Bone stress in females: what is the current state of play?

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The 'female athlete triad' is not uncommon in the sporting population.

Drs White and Sellwood present a practical approach to management.

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THE IMAGE BANK

Case presentation

A 20-year-old university student and recreational runner presents after recovering from her second tibial stress fracture in the last three years. She has been amenorrhoeic for this period of time but is otherwise well with no other significant medical history. Since her most recent stress fracture she has resumed running, and is now running about 70 km per week. She has no current musculoskeletal symptoms, and is presenting because a female relative has expressed concerns about her lack of menstruation and its possible association with her stress fractures.

Discussion

This history may be suggestive of the 'female athlete triad', which consists of three interrelated and distinct entities: disordered eating, menstrual disorders, and osteoporosis. The relationship between these – and particularly the possibility of causal links – is still to be confirmed, but each entity can occur independently or in combination in exercising females.

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Disordered eating

Many athletes fail to have an adequate caloric intake to balance their elevated energy requirements. Not only females are affected. The effects of this can range from a negative effect on performance through to full blown eating disorders such as anorexia and bulimia. Disordered eating for weight control is particularly prevalent in the athletic population (15 to 62%), particularly in weight-restricted sports such as rowing.[1]

Menstrual disorders

Menstrual disturbance is more prevalent in athletes (1 to 44%) than the general female population (2 to 5%).[2] Inadequate caloric intake, low body fat, exercise and psychological stress can impair hypothalamic function, resulting in decreased gonadotrophin releasing hormone that inhibits release of luteinising hormone and follicle stimulating hormone. This has a detrimental effect on oestrogen and progesterone levels and leads to menstrual disturbances that range from luteal phase abnormalities through oligomenorrhoea to amenorrhoea.

The effects of menstrual cycle irregularity are many and include temporarily reduced fertility, which can be reversed when normal menstrual cycles are resumed, and negative effects on bone health.

Bone health issues

Lower bone mineral density

Females with exercise-related amenorrhoea or oligomenorrhoea have lower bone mineral density (BMD) than active eumenorrhoeic controls matched for age.[3] Bone loss occurs rapidly in the first three to five years of amenorrhoea, and continues while an individual remains amenorrhoeic. When normal menstruation resumes, bone loss ceases and BMD usually increases. Interestingly, studies have shown that artificially induced menstruation (i.e. using the oral contraceptive pill), although associated with the cessation of bone loss, does not cause an increase in BMD.

Reduced peak bone mass and premature bone loss

If an individual's accrual of BMD is interrupted during her late teens and twenties because of menstrual irregularities then her peak bone mass is not achieved

(Figure 1). This means that the maximum that is actually attained is lower than it could have been and therefore closer to the theoretical fracture threshold. A woman may reach this threshold in her 40s or 50s (rather than her 70s and 80s), depending on her potential bone density (which has a strong hereditary component), the maximum bone mass that she actually achieves (which is affected by menstrual irregularities), and her age at menopause. As a result, osteoporotic fracture could occur much earlier.

After peak bone mass has been achieved, menstrual irregularities can result in premature bone loss (i.e. loss prior to the usual menopausal bone loss). This results in an increased likelihood of a menopausal fracture at an earlier age. However, the incidence of reduced peak bone mass and early osteoporosis in the athlete population is unclear.

Stress fractures

Stress fractures are more common in athletes with menstrual disturbances than in eumenorrhoeic athletes, with the relative risk being up to four-fold.[4] The risk of multiple stress fractures is also elevated in sportswomen with ongoing menstrual irregularities. However, no significant direct link has been established between low BMD and stress fractures in the current literature. So although low BMD and stress fractures are more common in amenorrhoeic compared with eumenorrhoeic athletes, it is not clear that low BMD is causative of the elevated incidence of stress fractures. Notably, the low BMD documented in amenorrhoeic athletes occurs primarily at the hip and spine, but stress fractures are most common in the metatarsals and tibia, where no BMD abnormalities are observed.

Other considerations

There are other factors to consider in an amenorrhoeic athlete presenting with recurrent stress fractures.

