ISCD) were used in all participants. Low bone mass was defined as a bone mass measurement that is 2.0 standard deviations below the expected value for the healthy young adult (Z-score below −2.0) (27).

Appendicular skeletal muscle mass index (ASMI) was calculated as the sum of the lean soft tissue masses for the arms and the legs (kg) divided by the squared height (m^2). According to previous studies, ASMI values below 7.26 kg/m^2 indicate sarcopenia in men (28).

The cyclists performed a stepwise incremental exercise test to exhaustion on a cycle ergometer (Monark Ergomedic 818 E, Monark Exercise AB, Stockholm, Sweden), aiming to determine the VO_{2max}. The subjects breathed through a facial mask connected to a low-resistance valve system to guide the expiratory airflow through a pneumotachograph into a metabolic system. Both respiratory and metabolic variables were acquired using metabolic system monitor (SensorMedics−Vmax 29 Series Metabolic Measurement Cart; SensorMedics Corporation, Yorba Linda, CA) (22). The metabolic system was calibrated before each maximal oxygen uptake test, with a commercially prepared gas mixture of a known composition. Reference values for cyclists and sedentary individuals described by Barros et al (2001) (29) were used. The same protocol was used to measure VO_{2max} in the controls (29).

Food intake was measured using a 4-d estimated diet record (3 week days and 1 d on the weekend) as previously described (30). Calculations were performed using the Universidade Federal de São Paulo (UNIFESP's) Nutrition Support Program—NUTWIN (31,32), and the measured parameters included the energy consumption, macronutrients (carbohydrates, proteins, and lipids), and micronutrients (calcium, phosphorus, and magnesium). Recommendations from the American College of Sports Medicine (ACSM, 2000) and from the Brazilian Society of Sports Medicine (2003) were used to evaluate the adequacy of the energy and macronutrient consumption in the athletes (energy: 40−70 kcal/kg; carbohydrates: 5−8 g/kg; protein: 1.2−1.6 g/kg; lipids: up to 1 g/kg) (33,34). The adequacy of the diet in the control individuals was assessed using Dietary Reference Intakes (DRIs) for energy and macro- and micronutrients (35−37).

Table 1
Demographic and Anthropometrical Data and Relative Maximal Oxygen Uptake (VO_{2max}) for Cyclists and Sedentary Controls

	Cyclists (N = 31)		Controls (N = 28)		
Parameters	Mean	SD	Mean	SD	p[a]
Age (yr)	24.7	3.19	26.64	3.04	0.165
Weight (kg)	70.98	9.24	70.00	6.94	0.649
Height (m)	1.75	0.06	1.74	0.05	0.376
BMI (kg/m^2)	22.9	1.82	23.05	1.74	0.805
VO_{2max}	64.41 (N = 26)	7.05	32.81 (N = 26)	4.11	<0.001

Abbr: SD, standard deviation; BMI, body mass index.
[a] Student's *t*-test.

Statistical Analyses

The SPSS/PC (Windows version 11, Statistical Package for the Social Sciences, USA) package was used for all statistical analyses. Data with normal distribution by the Anderson-Darling's test were compared using Student's *t*-test. Non-normal variables were analyzed by Mann-Whitney *U*-test and chi-squared tests. Pearson's correlation analysis was used to test association between continuous variables, whereas Spearman's correlation test was used for non-normal variables. Multiple regression analyses were performed considering BMD measurements (L1−L4, femoral neck, trochanter, total hip, and whole body) as the dependent variable, and all other parameters (body composition, nutritional data) as independent variables. Correlations and models obtained were adjusted for age, weight, lean body mass, and weight lifting workout time. Significance level was set as $p < 0.05$.

Results

Demographic, anthropometrical data and VO_{2max} values for cyclists and controls are shown in Table 1. Data demonstrated that cyclists and controls were not different, except with regard to the VO_{2max}, which was twice as high as in the cyclists compared with the sedentary controls.

Mean career duration for the cyclists was 5.23 ± 3.32 yr, and they dedicated about 21.64 ± 5.21 h per week for the sport (360 ± 45 km/wk). Only 8 athletes practiced weight lifting workout, with mean annual time for the workout of 6.2 ± 4.07 h in the last year. The number of individuals with previous fracture did not differ between athletes and controls ($p = 0.681$), and all the fractures were related to high-energy trauma. Family history of osteoporosis was more prevalent in the controls when compared with the athletes (28.57% and 6.45%, respectively; $p = 0.021$). None of the athletes and only a small number of the controls (2 individuals) were smokers, and no significant difference in this variable was observed between groups ($p = 0.093$). Alcohol use also did not differ between athletes and controls ($p = 0.267$). The use of medication with potential effect on the bone mass was not observed in our sample.

