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The Female Athlete Triad

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Abstract

Increasing psychological and physiological demands on young female athletes, as well as the pressure from society for a lean and slim body can result serious health risks. Briefly, the triad is a combination of menstrual disturbances (amenorrhea or dysmenorrhoea), which may lead to a low mineral content of the bones and the risk of osteoporosis, and eating disorders (anorexia nervosa, bulimia nervosa, or a combination of both), while the athlete undertakes excessive exercise. **Keywords:** female athlete, energy availability, menstrual cycle disturbances, eating disorders, osteoporosis

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Introduction

The increase of psychological and the physiological demands in young high-performing athletes, with the lean and slender body seen by society as attractive, often results in serious health risks, particularly in young females. This triad consists of menstrual disturbances, osteoporosis, and eating disorders. Each of these changes on their own can result in serious health consequences. The basic mechanism is a negative energy balance, which leads to a decrease in oestrogen, dysmenorrhoea or amenorrhoea, which can in turn result in a decrease in bone mass, which may cause a stress fracture.

Gender-related performance

Performance mechanisms are similar in both women and men. However, there are some differences in the adaptation to training which may include more performance problems in women. In general, this is related to reproductive regulation and the feedback cycles discussed below.

The different hormonal dispositions of men and women have certain disadvantages, as well as important benefits. It is well documented that there is little decrease in the functions and performance of the internal organs of women compared with men until menopause. Moreover, on the one hand, there is a basic genetic disposition with regard to training ability and, on the other hand, high psychological stability and performance willingness. As a result of a normally decreased performance, orthopaedic load capacity, and certain organ functions in women, the sport disciplines which focus on these aspects show a gender differentiation¹.

Sports in puberty

The phases of puberty must be carefully observed, especially in sports medicine. Extreme peak loading during physical activity leads to individual changes in the endocrine system, and to different adaptations.

Disturbances in the menstrual cycle comprise a late menarche (the first menstruation occurring after the age of sixteen), primary and secondary



amenorrhoea (3 to 6 months without menstruation) and the oligomenorrhoe (cycle occurring at intervals of 36 days and longer). There also other disturbances such as luteal phase insufficiencies and long existing anovulatory cycles which are chemically difficult to identify. They in turn lead to further physical alterations².

Menarche

Intensive training in high performance female athletes can result in the start of the first menstruation being delayed by 1-2 years (menarche)³. A later menarche predisposes these girls to a higher risk of osteoporosis in later life. There is evidence that intensive training at the

beginning of the menarche, before the age of 18, does not necessarily result in defective or decreased fertility.

Oligomenorrhoe - amenorrhoea

The feedback of intensive physical activity on hormonal regulation must be examined. Comparable influences are the feeling of hunger or other psychological or physiological stress in other fields, so that the same stress management is necessary in the end. Therefore to separate the influencing factors, which actually are a combination of factors, is not easy. In summary the hormonal feedbacks which influence certain factors are shown in Table 1⁴.

Table 1: Factors that influence the hormonal response

- training condition
- training capacity
- load capacity
- form of load capacity (aerobic, anaerobic, and muscle groups utilised)
- nutrition (the amount of fat, carbohydrate and protein, and their deficiencies)
- central (or core) body temperature
- the time of load capacity in the menstrual cycle
- the psyche (competition and training conditions, conflicts between performance and expectations)

It is well known that menstrual cycle disturbances are often related to particular types of sport, e.g. in endurance sports like long- distance running, cycling, and weight-dependent and aesthetic sports like gymnastics and ballet³. The physiological cause of primary and secondary amenorrhoea can be explained by disturbances of the pulsative Gonadotropin-releasing hormone (GnRH), GnRH distribution which is very sensitive to any stress factors in the surroundings in general and to metabolic disturbances. In fact, where there is no balanced energy there is an inhibition in the release of GnRH which is combined with a decrease in the distribution of luteinizing hormone (LH) and the follicle-stimulating hormone (FSH) and therefore a decrease in oestrogen production. This hormonal down-regulation leads to a decrease in bone density. Therefore these deficiencies must be recognised initially. New studies support the fact that the basis of this malfunction of the reproductive system through physical activity is caused by a deficiency of energy availability as a result of a higher daily requirement¹.

