

Problems of High Performance Female Athletes

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Although male and female athletes from the same sporting discipline are prone to develop many similar types of problems, this article explores the problems that are associated with female athletes. Many common injuries from sport are just as likely to occur in men as in women. For example, all athletes are just as susceptible to dehydration (the loss of body fluids) which increases the risk of hyperthermia (very high body temperature) and hypothermia (very low body temperature). Broad participation by females in athletics is not a new phenomenon; however, detailed research into the medical difficulties faced by women athletes is not widely available. Typically, coaching education programs ignore the medical aspects of coaching and, in particular, aspects related to coaching women.

Many injuries are the result of anatomical abnormalities. These abnormalities should be identified by coaches during the early phases of the athletes' athletic careers. However, in many instances, early identification does not occur and the risk of later, more serious injury is heightened. Coaches should be aware of the anatomical requirements of their sports and use common sense.

It is important, even at the elite level, to emphasise the correct stretching technique and the correct exercises. Injuries to the ligaments of the ankle and knee joints are the most common training related injuries in female athletes. Pain due to a problem in the pelvis may present as pain in the knee or the back as they have the same nerve supply; the breast is rarely injured (White, 1980; Garrick and Shiveley, 1981).

The most frequent injury today in high performance athletics is an overuse injury, i.e., doing too much too quickly. Musculoskeletal (muscles, bones and joints) injuries are more common in female athletes who are amenorrhoeic (no menstrual periods for at least six months). Female athletes who develop recurrent shin splints (pain along the shin bone) or stress fractures should have a biomechanical assessment performed and should consider a full hormone profile, a dietary analysis, and a bone mineral density assessment (calcium content in bone). Athletes whose training is physiologically monitored, and who are regularly seen by a physician, are less likely to become overtrained.

Societal Problems

Family commitments frequently put a great strain on women because, in many societies, cultural norms or religious teachings continue reinforcing the belief that a woman's place is in the home. This obviously makes it more difficult for those women who wish to participate in high level sport. This attitude adds to their stress and may be reflected in changes in their menstrual cycle.

There are still many myths circulating about the effects of exercise on women (e.g., that it makes woman less feminine, and that they will tend to bulk up (develop marked hypertrophy, increase in size, of their muscles). This is due to the action of testosterone (a male hormone) and only occurs in the low percentage of women who have naturally high levels of testosterone or those who are taking steroids.

Dietary Problems

Dietary problems occur very frequently in female athletics, particularly in women's sports requiring low body fat (e.g., women's gymnastics or synchronised swimming). Eating disorders occur in 6% of non-athletes, 20% in sports where low fat content is emphasised, and a further 10% in athletes who are exceptionally preoccupied or have tendencies toward eating problems. In a recent British survey, 40% of synchronised swimmers were found to be below the recommended levels in 10 out of 12 nutrients and one athlete was low in all.

A correct diet plays a chemical role in the health and performance of all athletes. Research shows that inadequate caloric intake is more likely to occur in female athletes, and this will affect the hormones associated with the menstrual cycle. Fasting or reduced calorie intake increases the serum hormone binding globulin (SHBG) or the substance that combines with the male and female hormones and transports them in the blood. This then reduces the level of the biologically active oestrogen and testosterone. In young athletes, this may delay menarche (their first period) and in older athletes may result in long periods without menstruation. An increase in SHBG also occurs in athletes on a high fibre diet and a low meat protein diet (i.e., vegetarians) with the same result.

Female athletes are more likely to be iron deficient. Iron deficiency also affects vegetarians who, if they are on the contraceptive pill, may develop problems with the metabolism of their folate and vitamin B12 which are essential for the maturation of the red cells that transport oxygen in the blood. Vitamin C helps to absorb non-haeme iron (iron found in cereals but not in meats) while tea prevents 60% of the absorption of non-haeme iron.