BMD measurements at the spine, hip, and whole body did not differ significantly between athletes and controls, as shown in Table 2. A total of 10 cyclists and 9 controls had

Table 2
Body Composition and BMD Measurements in Well-Trained Cyclists and Sedentary Controls

	Cyclists (N = 31)		Controls (N = 28)		
Parameters	Mean	SD	Mean	SD	p[a]
Fat (%)	10.97	3.71	23.20	6.12	<0.001
Total lean mass (kg)	59.68	6.10	51.09	5.67	<0.001
ASMI (kg/m^2)	9.11	0.69	8.07	0.818	<0.001
Lumbar spine BMD (g/cm^2)	1.159	0.14	1.196	0.15	0.335
Total hip BMD (g/cm^2)	1.085	0.16	1.116	0.14	0.421
Femoral neck BMD (g/cm^2)	1.081	0.16	1.098	0.13	0.657
Trochanter BMD (g/cm^2)	0.911	0.13	0.914	0.13	0.933
Whole-body BMD (g/cm^2)	1.187	0.09	1.234	0.09	0.073

Abbr: SD, standard deviation; ASMI, appendicular skeletal muscle mass index; BMD, bone mineral density.
[a] Student's *t*-test.

Table 3
Energy and Macro- and Micronutrient Consumption in Cyclists and Sedentary Controls

	Cyclists (N = 31)		Controls (N = 28)		
Parameters	Mean	SD	Mean	SD	*p*
Recommended energy (kcal)					
DRIs	4237.7	536.7	2471.9	127.9	<0.001[a]
ACSM	2839.2−4968.8		−		
Consumed energy					
kcal	3280.7	447.7	2302.0	478.4	<0.001[a]
kcal/kg	46.7	7.3	32.9	6.6	<0.001[a]
Carbohydrates					
Raw (g)	484.91	88.54	294.87	74.1	<0.001[a]
g/kg	6.86	1.18	4.23	1.03	<0.001[a]
Energy adjusted[b]	148	12.5	128	10.1	<0.001[a]
Proteins					
Raw (g)	128.26	22.36	96.50	21.79	<0.001[a]
g/kg	1.83	0.41	1.38	0.31	<0.001[a]
Energy adjusted[b]	39	2.8	42	3.2	NS
Lipids					
Raw (g)	90.96	19.31	79.28	20.08	0.027[a]
g/kg	1.30	0.32	1.13	0.26	0.029[a]
Energy adjusted[b]	28	4.3	35	5.7	0.01
Calcium					
Median (g)	1100.1		644.21		<0.001[c]
Energy adjusted[d]	335	27.3	280	25.6	<0.001[c]
Phosphorus					
Median (g)	1305.1		909.05		<0.001[c]
Energy adjusted[d]	398	35.4	430	30.4	NS
Magnesium					
Median (g)	311.20		172.65		<0.001[c]
Energy adjusted[d]	95	14.6	75	11.9	NS

Abbr: SD, standard deviation; DRIs, Dietary Reference Intakes; ACSM, American College of Sports Medicine; raw, raw intake.
[a] Student's *t*-test.
[b] g/1000 kcal.
[c] Mann-Whitney *U*-test.
[d] mg/1000 kcal.

low bone mass according to the ISCD criteria (Z-score below −2.0). Cyclists had significantly higher total lean mass and ASMI than the controls. After the reference cutoff was described to define sarcopenia (28), all the athletes had normal muscle mass, and 4 controls were found to have sarcopenia. The percentage of body fat was twice as high as in the controls than in the cyclists.

Cyclists had significantly higher energy consumption and total energy requirement than the controls. Some macro- and micronutrient consumption was also significantly different between athletes and controls as shown in Table 3. Cyclists had higher energy-adjusted carbohydrate, similar protein, and lower fat intakes compared with those of sedentary controls. Energy-adjusted calcium intake was significantly higher in the athletes, whereas phosphorus and magnesium intakes did not differ between athletes and controls.