Actual examinations show that the resting metabolic rate (RMR), with a negative energy balance, is combined with menstrual cycle disturbances. Even women with a normal weight can suffer from an energy deficit. Their normal

weight can only be maintained by a low resting metabolic rate.

The aetiology of the hypothalamic-caused amenorrhoea is not well understood although the inhibition of the release of GnRH could mainly be responsible for this. The hormone leptin produced by adipose tissue seems to independently regulate the basic metabolic rate and control the pulsing GnRH release. Low leptin levels show a correlation between amenorrhoea and an eating disorder. It seems that menstruation is not possible if the leptin concentration has dropped to a critical level. Because leptin regulates the resting metabolic rate (RMR), leptin is an indicator of the nutrition status. Therefore athletes with amenorrhoea typically have low resting metabolic rates. Leptin may be a significant mediator of the reproductive system, because its concentration responds to the negative energy balance in women with amenorrhoea caused by excessive physical activity. Moreover, leptin is involved in the thyroid function and the start of puberty. It could be demonstrated that changes of leptin levels are correlated directly with changes in the thyroid hormones (low levels of free Triiodothyronine, T₃) and other metabolic hormones such as insulin and ghrelin during periods of malnutrition⁵.

In this context, it is important to examine another hormone. Cortisol, a glucocorticoid which regulates the body's glucose level, is released



more in the case of low blood glucose and even shows increased levels in the hypothalamus caused by amenorrhoea, anorexia, and also caused by high levels of physical activity. A link between treatment with hormones or oral contraceptives as a cause of low cortisol levels has not been finally proved. Long-term amenorrhoea needs to be determined by diagnosis and therapy. The frequency in the normal population is given between 2% - 6%, while the frequency in athletes varies between 3,4% - 66%¹.

Osteoporosis – stress fractures

There is no question about the positive effects of physical activity on the musculoskeletal system. Bone conversion is coordinated by an ensemble of osteoclasts, osteoblasts, osteocytes and vascular cells. A fine tuning by means of electrical stimulation leads to increased bone mass on the pressure site and to decreased bone mass through tractive force. Besides these mechanical changes, an endocrinological regulation of bone metabolism exists by means of parathormone, as well as the sex-, thyroid- and growth hormones. Only a few studies have looked at changes during acute and chronic work loads, and the results are inconsistent. Changes can be measured by means of osteodensitometry, depending on the intensity, time and frequency of physical activity, but also related to menstrual cycle disturbances and eating disorders. New studies show a relationship to stress fractures. Athletes suffering from malnutrition and menstrual cycle disturbances are especially at risk for stress fractures. A stress fracture can be defined as a fracture caused by repetitive stress as may occur in sports, physical activity, or physical labour and repeated work load on the healthy bone, the so-called "bone remodelling". During repeated work load the bone, as dynamic tissue, shows physiological reorganisation. Because the bone rebuilding continues over several weeks, the imbalance of osteoblasts (increased bone mass) and osteoclast activity (decreased bone mass) can lead to a weakness over time. With the further addition of high work load and an imbalanced situation resulting in repeated micro damage and bone repair, a stress fracture can occur.

Osteopenia - osteoporosis

A longer lasting hypoestrogenemia leads to a decrease (Osteopenia) or loss of bone mass. This is not found as frequently in the late pubertal girls with primary amenorrhoea but rather in women with secondary amenorrhoea. On the one hand, stress fractures are associated with running, while on the other hand the work load is increased, so that the correlation seems to be unclear. There is

no doubt that it is an advantage to get a very high bone mass at a relatively young age when 40% of the bone mass can be constructed.