Menstrual Problems

There is a great variation in the effects of the menstrual cycle on performance, and this may vary from one cycle to the next in the same individual. In a recent survey, about one third of female athletes believed that menstruation affects performance. Nevertheless, medals have been won by female athletes during all phases of the menstrual cycle (Delaney, Upton et al., 1976).

Athletes who have menstrual problems often had them prior to training. Excessive bleeding often is due to wearing an intrauterine device. The effects of menstruation on performance in sports may be sports-related as well. Dysmenorrhea (severe period pain) is rare in athletes and, if reported, should be investigated. It only occurs in ovulatory cycles (when an ovum or egg is released). It is the only menstrual symptom to which a specific biological cause has been attributed, namely the release of prostaglandins (pain producing substances) from the lining of the uterus or womb. Two out of 57 Irish athletes developed dysmenorrhea and, on investigation, one proved to have fibroids which had to be removed, the other an ovarian cyst. The treatment for dysmenorrhea is an anti-

prostaglandin (i.e., Ponstan or the oral contraceptive pill). Some athletes take medication for pain that contains codeine which is on the IOC list of banned substances. Athletes should read the contents of any medication carefully or consult with their National Olympic Committee's Banned Substances office.

Athletes with pre-menstrual tension (fluid retention and irritability) are at a disadvantage in sports where fine judgement is required and they are often more accident-prone. Diuretics should never be given as they are also banned by the IOC. If an athlete has pre-menstrual tension or dysmenorrhea, treatment should be started several cycles before a major competition. All athletes should keep detailed records of their menstrual cycle.

Hormones which control the menstrual cycle are also affected by exercise, circadian rhythms and seasonal variations.

Factors which predispose athletes to menstrual irregularities are:

1. late commencement of menstruation (menarche).
2. irregular menses prior to sports participation.
3. nulliparity (never had a pregnancy).
4. intensity of training prior to menarche.
5. immature reproductive axis (hormonal control).
6. psychological stress of training or competition.
7. low weight or loss of weight.
8. low body fat or loss of body fat.
9. poor nutritional status.
10. irregular menstruation prior to pregnancy.

The progression of changes in the menstrual cycle with increasing exercise are:

1. normal follicular (menstruation to ovulation, 14 days) and luteal phases (ovulation to menstruation, 14 days).
2. prolonged follicular and short luteal phases (less than 10 days).
3. euoestrogenic anovulatory oligomenorrhea (normal levels of oestrogen, not ovulating and reduced numbers of periods).
4. hypoestrogenic amenorrhoea (low levels of oestrogen and no periods) (Shangold, 1984).

Emotional Problems

Emotional stress may be another factor involved in exercise-induced menstrual cycle changes, possibly acting above the hypothalamic-pituitary system. Frisch et al., (1974) found that emotional stress was more frequent in women with secondary amenorrhoea (have menstruated, but now no periods) than in age-matched controls. Emotional stress is well-documented in nurses when they first attend hospitals. Anderson (1979) found that three-quarters of female West Point cadets were amenorrhoeic after two months of summer training camp, but after 18 months, only eight were still amenorrhoeic.

Menstrual disturbance is not consistent across the sports. Feicht (1978) found that 7% occurred in recreational runners, 10-12% in swimmers and 25% in competitive runners. The American College of Sports Medicine found that one third of competitive long-distance female runners experienced periods of amenorrhoea or oligomenorrhoea (Baker, 1981).

Many so-called normal cycles are abnormal when hormonal studies are carried out. Hormonal assessment increased the incidence of abnormal cycles from 60% to 89% in 32 women undergoing an intensive training program (Bullen et al., 1955). Amenorrhoea may cause problems if an x-ray or a bone scan is required because of the 10-day rule; they can only have x-rays done ten days from first day of menstruation.

Osteoporosis

Amenorrhoeic athletes who are hypoestrogenic (low levels of oestrogen) develop osteoporosis; that is, they have a reduced bone mass in trabecular bone [the body of the vertebrae and the neck of the femur as reported by Cann (1980), Drinkwater (1981) and others].