According to the recommendation criteria from the ACSM (2000), about 81% of the athletes had energy consumption considered adequate (33). Six cyclists had energy consumption lower than 40 kcal/kg, an insufficient amount for endurance modalities. As shown in Fig. 1, most of the athletes had protein and lipid intake above the ACSM-recommended amounts (protein: 1.2−1.6 g/kg; lipids: up to 1 g/kg).

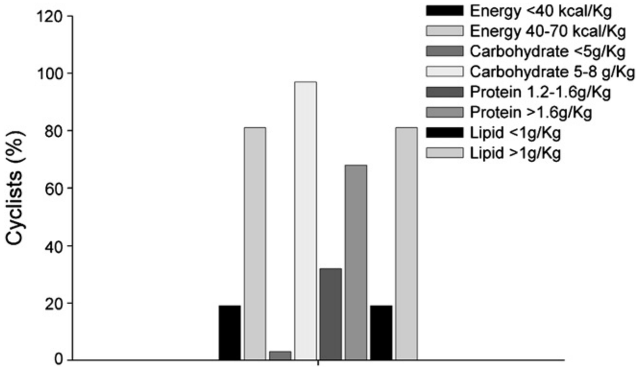

Fig. 1. Percentage of cyclists with adequate energy (kcal/kg), carbohydrate (g/kg), protein (g/kg), and lipid (g/kg) intake according to recommendations from the American College of Sports Medicine (2000) (33).

None of the cyclists reached the target carbohydrate intake of 10 g/kg suggested for endurance activities. On the other hand, about 97% of the athletes had carbohydrate intake between 5 and 8 g/kg, the adequate amount for the athletes. Energy and macronutrient intake in the athletes and its adequacy according to the ACSM recommendation are shown in Fig. 1.

According to the DRIs, most of the controls had energy intake considered adequate (35−37). Using these criteria, the probability of inadequation for protein and carbohydrate intake among the controls was 10.56% (3 individuals) and 3.56% (1 individual), respectively. It is important to point out that both athletes and controls had protein intake superior to the recommended daily allowance (RDA) of 0.8 g/kg. In the athletes, protein intake was more than double the value of the RDA (1.83 ± 0.41 g/kg). Even though neither the RDA nor the ACSM recommendation is considered to be a limit for protein intake and it is indeed an intake that ensures against deficiency, it is important to remember that increasing protein intake beyond the recommended level is unlikely to result in additional increases in lean tissue, because there is a limit to the rate at which protein tissue can be accrued.

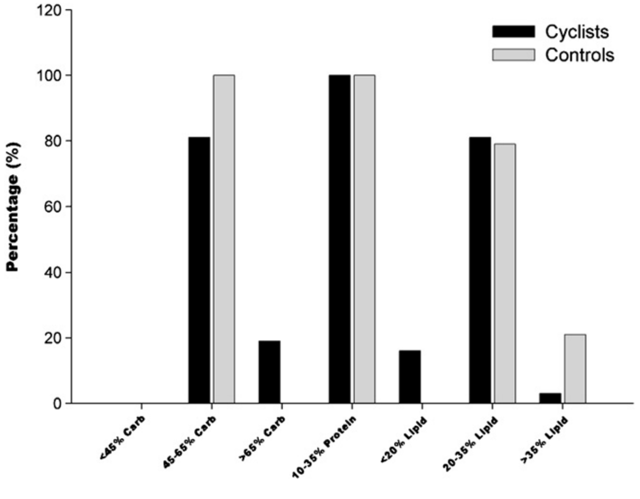

Fig. 2. Percentage distribution of carbohydrate, protein, and lipid intake in relation to total energy in cyclists and controls according to the proposed Dietary Reference Intakes (2002).

The micronutrients evaluated did not have normal distribution even after log transformation, and thus, it was not possible to determine the probability of inadequation. Median values for phosphorus intake in both groups were higher than the RDA for this micronutrient of 700 mg/d (1305.1 and 909.05 mg/d for cyclists and controls, respectively). Conversely, median values for magnesium intake were lower than the RDA (400 mg/d) in both groups (311.2 and 172.65 mg/d for cyclists and controls, respectively). Median values for calcium intake were 1100 mg/d for cyclists and 644 mg/d for the controls (calcium RDA for this age group is 1000 mg/d).

The percentage distribution of intake intervals for macronutrients according to the proposed DRIs for cyclists and controls is shown in Fig. 2 (37). Using the DRIs as reference ranges, most of the controls and athletes had adequate raw intakes of carbohydrates, proteins, and lipids. After adjustments for energy, cyclists had higher energy-adjusted carbohydrate, similar protein, and lower fat intakes as compared with those in healthy sedentary controls. The ACSM recommends carbohydrate intake interval between 60% and 70% of the total consumed energy, and it was observed for only 12 cyclists (38.7%) (33).

