FEMALE ATHLETES

training for success

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

FEMALE ATHLETES

training for success

FEMALE ATHLETES

training for success

A CIP catalogue record for this book is available from the British Library.

Printed by:Baskerville Press Ltd
6-8 Newton Road, Salisbury, Wiltshire SP2 7QB

Published by Peak Performance Publishing

Peak Performance Publishing is a trading name of Electric Word plc
Registered office: 67-71 Goswell Road, London, EC1V 7EP
Tel: 0845 450 6404 Website: www.pponline.co.uk
Registered number: 3934419

ISBN: 1-905096-01-1

Publisher Jonathan A Pye
Editor Bob Troop
Designer Charlie Thomas

OTHER TITLES IN THE PEAK PERFORMANCE SPECIAL REPORT SERIES

ACHILLES TENDINITIS –
PREVENTION AND TREATMENT

CARBO LOADING –
FOR THAT EXTRA EDGE

COACHING YOUNG ATHLETES

CREATINE –
CUTTING THROUGH THE MYTHS

DYNAMIC STRENGTH TRAINING FOR SWIMMERS

SHOULDER INJURIES –
PREVENTION AND TREATMENT

TRAINING FOR MASTER ATHLETES

CONTENTS

From the publisher

When are the women athletes going to catch the men? Never! say the male chauvinists. But I’m not so sure. Already scientists are suggesting that females have better endurance qualities than males, and that the marathon record might eventually fall to them. Looking at the remarkable Paula Radcliffe, I can well believe it. A leading physiologist has even worked out that if you measure races by competitors’ heights rather than by distance covered, the women are already quicker than the men.

The aim of this special report is to hasten the day when the ladies take over (no chauvinist me) by considering the various special problems that female athletes face and helping them to overcome them. First of all, we asked two surgeons to explain why women suffer more from knee injuries – specifically of the anterior cruciate ligament – and to suggest what they can do about it. This is followed by a group of exercises that are designed to strengthen the knee.

Next, women tend to suffer more from eating disorders, usually because their sport demands that they keep their weight down. Two experts, a nutritionist and a physiologist, show you how to tackle the problem, with a few words of advice on iron and calcium and why they are so important for athletic performance – and afterwards.

And then, we have a practical article on strength training, plus a few words of wisdom on pre-menstrual tension from... I’ll leave it to you to find out. But that’s enough from me. I hope you enjoy this special report and find it useful.

J. A. Pye.

Jonathan A Pye
Publisher

Two surgeons explain why female athletes suffer so many ACL injuries

The anterior cruciate ligament (ACL) is the most commonly damaged ligament of the knee and accounts for up to 50% of documented ligamentous knee injuries. ACL injury rates are four to eight times higher in women than men[1]. Female athletes who take part in sports involving jumping and 'cutting' such as soccer, basketball, volleyball and gymnastics are particularly at risk[2]. This article will consider the basic anatomy and mechanism of injury of ACL injuries with particular emphasis on the epidemic of injuries in female athletes that has recently come to light. The following article will suggest exercises that will help keep your ACL injury-free.

The ACL is a strap of connective tissue which stabilises the knee joint and connects the back of the femur (thigh bone) with the front of the tibia (shin bone). The ACL prevents hyperextension (overstraightening) of the knee and is the primary restraint to anterior displacement of the tibia. The intact ACL is a secondary stabiliser to varus and valgus (side to side) stress at the knee, and also plays a role in limiting internal rotation of the knee. Unlike the medial collateral and posterior cruciate ligaments, the ACL does not have the capacity to heal. Once injured, it does not reconstitute as a functional entity and surgical repair has proved less efficacious than reconstruction using other tissues.

Why has the injury rate increased?

The cause of the increased ACL injury rate in females is unclear and is most likely to be a complex interplay between multiple variables. Speculation on the possible origins of ACL injuries in women has centred on anatomical differences, joint laxity, physiological differences between men and women, and the effects of hormones and training techniques. Investigators have not agreed on the causal factors for ACL injury but have started to profile the type of athlete who is at risk[3].

The primary factors involved in the high incidence of female ACL injury include:

- The effects of the wide female pelvis
- A narrow femoral intercondylar notch
- Physiological laxity of the ACL with hormonal interplay
- Muscle reaction time disparity.

Wide female pelvis. The wider female pelvis exaggerates the angle between the femur and the tibia at the knee. The resulting increased inward pressure on the knee with external rotation of the tibia may place excessive stress on the ACL[4].