The mean bone density in amenorrhoeic runners age 25 was comparable to that of women age 50. If not treated, they are guaranteed stress fractures at the menopause. Osteoporosis is associated with the age of onset of training, intensity and volume of training, duration of participation in training, the sport involved, diet and stress (Riggs, 1981). Osteoporosis must be investigated and treated.

Moderate exercise protects against osteoporosis but excessive exercise may be causative. Many further investigations must be carried out to enable us to understand why some athletes are more at risk than others. Amenorrhoeic athletes may have increased levels of prolactin (hormone that increases in times of stress and plays a role in the control of the reproductive hormones), and this may be due to a prolactin tumour. It cannot be assumed that an amenorrhoeic athlete is infertile; she may be pregnant. Pregnancy or the inability to become pregnant can be problematic in female athletes.

Much more information is required to help the female athlete to reach and maintain her peak level of performance. This involves close teamwork with all concerned: the athlete, coach, physiotherapist, dietician and physician.

The Physiology of Women

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Introduction

The article presented in this section has been condensed from a well researched and extensively referenced report titled "Women, Sport and Physical Activity" prepared by the author with the support of the Ministry of State, Fitness and Amateur Sport, Canada.

The FISA CDP recognises the fact that in many countries there has been an increase in the participation of women at all levels of sport. Unfortunately, this growth has not been supported by documentation to assist administrators and, particularly, coaches to recognise and work with specific physiological considerations related to women.

Although it is not possible to deal with every aspect of physiology pertinent to women's sporting performance, this section will present and discuss several topics to dispel some myths and provide practical assistance. This information should ensure that women are given an equal opportunity to improve their performance capabilities.

Physical Activity and General Health

Most of the health benefits of regular physical activity are common to both males and females: maintenance of optimal body weight and composition, prevention of coronary heart disease (CHD) and improved fat and carbohydrate metabolism. In fact, CHD, obesity, anxiety, low back pain and other conditions have been called the diseases of hypokinesia (inactivity). Since there is evidence that women lead more sedentary lives than men, there are special implications for women's health.

Although the incidence of CHD is higher for men than women, rates among women are rising, with high blood cholesterol levels, high blood pressure and cigarette smoking, particularly in combination with the use of oral contraceptives, constituting major risk factors. But, it should be noted that there is evidence of an association between improved physical fitness and a lowering of CHD risk factors in women. As well as having lower blood cholesterol levels, it has been shown that physically active women, specifically distance runners, tennis players and rowers, develop higher levels of high density lipoprotein, a major factor in protecting against CHD. Other health benefits of exercise include lowered blood pressure and improved fat and carbohydrate metabolism.

Physical Activity over the Adult Life Cycle

While it is commonly assumed that physical performance declines with age, it is possible that the decrease in regular physical activity found in both sexes over the

life cycle is a more important factor than actual physical degeneration. There is ample evidence that women who engage in lifelong sufficiently intense levels of physical activity experience significant physiological benefits, including increased aerobic capacity, greater flexibility, reduced blood pressure and recovery time and lowered incidence of osteoporosis. Further, although it is difficult to separate physiological from psychosocial effects, there are numerous psychological studies which report enhanced self-worth and self-image associated with women's physical activity.

Physical Activity and Age-Related Osteoporosis

Genetic, mechanical, hormonal and dietary factors have been found to act together on the skeleton in retarding or accelerating osteoporosis (bone porosity characterised by reduced bone mineral content). While genetic factors may account in part for this pattern, it is also possible that variations are due to cultural differences in physical activity levels or to quantitative differences in muscle mass.

Physical activity stimulates bone growth and bone remodelling: increased bone density has been found in athletes, specifically in those bones subjected to stress in a specific sport. It is necessary to distinguish between cortical bone (as found in the tibia, for example) and trabecular bone (found in the spine). It is only cortical bone growth that is stimulated by physical activity. In non-athletes, the first signs of porosity are found in cortical bone which is not regularly subjected to mechanical stress during movement. There is evidence that exercise is effective in the prevention and treatment of osteoporosis, by contributing to the building of maximum bone mass before age 35 and to its maintenance during the rest of the life cycle.