Weight and body composition play an important role in bone parameters during development and aging in healthy individuals. Correlations between BMD measurements and body composition parameters were then investigated and compared between athletes and controls, because body composition differed significantly between them. Among the athletes, we observed a positive significant correlation between total lean mass and BMD measurements at all sites (L1−L4: $r = 0.564$, $p < 0.001$; proximal femur: $r = 0.393$, $p = 0.029$; whole body: $r = 0.634$, $p < 0.001$), whereas only whole-body BMD had a positive correlation with the percentage of fat and fat mass ($r = 0.559$, $p = 0.001$).

A positive significant correlation was also seen between total lean mass and whole-body and proximal femur BMD ($r = 0.446$, $p = 0.017$; $r = 0.413$, $p = 0.029$, respectively) in the healthy controls. No significant correlation was observed between fat mass and BMD measurements in this group.

In the controls, we observed a significant positive correlation between VO_{2max} and whole-body ($r = 0.520$, $p = 0.006$) and total femur ($r = 0.554$, $p = 0.003$) BMD. Among the cyclists, VO_{2max} did not correlate with BMD measurements.

VO_{2max} correlated positively and significantly with the total lean mass in the cyclists ($r = 0.638$, $p < 0.001$), whereas a negative correlation was observed between VO_{2max} and fat mass ($r = -0.428$, $p = 0.029$). In the healthy controls, total lean mass and VO_{2max} were positively correlated ($r = 0.708$, $p < 0.001$), whereas no significant association was detected between VO_{2max} and fat mass ($p = 0.345$).

Among the macronutrients, only lipid intake correlated negatively and significantly with lumbar spine ($r = -0.371$, $p = 0.04$), total femur ($r = -0.487$, $p = 0.006$), and whole-body BMD ($r = -0.469$, $p = 0.008$) in the cyclists. Phosphorus intake correlated negatively and significantly with L1–L4 BMD ($r = -0.363$, $p = 0.045$) in the athletes. No other micronutrient analyzed correlated significantly with BMD measurements in this group. For the controls, we observed a significant negative correlation between lipid intake and whole-body BMD ($r = -0.398$, $p = 0.036$). The other nutrients studied did not correlate with BMD measurements in the sedentary controls.

A positive significant correlation was seen between carbohydrate intake and total lean mass ($r = 0.433$, $p = 0.015$) in the cyclists. No association between intake data and fat mass was observed for this group. In the sedentary controls, no correlation was detected between nutrient intake data and body composition analysis.

Multiple regression analyses (analysis of variance) demonstrated that total lean mass was the main determinant of lumbar spine ($p = 0.001$) and whole-body BMD ($p < 0.001$) in the cyclists. In the models, total lean mass was able to explain 29% and 38% of the variation in lumbar spine and whole-body BMD, respectively. Using the study variables, no model was significant for the total femur BMD. In the healthy sedentary controls, total lean mass was the main determinant of total femur ($p = 0.029$) and whole-body BMD measurements ($p = 0.017$). In the models, total lean mass was able to explain 14% and 17% of the variation in total femur and whole-body BMD, respectively. In this group, no model was significant for the lumbar spine BMD measurements.

Discussion

Lumbar spine, proximal femur, and whole-body BMD did not differ between cyclists and sedentary controls. Cyclists had significantly higher muscle mass and lower percentage of fat than the controls, corroborating the positive effect of the sport on body composition. Energy and macro- and micronutrient intakes were higher in the athletes than in the controls.

Previous studies have also demonstrated that cyclists and healthy controls have similar BMD measurements (9,10,12,38). Nichols et al (2003) have reported that master cyclists (mean age: 51 yr) have 10% lower BMD at the spine and femur than the reference range and have suggested that the lower BMD is probably because of prolonged cycling practice (more than 20 yr), usually with long periods of training (on average 30 h/wk) (12). As suggested by the authors, the relatively fixed body position while riding a bicycle induces a repetitive muscular strain pattern of relatively low magnitude and regular or even distribution. Thus, it is possible that cycling provides a rather poor osteogenic stimulus because of both the biomechanics of the sport and its lack of impact. Such a negative impact of the modality on bone mass was not observed in our study, and this could be related to the smaller age range of the studied population (26 yr old on average).