Narrow intercondylar notch. The intercondylar notch of the femur through which the ACL has to pass is generally smaller in women than it is in men[4]. This difference may not be statistically significant[5,6], since there is a wide overlap of notch sizes between the sexes. It is postulated that cutting and jumping movements in patients with narrow femoral notches may weaken and fray the ACL. Shelboune et al have shown that patients with narrow notches (<15mm) have a higher incidence of tears in their contralateral ACL[5]. After reconstruction with a 10mm autograft, the incidence of graft rupture appears the same for men and women.

It is unlikely that the increased incidence of ACL tears in females compared to males in the same sports can be attributed to notch width alone[6], but this factor undoubtedly plays a part. Graft impingement from regrowth of the notch is also recognised as a relevant factor that can result in late graft failure in the ACL reconstructed knee[7]. No attempt has been made to prophylactically enlarge the femoral notch, but the measurement of notch size helps to predict the risk of ACL injury.

Lax ACL and hormonal interplay. Receptors for both oestrogen and progesterone have been identified on the ACL. These hormones are believed to make the female ACL more lax and susceptible to overstretching[8]. Furthermore, recent research suggests that women are more susceptible to ACL injuries during the ovulatory phase of the menstrual cycle rather than the follicular phase[1]. ACL fibroblast proliferation and type I procollagen synthesis vary in a dose dependent manner with oestradiol concentrations[9]. Clinically, alterations in ACL cellular metabolism caused by oestrogen fluctuations in a menstruating athlete may render the ACL more susceptible to injury at this time.

Muscle reaction time disparity. Female athletes typically have less strength in their leg muscles and slower muscle reaction times than males. Strong fast-reacting hamstrings are needed to optimise the chance of keeping the ACL intact – for example, by keeping the tibia in place during landing from sudden jumps and stops. Even if the hamstrings are strong, if they react slowly they may be unable to protect the ACL in time to avoid injury[10]. A low level of hamstring activity and low angle of knee flexion at foot strike and during eccentric contraction, coupled with forces generated by the quadriceps muscles at the knee, could produce significant anterior displacement of the tibia, which may play a role in ACL injury[11].

Non-contact sports are worse

ACL injuries in women have until recently been underdiagnosed. This is partly because of the perception that this was primarily a male injury, but also partly because the extent of the knee injury is initially underestimated in many men and women. Contrary to popular belief, ACL injuries are more commonly seen after non-contact rather than contact sports. An understanding of the mechanisms involved is important as this gives a clue as to associated injuries and is occasionally pathognomonic of ACL injury on the history alone. Patients often describe one of the following modes of injury:

Non-contact injuries

Deceleration injuries. These may be seen in basketball or football players who decelerate to change direction. Increased quadriceps contraction induces an anterior force on the proximal tibia. If the tibia (lower leg) is internally rotated at the time, the ACL is at risk.

Flexion/valgus/external rotation. As the knee is bent and twisted out (for example if a football or rugby boot is stuck in the turf, or a ski binding does not release the boot in a twisting fall), the medial knee ligaments are initially injured, and then the ACL gives way. These injuries are often associated with medial meniscal tears – the so-called unhappy triad of O'Donoghue.

Hyperextension. This may be seen in basketball and volleyball players who land awkwardly, and in gymnasts during the dismount. It is the mechanism of injury in some footballers who cannot control their landing after going up for a header.

Quadriceps active tear. In skiers the sudden pull of the quadriceps with the knee bent can occasionally tear the ACL.

Contact injuries

A direct blow to the knee or shin can also lead to an ACL tear. These injuries are usually associated with damage to other structures within the knee. In over 50% of cases, the patient will hear a 'pop' or feel tearing within the knee. The patient is usually unable to continue playing sport and the knee swells rapidly. The swelling is due to a haemarthrosis (bleeding into the joint) and studies have shown that 80% of patients attending accident departments with acute haemarthroses have sustained ACL injuries. Of these, 60% have concomitant knee pathology at presentation, most commonly a lateral meniscal tear[12].

Most need reconstruction

The initial treatment of an ACL injury is based on reducing pain and swelling and getting the knee joint moving normally. The debate as to the need and timing of reconstructive surgery is ongoing. Conservative treatment involves the re-education of the quadriceps and hamstring muscles with an emphasis placed on the hamstrings as they can restrict the amount of forward tibial translation on the femur. Many less active patients manage their day-to-day activity after a rehabilitation programme. Difficulties arise when the athlete tries to return to her sport but finds that the knee gives way. Athletes who continue sports in spite of recurrent giving way have a very high rate of meniscal and chondral (joint surface) injuries.