Estrogen loss which occurs at menopause was thought to be a primary factor in age-related osteoporosis, but this does not explain the onset of bone loss before age 40 found in both sexes. Thus while estrogen deficiency is a factor in the increased rate of bone loss after menopause, it is not the basic cause.

Further, it has been reported that a conditioning programme can control the menopausal symptoms of vasomotor instability and depression for most women and that dietary calcium in conjunction with regular exercise has been recommended for prevention and treatment of bone loss, especially after menopause when estrogen loss may produce an imbalance in calcium absorption and excretion.

Physical Activity and Nutrition

General nutritional principles regarding energy, protein, vitamins, minerals and water apply to physically active individuals of both sexes. Other nutritional requirements specific to women are generally associated with the reproductive function, specifically, menstruation, pregnancy and lactation. As well, nutritional forms of prevention and treatment have been recommended for the pre-menstrual syndrome, osteoporosis and secondary amenorrhoea.

Blood loss through menstruation is a factor in the high incidence of iron deficiency found in the female population. Other factors include low dietary iron intake and reduced absorption of iron caused by dietary inhibitors (coffee, eggs, bran and

other foods). **There are three stages of iron deficiency, all of which can affect physical performance: iron depletion, iron deficiency without anaemia, and iron deficiency anaemia.** At stage one, low serum ferritin concentration indicates depleted iron stores. Stage two is indicated by low levels of serum iron concentration and transferrin saturation and by increased levels of iron-binding capacity. Stage three, iron deficiency anaemia, is indicated by low haemoglobin concentration and other hemotologic data. **There is some evidence that female athletes are more susceptible to stage one deficiency than sedentary women, and pre-season testing of iron status through a battery of tests is recommended, since stages one and two cannot be detected through hemotologic data alone.**

Iron supplements are recommended for pregnant women and for those in whom iron deficiency or anaemia has been confirmed. The pregnant or lactating woman who maintains a regular programme of physical activity has nutritional needs above those of a nonpregnant athlete, in regard to her intake of calories, protein, iron, calcium and certain other minerals and vitamins.

Physical Activity and Weight Control

There is evidence that regular physical activity, in combination with caloric restriction, will bring about weight loss. However, even in the absence of changes in body weight, there are other important beneficial results of exercise for overweight individuals: increased lean body mass (fat-free tissue), decreased plasma insulin, improved glucose tolerance, reduction in blood lipids, decreased blood pressure and improved cardiovascular efficiency. It should be noted that improvements in fat/lean ratio are not necessarily accompanied by weight loss, since increases in muscle mass may offset decreases in body fat. Further, and perhaps more importantly, in the case of overweight women, regular exercise promotes physical fitness and psychological well being.

Body Composition and Skeletal System

Females as a group have a higher percent body fat than males. The two major classifications of fat are essential fat and storage fat. Essential fat is required for normal physiologic functioning and is stored in bone marrow, muscles and organs. Storage fat includes the fatty tissue that protects internal organs and subcutaneous fat. Sex-specific fat, thought to be associated with female hormone synthesis, is classified as an essential fat. The sex difference in body fat of approximately 9% is also found between male and female athletes within a particular sport. In addition to sex and sport, ethnicity and age have been identified as key variables in fatness and fat patterning among athletes. There is, however, a wide variation for both sexes across all sports. For example, female and male field event athletes have 23.9% and 15.6% respectively - levels that are close to the average non-athlete - while the figures for distance runners are 15.7% and 5%.

The high body fat levels in female swimmers aid in buoyancy and thermoregulation (regulation of body temperature), especially in open-water distance swimming. At the other extreme, the low body fat level of female distance runners is an important factor in any sport which requires moving the body through space. Thus, body composition may play a part in determining

suitability for particular sports, and conversely, participation in these sports may contribute to developing and maintaining a certain body fat level.

