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BONE MINERAL CONTENT (BMC) AND BONE MINERAL DENSITY (BMD) IN POSTMENOPAUSAL WOMEN FORMERLY PRACTISING KAYAKING AND FENCING

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Abstract. The investigation was aimed at answering the following questions: 1) Can a prolonged career in sports associated with considerable training loads, in conjunction with other osteoporosis risk factors (both past and present), affect the bone mineral content (BMC) and bone mineral density (BMD) of the former female athletes in their postmenopausal period of life?, and 2) How does the present lifestyle of the tested women, including physical activity and diet (calcium intake), influence the preservation of the optimal bone mass in these subjects? The postmenopausal subjects recruited to the present study included 15 former athletes (ten kayakers and five fencers) and 11 women who never actively engaged in sports (control group). BMC (g) and BMD (g/cm^2) were densitometrically determined in the lumbar segment (L_2-L_4) of the spine, and the bone stiffness coefficient was ultrasonically determined in calcaneus. The effects of the osteoporosis risk factors (both past and present) were estimated from individual replies to the questionnaire inquiries about the past career in sports, present physical activity, gonadal dysfunctions (dysmenorrhoea during the career and the present need for hormonal supplementary treatment), and the current dietary patterns. The results indicate that mean BMC and BMD values detected in the former athletes did not differ significant from those obtained in the non-athlete, control women: the BMC values equalled to 54.5±10.5, 52.6±14.6, and 46.5±3.2 g in the kayakers, the fencers, and the control women, respectively, while the respective BMD values were 1.05±0.45, 0.96±0.66, and 1.08±0.58 g/cm^2. The questionnaire-based studies showed that neither the former female athletes nor the non-athlete controls exhibited in the past longer (i.e., lasting more than three months) periods of hormonal disorders (amenorrhoea). As assessed from the dietary intake, only in the former fencers the diet covered the demand for calcium in 100%. In conclusion, in the absence of such risk factors of osteoporosis as dietary and hormonal disorders, the prolonged career in sports associated with

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considerable training loads do not seem to adversely affect bone mineralisation and bone density in the former female kayakers and fencers.

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Key words: Former female athletes - Non-athlete women - Postmenopausal period - Bone density

Introduction

Osteoporosis is currently viewed as one of the major health problems in the world. This ailment, which leads to the frequent bone fractures in the elderly, is characterised by the gradual reduction in bone mass as a result of imbalance between bone resorption and osteogenesis. Apart from the genetically determined susceptibility, the most important risk factors of osteoporosis include small bone mass, low physical activity, insufficient calcium intake with the diet, and hormonal disorders [11,13,15].

The effect of physical exercise on the bone mass depends on the physical load applied. In contrast to the advantageous effect of moderate physical activity, excessive volume and intensity of exercising, especially during pre-pubertal and pubertal periods, as well as prolonged training, may lead to increased bone loss predominantly due to gonadal hypofunction. Adverse effects may also result from hyperactivity of the adrenal cortex triggered by an excessive physical load [14].

In Polish athletes, osteoporosis has only recently been regarded as a health problem. In fact, disorders in skeletal system of a number of record-seeking athletes detectable many years after completion of their career in sports have been reported [14]. The aim of the ongoing studies in this regard (both in Poland and abroad) is to recognise groups of athletes with the increased risk of osteoporosis [5-7] in order to introduce prophylactic measures at a proper time. Presumably, one of such increased risk groups are female athletes. In fact, a lot of factors accompanying both the athletic career and ordinary life of women may frustrate the advantageous effects of exercising. In view of this, it was interesting to examine former female athletes who during many years of their activity in sports used to be exposed to considerable physical training loads. Specifically, the present study was aimed at answering the following questions:

1. How does a prolonged training associated with considerable physical loads in conjunction with other osteoporosis risk factors (both past and present) affect the

bone mineral content (BMC) and bone mineral density (BMD) of the bones of the former female athletes, as compared to the same parameters detected in the age-matched non-athlete women?

2. Can the present-day lifestyle of the tested women, including their physical activity and diet (calcium intake), affect the preservation of the optimal bone mass?