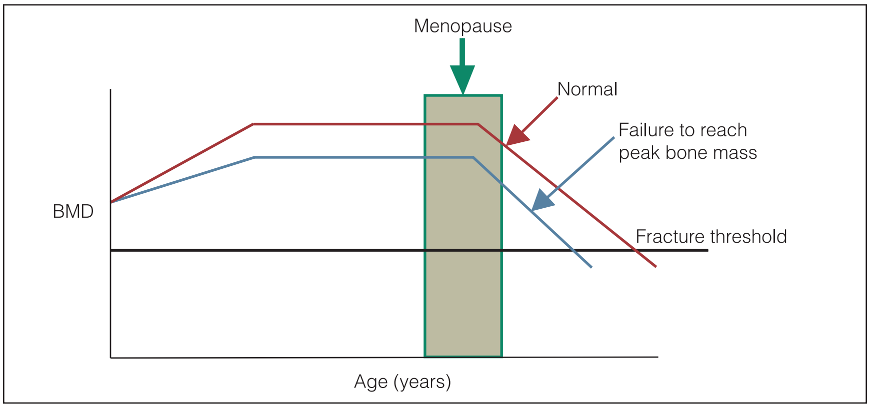


Figure 1. Changes in BMD with age in females. Interruptions in bone mass accrual in earlier life can reduce a woman's age at which her fracture threshold is reached after menopause.

Amenorrhoeic v. postmenopausal bone loss

Interestingly, osteopenia and osteoporosis in amenorrhoeic athletes are probably not the same as osteopenia and osteoporosis that develop in postmenopausal women, with studies showing that they are characterised by different bone remodelling abnormalities.[5] Postmeno - pausal (oestrogen-deficient) osteoporosis is characterised by increased bone turnover with excessive resorption, and can be managed with oestrogen replacement. Conversely, amenorrhoeic athletes exhibit an apparent reduction in bone turnover and reduced bone formation when compared with eumenorrhoeic sedentary controls.

This challenges the commonly held belief that low bone density in these athletes is primarily due to oestrogen deficiency. It also suggests that supplemental oestrogen (usually in the form of the oral contraceptive pill) as a primary management strategy for these young women is not necessarily appropriate.

Mechanical loading effects

Mechanical loading is protective against loss of BMD in amenorrhoeic athletes. For example, an amenorrhoeic rower with reduced hip BMD will usually have normal or enhanced BMD at the spine, whereas an amenorrhoeic runner will usually have a lower spinal BMD and high or normal BMD at the hip. One study of gymnasts, who physically load all parts of the body, found no BMD deficits.[6]

Nutritional status

The fact that oestrogen deficiency does not explain bone loss in female athletes suggests nutritional status may play an important role. Nonsporting anorectic women are usually amenorrhoeic with reduced bone formation and rapid bone loss that can be reversed by increased dietary intake, so it is possible that the chronic energy deficiency that contributes to menstrual irregularity also contributes to metabolic processes that affect bone formation.

In female athletes, chronic energy deficiency may be brought about by a combination of excessive training and inadequate caloric intake. This state is most likely the largest contributing factor to menstrual irregularity and also contributes to poor bone health. The volume and intensity of training, while being partly responsible for the negative energy balance, is also a major contributing factor of stress fractures in this group of female athletes.

Management of this athlete

Management of the 20-year-old amenorrhoeic runner with a history of stress fractures is based on the interconnected factors described above and will involve:

- determining whether the amenorrhoea is primary or secondary, and excluding causes other than athletic amenorrhoea
- establishing baseline BMD
- identifying contributing factors and advising modifications
- providing education.

Cause of amenorrhoea

Primary amenorrhoea (absence of menarche) requires specific investigation to establish the cause – possibilities include anatomical and genetic abnormalities. Nonathletic causes of secondary amenorrhoea (suspension of menses) include pregnancy, prolactinoma and hypothyroidism, which can usually be confirmed by history and simple blood tests.

Baseline BMD

A DEXA scan at presentation will determine this athlete's current bone density in the hip and spine. It can be used to monitor bone density (usually at intervals of 12 to 24 months) and to determine the bony response to the changes the athlete makes to her training and diet.

Most athletes will have BMD within normal limits on DEXA scan, although possibly with relatively different values for the hip and spine, depending on their sport. They can be reassured that with resumption of regular menstruation they will maintain reasonable levels of BMD and therefore not be at increased risk of premature osteoporosis (Figures 2a and b).