The same relationship applies to somatotype. A particular type of physique may be a factor in the selection of a sport, and participation in that sport may influence body type, for example, by increasing muscularity or by retarding menarche so that the limbs grow longer during the extended growth period. **In females, ossification - the hardening of the bones - begins and ends from one to three years earlier than in males.** Since this process ends at puberty, late-maturing girls achieve greater height and longer limbs than those who mature early, while females, on average, tend to have smaller, shorter skeletal systems than males.

Research on body composition has tended to focus on high performance athletes. Even in this elite group, there are many exceptions to the general trend; thus, there are often highly successful individuals whose physiques and fat levels differ from what is considered ideal for their sport. **Therefore, the general relationship between body composition and suitability for particular sports need not be interpreted as a deterrent to participation for women with different physiques: body composition is only one of many factors contributing to athletic competence.**

Performance Capacity

Anaerobic/Aerobic Energy Systems

Three interrelated systems provide energy to muscles: two are anaerobic (oxygen-free) and one is aerobic (oxygen-utilising). Short term energy requirements (up to about 10 seconds), as in explosive events such as sprints and jumps, are provided for by the breakdown of phosphates stored in the muscles. Stair-running tests, which measure the ability to use phosphate stores in the leg muscles, show little difference between males and females when values are expressed relative to body weight. There are the expected differences based on intensity of training and type of sport: the most highly trained female athletes, and those in sports which require optimal leg power, produce the best performances on stair-running tests.

Medium term energy requirements (approximately 30 seconds to two minutes) are met by the lactic acid system. Glycogen stored in the muscles is partially broken down, producing lactic acid and adenosine triphosphate (ATP). Lower levels of lactic acid have been found after prolonged exercise in women than in men, indicating that less energy was available to them, but some past studies may have given female subjects lower workloads than males. Both sedentary women and trained female athletes respond to high intensity training regimens, showing improved anaerobic threshold as well as gain in anaerobic power.

The third system, the aerobic or oxygen system, uses glycogen and fat as energy sources and is important for activities performed at a submaximal rate over a lengthy period. Major factors involved in oxygen uptake include the oxygen carrying capacity of the blood (dependent primarily on haemoglobin concentration), cardiac output (related to heart volume and heart rate) and cellular utilisation of oxygen (arterial-venous oxygen difference). Up to puberty, sex differences in these areas are minimal. After puberty, sex differences in lean body mass and percent body fat are, to a certain extent, reflected in differences in the

efficiency of the aerobic system, although environmental as well as physiological factors contribute to these differences.

Maximum oxygen uptake, or $\dot{V}O_2$ max, is the usual measure of cardiovascular fitness and maximal aerobic power. It can be expressed in absolute terms or relative to body weight or to lean body mass. For athletes competing in the same sport, the differences between males and females average 51.5%, 18.6% and 9% respectively. **Differences in body size and composition have been found to account for most of the sex difference between male and female athletes in the same sport.** Although some basic biological differences in cardiac output, oxygen-carrying capacity of blood and muscle mass in males and females might be expected to produce about 10% difference, Nordic skiers have shown a sex difference of only 4% to 5%.

Thus, it cannot be said with certainty that any sex difference in $\dot{V}O_2$ max is biologically determined. The physical demands of a specific sport, and not the sex of participants, constitute the major determinant of $\dot{V}O_2$ max in athletes. Males and females in the same sport are closer in $\dot{V}O_2$ max than females in different sports.

Training Responses

Research has shown that women demonstrate the same training response and percent improvement as men when they train at sufficiently intense levels. Therefore, women are able to achieve their full physical potential provided they are not restrained by a variety of social-cultural reasons.

Muscular Strength and Endurance

Muscle fibres may be designated as slow-twitch (ST) or fast-twitch (FT) depending on their composition and metabolic potential: ST fibre is suited to prolonged aerobic exercise and FT fibre to explosive power. Thus, individuals (of either sex) with a higher percentage of ST fibres are predisposed to greater success in endurance activities. Since ST/FT ratio is determined by heredity, it does not change with training although training increases the size of fibre area. There are no significant sex differences in the ST/FT ratio for athletes in the same sport.