Material and Methods

Twenty six postmenopausal women were recruited to the present study. The subjects included 15 former athletes (10 kayakers and five fencers) and 11 women who never engaged in sports (the non-athlete controls); the athletes were former representatives of Poland in the Olympic Games, and the control group consisted of women whose time of the manifestation of menopause matched that of the athletes. Anthropometric characteristics of all the tested subjects are presented in Table 1.

BMC (g) and BMD (g/cm^2) were determined in the lumbar (L_2-L_4) segment of the spine, which is recommended by the WHO as one of the four equivalent sites of measurements for the assessment of the risk of bone fractures [3]. The stiffness coefficient (Stiffness) expressed in percentages was determined in calcaneus using the ultrasonic technique; BMD and Stiffness were additionally expresses in percentages of the average normal values for the given age and in relation to the peak bone mass in young women. In the analysis of the results, the WHO-recommended diagnostic criteria for the risk of osteoporosis, such as the t-score and z-score, were also considered [3].

The effect of the present and past osteoporosis risk factors on the current state of the osseous tissue was determined using questionnaires containing inquiries about the career in sports such as time of its commencement and completion, weekly training loads, and achievements, as well as the current physical activity estimated based on the four-grade scale: very low, low, moderate, and high. In addition, the questionnaire contained inquiries about the function of gonads and use of contraceptives during the athletic career, present supplementary hormonal therapies, as well as health status including past and present dietary patterns. The present energy and nutrient intake was assessed by 24-hr dietary recalls on the day preciding the tests, and the frequency of consumption of certain products and dishes over a one-week period were determined. The quantity of the food consumed was estimated using the "Album of photographs of food products and dishes of different quantities" [19]. The energy, protein, calcium, and phosphorus intakes with the diet were calculated using the "Dietus" software based on the

Polish tables of nutrition [16]. Results were compared to the recommended dietary allowances (RDA) for Poland [24]. For statistical analysis of the differences between the results recorded in the former athletes and the non-athlete women, Student's t test for independent variables was used and $P \leq 0.05$ were regarded as significant.

Results

As indicated in Table 1, anthropometric parameters of the former female kayakers and fencers did not differ significantly from the respective characteristics of their non-athlete counterparts (control group).

Table 1
Anthropometric characteristics of the tested women (means ±SD)

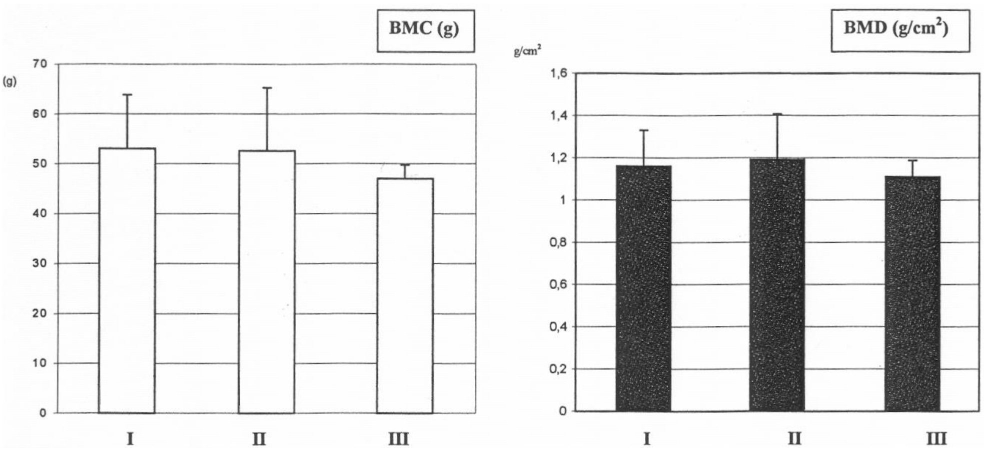
	Group	N	Age (years)	Body mass (kg)	Body height (cm)	BMI (kg/m^2)	Body fat content (%)
I	Former kayakers	10	51.8±2.4	74.2±8.2	163.0±3.7	28.5±7.8	34.6±8.8
II	Former fencers	5	51.2±1.2	65.0±3.9	161.0±7.4	24.9±1.2	36.2±7.3
III	Non-athletes (control group)	11	52.5±4.0	68.7±5.9	163.0±3.9	25.7±2.3	36.3±8.3

Data describing the past athletic career of the female athletes as well as the present physical activity of both the athletes and the control women are shown in Table 2. As indicated, in spite of the relatively long training period of the athletes (on average 17.5±3.3 years in the kayakers and 23.5±4.0 years in the fencers) and their considerable training loads in the past, only eight former athletes (i.e., 53% of the tested female athletes) were able to describe their present physical activity as moderate (three kayakers and three fencers) or high (two fencers), whereas the remaining seven (47%) athletes regarded it as low. In the control group, one woman (9%) described her present physical activity as moderate and the remaining ten (91%) described it as either low or very low.