In the majority of sporting individuals who wish to return to full activity, some form of reconstruction is required. The results of operative reconstruction obviously vary but the majority of studies suggest that 80 to 90% of patients can return to their pre-injury sporting activities. Most studies after reconstruction have been male dominated. Barber-Westin et al compared results of ACL reconstruction between sexes and concluded that they were similar and that sex alone cannot be used as a selection criterion for ACL reconstruction[15].

Alex Watson and Fares Haddad

'The results of operative reconstruction obviously vary but the majority of studies suggest that 80 to 90% of patients can return to their pre-injury sporting activities'

References

1. American Journal of Sports Medicine, vol 26 (5), pp 614-619, 1998

2. American Journal of Sports Medicine, vol 23, pp 694-701, 1995

3. Clinical Orthopaedics & Related Research, vol 372, pp 50-63, 2000

4. American Journal of Sports Medicine, vol 10, pp 297-299, 1982

5. American Journal of Sports Medicine, vol 26 (3), pp 402-408, 1998

6. American Journal of Sports Medicine, vol 25 (5), pp 687-690, 1997

7. American Journal of Knee Surgery, vol 11 (2), pp 81-88, 1998

8. American Journal of Sports Medicine, vol 24, pp 427-436, 1996

9. Clinical Orthopaedics & Related Research, vol 366, pp 229-238, 1999

10. Peak Performance, vol 140, pp 1-6, 2000

11. American Journal of Sports Medicine, vol 28 (2), pp 234-240, 2000

12. Knee Surgery, Sports Traumatology, Arthroscopy, vol 6 (1), pp 26-30, 1998

13. Journal of Bone and Joint Surgery, vol 65A, pp 154-163, 1983

14. Clinical Journal of Sport Medicine, vol 9 (2), pp 63-69, 1999

15. American Journal of Sports Medicine, vol 25 (4), pp 514-526, 1997

The Pill may be the most effective contraceptive and the best way to manipulate your cycle for important events, but are you aware of its physiological effects and their impact on performance?

The oral contraceptive pill (OCP) is the form of contraception most widely used by women in general and sportswomen in particular. Undoubtedly, the main reason for its popularity with both groups is its high effectiveness in preventing pregnancy.

Female athletes may also choose the Pill on the basis of other perceived benefits, including bone health, the ability to manipulate the menstrual cycle and control of premenstrual symptoms.

However, the impact of the Pill goes further than that, and the purpose of this article is to make sportswomen and their coaches fully aware of its physiological effects, both positive and negative, and their impact on performance and health?

An OCP is made up of hormones which can be combined in four different ways, defined by the ratio of oestrogen to progesterone:

- The monophasic pill has a low oestrogen content and the dose of both hormones remains constant throughout the cycle, allowing for easy manipulation of cycles when competing and travelling;
- The triphasic pill provides three different dosages of hormones during the cycle. Because it contains less total progesterone (and therefore a lower overall dose of hormones)

than the monophasic pill, it is thought to mimic the 'natural' cycle more closely than other types of OCP. It is recommended for women who experience side effects, such as weight gain, when using the monophasic pill. However, the varying dosages employed throughout the cycle make cycle manipulation more difficult;

- The biphasic pill maintains a constant oestrogen dose throughout the cycle, with a change in progesterone mid-cycle. It offers no particular advantage over the other two preparations and is not often prescribed;
- The 'minipill' contains progesterone only and is recommended for new mothers and those who are sensitive to the oestrogen component of other pills. Its main drawback is that it has a higher failure rate than the other formulations.

'A reduction in pre-menstrual symptoms, which is a confirmed effect of OCP usage, might well outweigh a slight drop in VO_2max during training or competition'

The manner and extent to which these combinations affect athletic performance is far from clear. Some investigators have reported reductions in VO_2max associated with the use of the OCP.

A recent Canadian trial, involving 14 female athletes with average VO_2max values of over 50 ml/kg/min, demonstrated a mean reduction in aerobic capacity of 4.7% following two months of OCP usage [1].

Similarly, another research group reported a 5% reduction in VO_2max in a group of élite subjects after two months on OCPs [2]. Other performance variables measured, including maximum heart rate and endurance at 90% VO_2max, were not affected by OCP usage. And both sets of researchers concluded that the observed reductions in VO_2max were reversible following cessation of medication, typically within 4-6 weeks.

