Bone mineral density and menstrual function in adolescent female long-distance runners –

A prospective comparative study of bone structure and menstrual function in adolescent female endurance athletes from five secondary schools in Pretoria.

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ABSTRACT

Background. In recent years, endurance running as a sport has become very popular. This trend has led to the identification of specific problems during the female athlete's life, especially with regard to reproduction, delayed sexual maturation, menstrual abnormalities and early osteoporosis.
Methods. Bone mineral density (BMD) and menstrual function were compared between a group of long-distance female adolescent runners (N=17) from five schools in Pretoria and an age-matched inactive control group of adolescents (N=18). Groups were matched for body height, mass index (BMI 18 to 25) and eating habits. The SAHARA Clinical Sonometer was used to measure BMD on the calcaneus. Menstrual function was denoted by onset of menarche, duration of menstrual periods (days) and number of menstrual periods per year.
Results. Baseline BMD was significantly higher in the athletic group: mean = 0,6126 g/cm^3 and SD = 0,1217, versus non-athletes: mean = 0,5329 g/cm^3 and SD=0,0733 (p = 0,0228). There was a significant delay in the onset of menarche in the athletes: mean = 14,873 and SD = 1,37798, in comparison to the non-athletes: mean = 13,468 and SD = 1,2194 (p = 0,0030). The athletes had a significantly higher incidence of menstrual abnormalities (p = 0,005).
Conclusions. BMD at the focus of strain for running (the legs) is higher in endurance adolescent female runners. Endurance runners have a significantly higher incidence of menstrual abnormalities.

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Background

Women of all ages are becoming increasingly involved in strenuous athletic activity for fitness and/or competitive reasons. The growth in the participation of women in sport occurred as a result of legislation passed in the USA in 1972 called "Title IX". This states that any school receiving federal assistance must offer equal athletic opportunities to men and women (participation, scholarship, money and athletic benefits).

Despite the numerous benefits of physical activity, specific problems might occur in the female athlete's life, especially with regard to reproduction. These include delayed sexual maturation in the growing athlete and abnormal or absent menstrual cycles in the mature woman, with potential adverse effects on the foetus of the pregnant woman. Other problems are eating disorders and skeletal abnormalities, including reduced bone density (BMD), scoliosis, stress fractures and failure to reach peak bone mass.[1]

The BMD might be influenced by several variables, such as current menstrual status, menstrual history, body mass, functional loading, family history of osteoporosis, nutritional status, training intensity and frequency, and calcium balance.[2,3] These problems are encountered by female athletes who take part in endurance running, rowing, gymnastics, ballet, swimming, basketball and cycling.

The decrease in BMD can predispose the female athlete to an increased risk of stress fractures. BMD loss is a silent process and the athlete is usually unaware that a problem exists until a related injury (such as a stress fracture) occurs.

In 1992, the American College of Sports Medicine published an article about the so-called "Female Athletic Triad", describing the large increase in the prevalence of three disorders presenting together in the athletic female. This triad consists of disordered eating, delayed menarche/menstrual abnormalities and osteoporosis. It is the major health risk factor facing women athletes today. The aetiology of this triad is multifactorial, with risk factors including nutrition, menstrual status, training intensity and frequency, body mass, family history of osteoporosis, calcium balance and psychological/ physical stress. Medical management of this triad requires a multidisciplinary approach, with the key being early diagnosis and therapy.[4]

The consequences and long-term effects of delayed puberty on young athletes are not completely clear. Bone mass accretion, which normally occurs during adolescence (18 to 25 years,[4] while other authorities claim 16 to 18 years[5]), is compromised in girls maturing late due to the negative impact on gonadal function. Maximising peak bone mass in the adolescent woman is of the utmost importance, as it is the time when athletes should be storing bone for the inevitable loss in later years. The two to three years of the pubertal growth spurt are accompanied by deposition of 60% of the final bone mass, and any dietary inadequacy and high exercise intensities at this time could severely alter bone formation.[3]

There have been conflicting results concerning bone mass accretion (measured by the BMD) and menstrual abnormalities in different studies over the past few years. There are no long-term follow-up studies of former amenorrhoeic athletes that enable the determination of whether normal BMD can be attained following several years of abnormal menses or use of oral contraceptives. Martin et al. state that the bone mass of the lumbar spine of women with a history of oligomenorrhoea/amenorrhoea might never reach that of women who have had regular menstrual cycles.[6] A recent study by Drinkwater et al. reports that, after six to 10 years of amenorrhoea, oligomenorrhoea or oral contraceptive use, even previously amenorrhoeic athletes did not show significant improvements in vertebral BMD values. Thus, these findings suggest that oligomenorrhoea is as detrimental to the lumbar spine as amenorrhoea.[7] Moreover, the long-term effects of amenorrhoea on fertility are still unclear, although there are data suggesting that the reproductive deficiencies associated with amenorrhoea are reversible when the problem is treated.[8]

Most of the data come from the USA and it was interesting to see whether these findings would apply to South Africa. In recent years, long-distance running as a sport (primary and secondary school level) has become more popular, and children as young as eight years are practising and competing all year round.