There are sex differences in the size of fibre area and these are reflected in differences in the strength of males and females. However, if values for specific areas of the body are expressed relative to body size or lean body mass, sex differences are greatly reduced, especially in terms of leg strength. Overall, muscles form a lower proportion of a female's body weight than a male's. **Muscular flexibility is greater in females, compensating in part for their overall lower levels of muscular strength.** The relation of muscle strength to muscle cross-sectional area is the same for both sexes.

Strength training programmes have been shown to produce higher rates of strength improvement (up to 50%) in females than males, probably because females were initially further from their strength potential. Strength increases in women are accompanied by slight increases in muscle girth, especially in the arms and shoulders. With the lower levels of the growth-promoting hormone testosterone in females than in males, women will probably not experience the marked increase in muscle girth seen in men who engage in strength training programmes.

Flexibility

Flexibility of muscles, tendons and ligaments is related to more efficient sporting performance: for example, longer running strides, better hurdling techniques and better kick and arm movements in swimming. Females of every age group are more flexible than males. Greater flexibility of the joints and cartilage of the vertebral column, pelvic girdle and foot make women better adapted to springing, landing and extensions. The smaller tendons and ligaments, on average, in females may account for the greater mobility of some joints.

The most common flexibility test is the sit and reach, which measures trunk flexion and hamstring flexibility. Girls show continuous improvement from ages 10 to 18, with a gradual decline throughout the adult years. Although flexibility is increasingly recognised as both an integral component of physical fitness and an important factor in injury prevention, it is perhaps significant that some fitness surveys fail to include it. The emphasis on the "swifter, higher, stronger" ethos in male competitive sport is reflected in the attention paid to those measures of physical fitness which have clear and direct links to sporting performance, that is, measures of speed, strength and endurance.

Thermoregulation

Temperature regulation in females during exercise in hot environments is related to such factors as sweating rate, ratio of skin surface area to weight, body water content and metabolic rate. A review of studies investigating thermoregulation in males and females found more similarities than differences between the sexes and reported that some of the earlier research did not take into account the athletes' fitness levels, degrees of heat acclimatisation and exercise intensity. Overall, response to heat stress was found to depend more on the state of the cardiovascular system than on sex: training lowers the thresholds for sweating and vasodilation.

When men and women exercised at the same relative intensity, in hot, dry environments, there were few differences, while in hot, humid conditions, women's higher skin surface area/weight ratio facilitated heat loss and gave them greater heat tolerance. Menstrual cycle phase has little effect on thermoregulation, nor has aging been found to decrease sweating capacity.

Injuries

Sport medicine literature over the past decade supports the claim that most injuries are sport specific, not sex-specific. Thus, American-style football, for example, produces head, neck and upper body injuries, whereas gymnastics is associated with knee, ankle and foot injuries. This does not mean that football players, being male, have weak necks, or that gymnasts, being female, have weak ankles, although this kind of faulty reasoning is often seen in discussion of female athletes' injuries. In considering sport specific injuries, it is useful to identify three categories: injuries which result from overuse, from biomechanical fault or from collision with players or equipment.

It is difficult to determine the extent, if any, to which inherent characteristics (for example, biomechanical faults) are responsible for existing injury patterns among females. If girls were encouraged to develop their full physical potential from birth, and if their coaches and trainers were fully informed regarding the best methods of conditioning and injury prevention, present injury patterns among female athletes might change dramatically.

When comparisons are made for the same sporting activity, there are conflicting results: some studies of injury patterns in track athletes and basketball players show minimal sex differences; some report a greater incidence of knee, ankle and foot injuries among females; others report a higher overall injury rate for males.

On the issue of childhood injury, recent studies have shown that both sexes sustain serious injuries in school athletic programmes and in school playgrounds, again pointing to the importance of proper coaching, training and supervision for school-age children, male and female.