Physiologically, peak bone mass will continue to decrease from the age of 20-30 years. In the case of low bone density at this age it can lead in later life to serious osteoporosis. Regular physical activity (not high performance activity) seems to delay the development of osteoporosis and be useful therapeutically as a preventative measure¹. Athletes with amenorrhoea, compared to women with a normal menstrual cycle, show a 10-20% lower bone density, which cannot be compensated for by physical activity. At the start of menstruation an increase of bone density can be reached but there may be no normalisation of bone. Taking macronutrition during a high work load, with a low calcium intake over an extended time period, seems to be heavily compensated.

Eating disorders: Deficiency and malnutrition, anorexia athletica, anorexia nervosa and bulimia nervosa

There are some studies which show that in aesthetic sports, such as gymnastics, where there is an emphasis on a lean body image, there are more cases of eating disorders with low body weight (32,4%) than in the normal population (1-6%)³.

In special types of sport where an individual low body weight is a pre-condition for a high performance rating, there are numerous cases of anorexia athletica, a self-demanded decrease of body weight until base- to low weight is reached. Normally these girls can regulate their own body weight depending on the phase of training. However, at the end of their sports career, they can normalise their weight again. This is in contrast to anorexia nervosa, which is a disease – especially in girls and young women - where the self- evaluation of body composition is destroyed and weight loss is primary in their thinking.

Sometimes there is a transition phase to bulimia nervosa or combinations thereof with this form of eating disorder. The patients are physically conspicuous and suffer from depression. Transitions between anorexia athletica and anorexia nervosa are not rare and lead to difficult diagnostic evaluation, because in both forms of the disorder somatic disturbances can exist.

When underweight this influences maximal bone mass accrual and metabolic disturbances in the growth and development of young girls. A loss of bone mass until the level of osteoporosis in anorexia nervosa has been demonstrated⁶. One-



third of the patients who have overcome the anorexia show a persistent osteopenia. Further nutrition-dependent factors in the case of underweight patients, such as increased cortisol concentrations, decreased progesterone levels, or deficiency of IGF-1 (Insulin-like growth factor 1) and T₃ can also lead to osteoporosis. New studies show the effect of leptin receptors on bone, so that it can be concluded, that, physiologically, leptin has a regulatory function on bone and energy intake and expenditure. Energy availability should not be below 30kcal per kg fat-free mass (muscle mass) per day. Often a weight gain of 1-2 kg can overcome existing amenorrhoea; the same can be reached with a 10% reduction of training intensity and duration. In the regime of therapy, nutrition has to be adapted to need with the macronutrition content playing a decisive role¹.

Summary

The female athlete triad includes low energy availability, menstrual cycle disturbances and decreased bone mineral density. Clinical symptoms are eating disorders (women - men 10:1), amenorrhoea and osteoporosis or stress fractures. Physical activity with proper nutrition provides a healthy balance for both the endocrine system and bone structure. The continuum from health to complete illness is described as total energy expenditure minus physical activity.

Energy availability is defined as whole energy. Low energy availability seems to have a negative effect on reproductive capacity and bone health, and in the triad, may become psychopathological. Energy availability should not be under 30kcal per kg fat-free mass (muscle mass) per day. At risk are women with restrictive eating disorders, who practice sports that emphasise body leanness. Preventive or early intervention must include a healthy lifestyle, surroundings, supportive parents, coaches and friends. Preventive counselling with a focus on early clinical symptoms of the triad must be held regularly at the annual medical examinations. The unhealthy practise of weight reduction with diuretics, laxatives or weight cycling in excess of 2-3kg body weight is risky. Endurance sports, weight-dependent sports and aesthetic

sports require an interdisciplinary team consisting of a physician, nutritionist and a psychologist. The first step in the intervention must be finding a way to increase energy availability which means an increase in total energy or a decrease in energy expenditure through excessive physical activity.

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