Table 2
Past career in sports and current physical activity of the tested women (means ±SD)

Group	N	Past training experience			Current physical activity			
		Time of commencement of training (years of age)	Total period of training (years)	Training load per week (hours)	Very low	Low	Moderate	High
I*	10	14.0±1.7	17.5±3.3	17.5±3.8	-	7	3	-
II	5	9.8±3.0	23.5±4.0	17.5±7.1	-	-	3	2
III	11				7	3	1	-

* explanations see Table 1



I – former kayakers, II-former fencers, III-non athletes (control group)

Fig. 1
Bone mineral content (BMC) and bone mineral density (BMC) in the tested women (means ±SD)

As shown in Fig. 1, no significant differences could be detected in the BMC and BMD values between the former athletes and the control women. Likewise, as indicated in Table 3, the two groups of the tested subjects did not differ in terms of

BMD and Stiffness coefficient (expressed as percentage of the mean normal values for the given age and of the peak bone mass in young women), even though the latter coefficient tended to be higher in the former kayakers than in the former fencers and the non-athlete women. Indeed, the t-score and z-score values calculated for the bone density and Stiffness coefficient did not indicate that the risk of bone fractures was increased in any of the tested groups of women.

Table 3

Mineral density (BMD) and stiffness coefficient (stiffness) of bones of the tested subjects expressed as fraction (in percentages) of the average norm for young women (means ±SD)

Group	BMD**		Stiffness***	
	related to sex and age	related to peak bone mass	related to sex and age	related to peak bone mass
I*	101±14	97±15	121±16	102±14
II	107±15	99±21	111±16	91±16
III	100±8	92±8	109±12	90±11

* explanations see Table 1
** determined in the lumbar (L_2-L_4) segment of the spine;
*** determined in the calcaneus

The questionnaire-based evaluations revealed that neither the former athletes nor the control women had suffered in the past from longer (>3 months) periods of hormonal disorders (amenorrhoea). In addition, none of the subjects had ever been on contraceptive drugs (Table 4). Mean age of the commencement of menopause in the former kayakers, the former fencers and the non-athlete women was 48.3±2.0, 49.9±1.2, and 49.3±2.0 years, respectively, and did not differ significantly between the groups of the subjects. At present, only two non-athlete women undergo supplementary hormonal therapy.

Daily intakes of energy, protein, calcium, and phosphorus are shown in Table 5. As indicated, the mean energy intake in the former kayakers and the non-athlete controls covered their mean requirement for energy in 71.5 and 75.0%, respectively, whereas in the former fencers this requirement was covered in 98%. The mean protein intake in the former fencers exceeded the save level of intake by 30%. In the former kayakers and control women, calcium intake equalled to 66 and 75% of the required norm, respectively, while in the former fencers the daily intake

of calcium exceeded the requirement by 30%. Finally, mean daily intake of phosphorus in the former kayakers, the former fencers, and the non-athlete women exceeded the save level of intake by 17, 21, and 28%, respectively.

Table 5
Daily intakes of energy, protein, calcium, and phosphorus by the tested women (means ± S.D.).