Virtually every discussion of women's sport-related injuries mentions the breasts. However, there is no evidence that female breasts are more susceptible to injury than any other part of the human body. Furthermore, the alleged causal relationship between trauma and breast cancer is not supported in the literature. Blows, punches or kicks to the breast sustained in contact/combat sports may produce bruises and, in extreme cases, a hard and sometimes painful lump may form in the fatty tissue (fat necrosis). Therefore, the wearing of chest protection is probably advisable, especially in martial arts. Depending on individual preference and physique, extra breast support may be helpful in increasing comfort during physical activity.

Exercise and Reproductive Function

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Introduction

Certain physiological events in women's life cycles - menstruation, pregnancy and menopause - have traditionally been regarded by the predominantly male medical establishment as diseased conditions, requiring medical surveillance and intervention. Contemporary sport medicine literature is no exception to this trend, as the volume of research on delayed menarche and secondary amenorrhoea among athletes illustrates.

There is a move towards the adaptive rather than the disease model on the part of some doctors. They argue that the variations in menarcheal age and menstrual functioning among physically active girls and women constitute an adaptation to their strenuous training regimens, just as the same kinds of variations in other female populations are adaptive, serving to reduce the risk of pregnancy at a time when women are undernourished.

Unlike the disease model which entrenches the notion of the passive female patient, wholly dependent on the authority of her physician, the adaptive model is compatible with the health principles of self-help, informed decision-making and avoidance of unnecessary drug therapy or surgical procedures. Therefore, the emphasis in the following discussion will be on the adaptive or self-help rather than the disease model approach.

Menstrual Function

Menarche

Numerous studies in the last decade have identified a trend for female athletes to reach menarche up to three years later than non-athletic controls. It has been concluded that a combination of physical, hormonal, nutritional, psychological and environmental factors determines the onset of menstruation.

In terms of physical factors, a minimum "fatness level" is considered necessary for menarche. Hormonal factors are related to lean-fat ratio, as well as to the direct effects of exercise on hormonal secretion. Energy drain associated with intense training regimes, in combination with inadequate caloric and protein intake, also delay menarche. Psychological factors are associated with the stress experienced by competitive athletes and dancers. Non-biological factors related to family size, birth order, place of dwelling and social class may also be important.

A researcher has suggested that early training in sport delayed maturation, but another proposed an alternative explanation based on selective processes. Some girls may begin, or continue, to train because they are late maturers and thus have the time to perfect their athletic skills before pubertal changes (fat patterning and

changing physique, for example) interfere with their performance in certain sports. Late menarche also signifies a longer growth period, and the resulting longer limbs of these girls, combined with their thinness, may be a factor in their continued success as athletes or dancers.

Delayed menarche is so common among athletes that at least one gynaecologist has suggested that it be considered as normal - the rule rather than the exception for female athletes. Longitudinal studies show that delayed menarche may be associated with amenorrhoea and temporary infertility, conditions which are reversible when strenuous training is reduced.

Menstrual Cycle Variations

The reproductive system's adaptation to intense physical conditioning includes delayed menarche, secondary amenorrhoea (no menses in six months), oligomenorrhoea (intervals of more than 35 days between periods), anovulation (failure to ovulate) and short luteal phase (when the second half of the menstrual cycle is shorter than ten days, a condition associated with infertility). A woman can monitor ovulation and luteal phase length herself, by recording daily basal body temperature; this is a self-help technique that does not require invasive medical procedures.

A number of factors, singly or in combination, contribute to the reproductive system's adaptive processes: physical or psychological stress, loss of weight or body fat and dietary/nutritional variations, which cause hormonal and hypothalamic changes (changes to the hormone-directing part of the brain). Most studies show that the effects are reversible; that is, a return to regular menstrual functioning occurs when body weight increases and/or when training programmes or other stresses are reduced. For their part, female athletes do not necessarily view secondary amenorrhoea as a problem.