There will, however, be the occasional athlete who has low BMD detected on DEXA in the hip, spine or both. In such a case, more strenuous monitoring of nutritional status and menstrual cycle is important. In addition, it is necessary to advise that rectifying contributing factors is paramount in order to prevent further bone loss that would put her at even greater risk of early osteoporosis.

Occasionally, an athlete may have such extreme BMD loss that she is classified as 'osteoporotic'. In this situation, referral to an endocrinologist is usually warranted for consideration of bisphosphonates and other medications, the effects of which are not well understood in this age group.

Contributing factors and modifications

Training

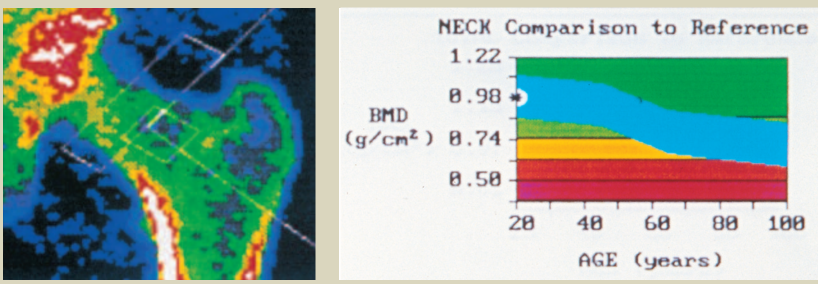
It is important to define the athlete's training in terms of volume, intensity and type because these are variables that can be modified. However, an athlete who is not injured is often not compliant with an enforced period of rest, and so an alternative way of reducing physical load is required.

Initially, a reduction in training volume is important. For example, this athlete completes a 10 km run on weekdays, with a rest day on Saturday and a longer 20 km run on Sunday. One way of reducing her load would be to incorporate another two rest days during the week so that she is running only on alternate weekdays (i.e. at a reduced weekly volume of 50 km).

The type of training is also important, and cross-training may be an alternative strategy for reducing physical load if the athlete finds rest days unacceptable. For example, she may be more compliant with a 20-minute swim or bike session for three days per week. Interestingly, a female swimmer training at the same volume is less likely to be amenorrhoeic than a female runner, but the reason for this is not clear.

If an athlete primarily performs one type of activity it can also be useful to cross-train to gain the protective effects of loading other areas of the skeleton. In other words, it is appropriate to suggest that runners do some rowing (usually using a machine in the gym) and that rowers do some running. Training modification will also play a significant role in decreasing the recurrence of stress fractures.

Interpreting a DEXA scan report



Figures 2a and b. DEXA scan of the femoral neck. This patient's BMD (0.984 ± 0.02 g/cm^2) falls within the normal range compared with a young adult population and age matched population (both matched for sex).

Diet

It is often useful to ask an athlete to keep a food diary over a period of weeks in order to ascertain her overall caloric intake. Other dietary issues may need to be addressed – examples include iron deficiency and food group inadequacies such as a low proportion of protein or carbohydrate.

It is essential to involve a dietitian in the process of assessing the diary and balancing it against the athlete's energy requirements. A dietitian will be able to make recommendations about overall energy intake requirements and maximising particular items (e.g. proteins or high iron foods). In addition, a dietitian can tailor advice to each individual's likes and dislikes, which should ensure greater compliance.

Psychological stressors

It is important to consider other factors that may have an input at the hypothalamic area and contribute to the menstrual irregularities. This often involves questioning the athlete about study or work, her social and home life, as well as the actual stress of training and competition. These factors can also be important in the development of an eating disorder.

Education

The athlete needs to understand the concept of negative energy balance as a result of the high volume and intensity of training as well as inadequate caloric intake. She also must be aware of the risks of ongoing menstrual disturbance to bone health (both short and long term) as well as other areas, such as fertility.

It is important to include the athlete's coach, family and other support personnel in this step. Information fact sheets suitable for athletes, coaches and trainers are available through the Sports Medicine Australia website (www.sma.org.au/information/women_in_sport.asp).

Final comments

The aim of introducing the changes described above in this athlete is to re-establish a normal menstrual cycle. A repeat DEXA scan in 12 to 24 months will indicate whether bone loss has halted (and bone density may have increased) if menstruation has resumed. It is also important to ensure other factors contributing to the development of stress fractures (such as inappropriate footwear, poor biomechanics and hard running surfaces) are modified to assist in the prevention of future fractures. MT

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