Methods

Eighteen female adolescent endurance runners, aged between 16,083 and 18,25 years, were recruited between February and May 2001. Twenty-one female adolescents (non-athletes) aged 17,167 to 18,250 years were recruited as controls (three had to be excluded due to the current use of oestrogen for acne). Both the athletes and non-athletes were matched for weight (BMI between 18 and 25) and length and a reasonable nutritional status was maintained in both groups.

The baseline investigation included a questionnaire (including menstrual history), weight, length and ultrasonographic (SAHARA) measurement of the right calcaneus.

Definitions

Endurance (long-distance) athlete: An athlete who does endurance running for >1_ hours per day for 5 days per week for 11 months per year.
Menarche: Age at first menstrual cycle
Delayed menarche: No occurrence of menstruation before the age of 16 years.
Eumenorrhea: 10 to 13 menstrual cycles per year.
Oligomenorrhea: 4 to 9 menstrual cycles per year.
Amenorrhea: 0 to 3 menstrual cycles per year.

Study population

All white female students between 16 and 18 years attending schools in the municipality of Pretoria, Gauteng (Republic of South Africa). Black and Asian students were not excluded from the study, but none responded to the request for volunteers.

Inclusion criteria

1. Consenting adolescent female scholars between 16 and 18 years in Pretoria, Gauteng (Republic of South Africa).
2. Female scholars of all ethnic groups were included (no African or Asian athletes volunteered for testing).
3. Endurance runners who had started practising before the onset of menarche and trained for 11 months a year and for 5 days a week and >1_ hours a day.
4. Controls were recruited who did not participate in any form of organised sport.
5. Maintenance of reasonable nutritional status.
6. Body mass index of between 18 and 25 – to avoid outlier bias, the students could not differ too widely in height and weight.

Exclusion criteria

1. Use of oral contraceptives or use of hormonal treatment (i.e. for acne)

in the previous six months.
2. Drug abuse (including marijuana).
3. Smoking.
4. No parental consent.
5. Delayed menarche.

Sample size calculation

The primary efficacy variable is BMD with normal values (0,5: 0,7 g/cm^3) and hence a SD = 0,05. In order to detect a difference of 0,05 g/cm^3 in the BMD between the athlete and non-athlete groups, a sample of 17 subjects per group will have 80% power when tested two-sided at the 0,05 level of significance. The sample size calculations therefore do not depend on sampling population size.
Software used: nQuery Advisor Release 4.0, Statistical Solutions Ltd., Cork, Ireland.
Author: Janet D Elashoff, May 2000.

Written informed consent was obtained from every participant, as well as from one parent (mother or father). The Protocol was approved by the Ethical Committee of the Pretoria Academic Hospital and the Faculty of Health Sciences of the University of Pretoria.

Results

The baseline BMD was statistically significantly higher in the athletic group, with a p-value = 0,0278. This might be due to the fact that the athletes in this study had been practising for a relatively short period (mean period = 6,5490 years, SD = 2,3819).

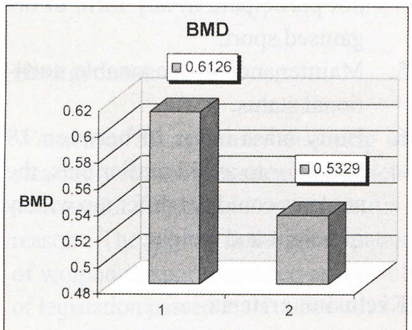

Figure I: Comparison of BMD in athletes (N=17) and controls (N=18) (g/cm2) (p = 0,0278)

There was a statistically significant difference in the onset of menstruation (menarche) between the two groups, thus suggesting a later sexual maturation in endurance athletes.

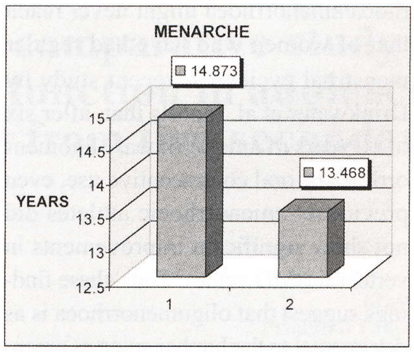

FIGURE II: Comparison of onset of menarche (years) in athletes (N=17) and controls (N=18) (p = 0,0030)

In correspondence with other studies, the expectation was to find a decrease in the menstrual flow (as measured by the menstrual period), but, surprisingly, there was no difference between the two groups. This is probably due to the fact that, even if athletes experience oligomenorrhoea or amenorrhoea (number of cycles per year), they might still have normal periods (number of days per cycle).