The low oestrogen levels associated with amenorrhoea may result in vaginal atrophy, as well as the obvious implications for fertility status, although it should not be assumed that amenorrhoeic women cannot become pregnant. Unless pregnancy is desired, exercise levels need not be reduced. For vaginal dryness, topical oestrogen replacement (oestrogen cream which, in small doses, has little systemic effect) is recommended.

Secondary Amenorrhoea and Osteoporosis Among Athletes

Low oestrogen and progesterone levels, which may increase susceptibility to osteoporosis, are found in amenorrhoeic athletes, as well as in athletes who are menstruating regularly but are not ovulating or are experiencing a short luteal phase.

The alleged link between exercise-associated amenorrhoea and bone loss has been a controversial subject since 1982, when it was first reported among a small number of female runners. Subsequent study and debate has pointed to problems of methodology, measurement and diagnosis associated with this line of research. The role of nutrition, overlooked in some of the earlier studies, is being carefully considered. Calcium supplementation is recommended as a safe preventive measure.

Molimina and Pre-Menstrual Symptoms

Women who ovulate regularly experience many kinds of cyclic changes, some positive and some negative. While these changes are experienced more intensely by some women, none are inherently pathological. They may include appetite changes, breast tenderness, fluid retention and mood changes. All these are normal changes which indicate ovulation and are termed molimina. When the normal changes of molimina are more severe or of longer duration, they may be defined as pre-menstrual tension.

On the question of cyclic changes and athletic performance, two studies found little or no effect on exercise-induced metabolic responses, except in subjects who fasted or were deprived of fluids for 24 hours prior to exercise. In fasting subjects, the differences in response occurred during the luteal (pre-menstrual) phase. In this regard, however, it is known that female athletes have performed at their best in international competition at every stage of the menstrual cycle, as well as during pregnancy.

For some women, pre-menstrual changes may be severe enough to warrant treatment. Dietary forms of treatment include calorie, sodium and caffeine reduction and increased intake of water and vitamin B6 supplement. One study showed that moderate aerobic exercise was effective in decreasing these symptoms. Yoga and relaxation have also been recommended.

Pregnancy and Lactation

From the time of Yaharieva's 1972 study of Olympic athletes, there has been increasing evidence that physical activity has no harmful effects on women's childbearing functions. Conversely, it has been amply demonstrated that athletic performance need not suffer as a result of pregnancy. Pregnant athletes have won Olympic medals, and many women, on resuming training, have surpassed personal best achieved before pregnancy.

Recent studies have suggested that physically fit women with normal pregnancies who exercise regularly have shorter labours, larger babies and fewer complications (Caesarean sections are an example) than those who do not exercise. Although data are inconclusive and medical opinion tends to be conservative, it is generally agreed that aerobic exercise has no harmful effects, and that a non-weight-bearing activity such as swimming is probably beneficial.

Maternal fitness level before conception is a factor in determining the level of exercise needed for an aerobic training effect during pregnancy. Ventilation, oxygen consumption and carbon dioxide production have been found to increase as pregnancy progresses, with gains in body weight accounting for most of the changes. Thus, exercising at reduced speed (walking instead of running, for example) may achieve the desired training effect in the later stages, although some women have maintained their running programmes throughout pregnancy. Studies of foetal heart rate and foetal movement have shown increases during maternal exercise (up to 80% maternal aerobic capacity), but these increases have been within normal limits.

There are specific concerns associated with participation in contact sports and in some water sports, since collisions and falls may be injurious to the pregnant woman and/or the foetus. Some studies of the effects of scuba diving on maternal and foetal health (in non-human subjects) indicate a high risk of decompression sickness and related problems. The results of human studies remain inconclusive, and therefore most advice on this issue is conservative, perhaps unnecessarily so, since it has been observed that Korean women who earn their living through diving continue through pregnancy and lactation with no ill effects.

Summary

The intent of both parts of this section was to provide a broad overview of issues relating specifically to women and their participation in sport. It is hoped that the information will be of practical assistance to both the coach and athlete.