Group	N	Energy (kcal)	Protein** (g)	Ca** (mg)	P** (mg)	Ca : P
		1550±394	60.1±19	844±113	947±224	1 : 1.66
I*	10	(71.5)***	(85.5)	(65.7)	(117.0)	
II		2087±1513	90.0±66	1022±761	1408±976	1 : 1.48
	5	(98.0)	(129.5)	(131.2)	(121.0)	
III		1694±529	63±19	602±327	1029±329	1 : 1.9
	11	(75.0)	(90.0)	(75.0)	(128)	

* explanations see Table 1
** safe level of intake
*** numbers in parentheses show the rate (in percentages) of coverage of the recommended dietary allowances for Poland

Discussion

The reported results of studies on the effects of the record-seeking practising of sports on bone status are quite inconsistent. This is partly due to the fact that, apart from the bone density, no other risk factors have been taken into account in these studies. It has become evident that in female athletes loss of the bone mass (manifested as the reduced BMC and BMD and/or osteoporosis) is always accompanied by dysmenorrhoea and disordered eating; hence the term 'female athlete triad' which has been introduced into the medicine of sport [17,23]. The protective effect of estrogens and perhaps also progesterone is related, among other things, to stimulation of calcium resorption in the intestines and its deposition in the bones [12]. As indicated by Loyd and co-workers [13], menstrual irregularities were causally related to osteoporotic bone fractures in 24% of female athletes, as opposed to only 9% in case of female athletes with regular menstrual cycles. In the present investigation, none of the former athletes reported on the presence of longer (i.e., lasting more than 3 months) periods of hormonal disorders during their career in sports, the fact that could positively influence the peak bone mass in these contestants. This suggestion is supported by the results of the densitometric measurements which, despite the considerable training loads in the past, in all the former athletes were comparable to the respective reference values. These results seem to support the observations of Warren *et al.* [21] that increase or reduction of BMD is probably related to the type and magnitude of the training load. In fact, the advantageous effect of training on the osseous tissue of athletes practising the weight-bearing activity has been documented [1,4,10.20].

Physical activity plays an extremely important role in preventing the loss of bone mass. Unfortunately, the former athletes tested in the present study did not seem to engage any longer in this type of activity. As demonstrated by a number of prospective studies, BMD in physically-active postmenopausal women tends to either remain on the physiological level or even increases. For example, Lane *et al.* [9] detected a marked augmentation of mineral density of the lumbar spine in 41 runners aged 50 to 72 years. Likewise, Krolner and Toft [8] reported that in 50 to 73 years old women who for eight months (one hour twice a week) engaged in a moderate physical activity mineral density of their lumbar spine increased by 3.5% as opposed to the 2.7% decrease detected in the physically inactive counterparts.

Also, it can be argued that nutritional abnormalities which are one of the underlying factors of pathological alterations in the osseous tissue leading to osteoporosis, did not occur in the tested women during the period of their active career in sports. Indeed, the former contestants, who were members of the national team, used to spend most of each calendar year attending training camps where the food served usually met the requirements recommended for athletes. Additionally, both kayak peddling and fencing are not the type of sports in which excessive care for staying fit is mandatory. On the other hand, the analysis of the present eating patterns of both the former athletes and the non-athlete women revealed the alarmingly low supply of calcium with the diet. In fact, only the diet of the former fencers covered 100% of the required level of intake of this element. Insufficient supply of calcium, as well as its decreased resorption resulting from the drastically reduced production of estrogens, constitute an increased risk of osteoporosis in postmenopausal women. According to Snead *et al.* [18], high supply of calcium with the diet does not translate directly into the increased mineralisation of bones, but intake less than 500 mg/day results in reduction of the bone mineral density. It is a subject of controversy whether increased consumption of calcium advantageously affects the osseous tissue in postmenopausal women. It is emphasised, however, that the proper nutrition and physical activity act synergistically to minimise the reduction of bone mass during the time of its physiological loss [2,22].

Prevention of osteoporosis is based on prophylactic measures which should be introduced long before the development of the disease. These include proper diet (with major emphasis on sufficient calcium uptake), physical activity, and supplementary hormonal therapy (which is still not widely applied to the former female athletes).

Since there are only few reports on the late effects of practising record-seeking sports on health status of women in particular, further studies in this regard are highly recommended.

Conclusions

Based on the present results the following conclusions can be drawn:

1. In the absence of such risk factors of osteoporosis as dietary and hormonal disorders, the prolonged career in sports associated with considerable training loads does not adversely affect bone mineralisation and bone density in former female kayakers and fencers;
2. Apparently, insufficient calcium intake with the diet and low level of physical activity during the postmenopausal period, especially in women who did not use to practice sports, may accelerate demineralisation of the bones;
3. For early detection of adverse changes in the osseous tissue of the former female athletes, periodic densitometric tests should be started at the beginning of the menopause.

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