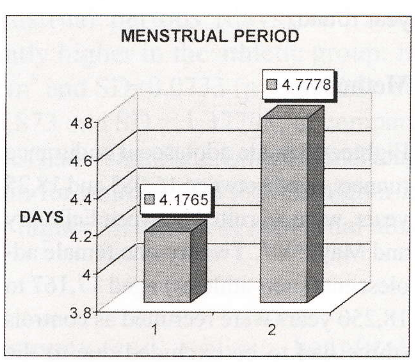

FIGURE III Comparison of menstrual period (days) in athletes (N=17) and controls (N=18) (p = 0,1875)

There was a significant difference in the menstrual function (p-value=0,005). In the athletes it was 41,2% eumenorrhoea, 35,3% oligomenorrhoea and 23,5% amenorrhoea, while in the non-athletes it was 88,9% eumenorrhoea, 11,1% oligomenorrhoea and 0% amenorrhoea. This is in accordance with other studies done elsewhere in the world.

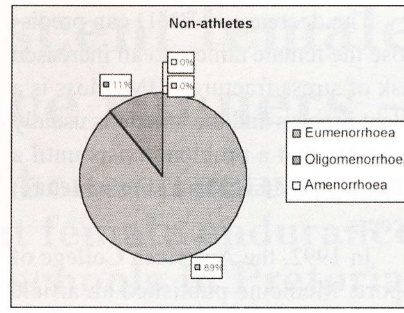

FIGURE IV: Menstrual function in athletes (N=17) and controls (N=18).

Conclusions

BMD at the focus of strain for running (the legs) is higher in adolescent female endurance runners when compared to age- and BMD-matched controls (whose training was started before the onset of menarche). When endurance runners are compared to controls in relation to their menstrual history, they display a significantly higher incidence of menstrual abnormalities, as denoted by a delay in the onset of menarche and a decreased number of menstrual cycles per year.

This study only explores exercise as the single most important factor, which is not necessarily true. Other reasons for the differences between BMD and menstrual function could be hormonal, dietary, socioeconomic, time of exercise before menarche and calcium balance. This warrants further research.

Recommendations

Identify the runners at risk for developing menstrual abnormalities. If abnormalities are present, decrease the intensity and amount of practising time, as it might have detrimental effects on their fertility and lead to early osteoporosis. These adolescent runners must be monitored carefully to help them attain peak bone mass (95% of maximum density is reached by the age of 18 years) and still perform well in their sport.

Coaching should involve a team approach, with the coach, biokineticist and psychologist all available to support the long-distance trainee. Parents need to be able to identify the symptoms of injuries and menstrual abnormalities early to avoid the child losing self-confidence and performing sub-optimally.

Randomised double-blind placebo controlled trials for safe training volumes, intensities and menstrual cycle regularity, with regard to their influence on BMD in the female athlete, are needed to prevent an unnecessary decrease in performance as well as to minimise long-term health problems.

It is believed that further studies assessing the long-term health consequences of athletic amenorrhoea are essential.

Limitations of the study

This study was not sponsored and, because of financial constraints, the SAHARA measurement (ultrasound of the heel) was used instead of DEXA. DEXA (Dual Energy X-ray Absorptiometry) is still the gold standard of BMD evaluation and might reveal the impact of oestrogen deficiency earlier and more accurately than ultrasound of the heel.

Only calcaneal BMD was done (SAHARA). It would have been better to do BMD on spinal trabecular bone (DEXA) as well. Ultrasonographic measurements (SAHARA) are good and reliable, but it is known that exercise could positively influence the results of this method. Clearly defined conclusions regarding the place of quantitative ultrasound still need to be established.

All the subjects had undergone menarche, although this was slightly delayed in the trained individuals. The duration of exposure to possible hypo-oestrogenemia is therefore limited and might explain why only positive effects of exercise are noted in the study subjects.

This study demonstrates a beneficial effect in weight-bearing exercise in relationship to the BMD in female **adolescent** runners, but does not address the long-term effect of constant training on the weight-bearing bones.

Only Caucasian girls were used and it is therefore not clear whether these findings will apply to other groups. Black and Asian students could not be recruited. This necessitates a further study to include these students. No blood tests were done to assess the hormonal status of the athletes.

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