Biking is considered a low-impact sport with low influence of the gravity forces and regular homogenous distribution of load on the skeleton. With such mechanical characteristics, a relevant osteogenic effect of biking is thus not expected. Direct comparison of BMD among runners, bikers, and healthy sedentary controls has demonstrated that bikers have lower spine BMD than that in sedentary controls and lower spine, femur, and whole-body BMD than those in runners (7). The type of mechanical stress has a decisive role to increase bone mass in athletes.

In agreement with previous studies, our results suggest that cycling is not to be recommended for individuals with low bone mass or those at risk for osteoporosis. On the other hand, the modality has significant benefits on the aerobic conditioning and body composition. VO_{2max} values in the cyclists and controls significantly correlated with lean mass. Among cyclists, the higher the VO_{2max}, the lower the percentage of fat. Evaluating cyclists from the United States Cycling Federation in the same age range as our population, Tanaka et al found similar results (39). Irrespective of the type of sport, it has been demonstrated that higher VO_{2max} is associated with higher skeletal muscle mass and lower fat mass.

In our study, lean mass was the main determinant of BMD measurements for both athletes and sedentary controls. In the cyclists, about 30% of the variation in lumbar spine BMD and 40% of the variation in whole-body BMD was justified by total lean mass. The impact of lean mass on BMD measurements in the sedentary controls was smaller. Other authors have also demonstrated the association between muscle mass and bone density in athletes. Lima et al (2001) studied this correlation among young athletes engaged in high-impact (running, volleyball) and low-impact (cycling, swimming) activities and healthy controls (40). The highest values for BMD measurements were seen in athletes practicing high-impact modalities.

According to the nutritional guidelines proposed by the ACSM (2000) and the Brazilian Society of Sports Medicine (2003), most of our athletes had energy and carbohydrate intakes within the recommended range (33,34). However, none of the cyclists reached the intake of carbohydrates recommended for endurance modalities. More than half of our athletes had unbalanced distribution in macronutrient intake. There was an overestimation of protein intake in their diets, leading to higher consumption of lipids, once these macronutrients are associated in the food. Similar eating vices have been formerly described in endurance cyclists (41,42).

Eating behavior of cyclists is a controversial issue in the literature (14,42–44). Conflicting information has been reported, and it probably reflects the heterogeneity of individuals with diverse diet habits and socioeconomic and cultural backgrounds. Moreover, competitive level of the athletes seems to determine different eating patterns. Higher nutritional requirements are seen in the most competitive athletes.

In our sample of cyclists, we observed that higher carbohydrate intake was associated with higher skeletal muscle mass. This association has also been observed in other sport modalities (45). Kreider (1999) states that the adequate intake of carbohydrates and its supplementation before and after the exercise reduces muscular catabolism and leads to hormonal changes that are more prone to increase in lean mass (46).

In our present work, calcium intake was probably adequate in the cyclists and below the recommended amount in the controls. Phosphorus intake was higher than the DRIs in both groups, probably reflecting the high protein intake for this population. On the other hand, magnesium intake was inferior to the recommended goal for both groups. Taken together, one can speculate that eating habits in the described population might eventually have a negative impact on their bone status. High phosphorus and protein intake leads to higher renal excretion of calcium and higher Parathyroid hormone (PTH) secretion. Low magnesium intake for its part might also be associated with higher bone resorption and skeletal fragility (15,17,18,20,47). In fact, we identified 9 cyclists and 10 controls as having low bone mass, and eventually, their diets might be contributing to their bone status.

In conclusion, our findings demonstrated that BMD at the lumbar spine, femur, and total body did not differ significantly between cyclists and sedentary controls, and that total lean mass appeared to be the strongest determinant of BMD in both athletes and controls. Apart from a few exceptions (e.g., magnesium), it appeared that nutritional intake of both athletes and controls matched different published recommendations.

In-depth evaluation of nutritional habits and body composition of the different sportspersons allows us to recognize the negative factors that could potentially be minimized. Our findings suggest that adequate nutritional guidance is required for cyclists, and they could provide specific strategies to reach their best sportive performances and ensure their global and bone health.

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Author contributions: V.S.R.P. and M.M.P. performed the experimental work. C.H.M.C. and V.L.S. designed the study and wrote the article. M.M.P. performed all BMD measurements. M.S., S.B., and M.T.M. performed VO_{2max} measurements in the participants.

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