However, other researchers have observed no negative impact of the OCP on performance. One recent study found no differences in exercise performance between an OCP and control group despite differences in blood lactate and temperature [3]. In another, a low-dose OCP taken over a single cycle was found to have no effect on breathing rate, VO_2max during a treadmill assessment, or an endurance running test [4]. These findings have been echoed by numerous other studies investigating the effect of the OCP on aerobic and anaerobic variables.

Even if the OCP does lead to a slight drop in VO_2max, it is unclear whether this would translate to a fall-off in performance. And against this possibility should be balanced the known supplementary benefits of the OCP. For example, a reduction in pre-menstrual symptoms, which is a confirmed effect of OCP usage, might well outweigh a slight drop in VO_2max during training or competition.

Another benefit of OCPs is that they reduce menstrual blood loss by up to 50%, so also reducing the risk of iron deficiency anaemia posed by heavy menstrual loss combined with inadequate dietary iron intake. Increased stroke volume, blood volume and cardiac output have also been reported with OCP usage, potentially increasing oxygen delivery to the muscles.

How the Pill impacts on body weight and muscle strength

The issue of weight gain is of great concern to athletes and often of even greater concern to their coaches. This is particularly the case in power-weight ratio dependent sports such as distance running, light weight rowing and gymnastics.

Individual responses to the hormones in the OCP may include some weight gain as a result of either fluid retention or, possibly, appetite stimulation. Nevertheless, contrary to popular belief, most population studies indicate no overall effect on body weight while taking the OCP. This is particularly the case with the newer low-dose pills.

Few studies have investigated the effects of OCP on muscle strength in female athletes, and those which have been carried out have found no significant differences in the strength of various muscle groups with OCP usage. Fluctuations in muscle strength have been noted during a normal menstrual cycle, and these appear to relate to changes in levels of oestradiol, the major female sex hormone produced by the ovaries. Increased strength has been reported late in the follicular (pre-ovulatory) phase of the cycle, corresponding to increases in oestradiol before ovulation, with reduced strength reported in the luteal (premenstrual) phase, possibly due to increases in deep muscle tissue.

The point about OCP usage is that it appears to eliminate these natural fluctuations in muscle strength.

Adverse effects on risk factors for cardiovascular disease have been highlighted with higher dose OCPs. However, researchers have hypothesised that exercise itself may counteract these potentially negative effects.

Substrate utilisation during exercise has also been studied in relation to the Pill. In one study, a group of women on OCPs was shown to have lower blood glucose levels and lower carbohydrate usage during prolonged submaximal exercise than a control group[5]. Another trial documented an increase in free fatty acids with exercise in association with these lower blood glucose levels[6]. This trial also found an increase in the growth hormone response to exercise, possibly as a result of direct stimulation by the oestrogen component of the Pill.

Such findings suggest that the OCP may facilitate carbohydrate sparing during prolonged exercise, thus delaying time to exhaustion. An alternative interpretation, however, is that the increase in free fatty acid utilisation is a compensatory response to a decreased glucose release, suggesting that, even with increased free fatty acid availability, endurance performance might be negatively affected.

In summary, the pros and cons of OCP use for female athletes and sportswomen may be set out as follows, with the benefits appearing to outweigh the costs:

Advantages

- Highly effective, convenient and reversible;
- Provides a source of oestrogen for athletes without periods, decreasing their risk of stress fractures and osteoporosis;
- May decrease menstrual blood loss, which reduces the risk of iron-deficiency anaemia;
- Reduces painful period cramps;
- May decrease premenstrual symptoms (eg mood swings, nausea, headaches) which could have a negative impact on training and competition;

● Can be used to manipulate the menstrual cycle for important events and travel;
● Associated with a decreased risk of cancers of the ovary and uterus;
● No known long-term effect on fertility.

Disadvantages

● Possibility of breakthrough bleeding, fluid retention, weight gain, breast tenderness and headaches (although these usually settle within a few months and can be controlled by changing to a different OCP);
● No protection from sexually transmitted diseases;
● Associated with a small increased risk of breast cancer in women using OCPs for more than 10 years without having children;
● Possibility of decreased VO_2max /endurance performance.

The conflicting results found in the scientific literature are often difficult to interpret, given the known differences in such variables as Pill dosages and formulation, menstrual history, duration of OCP use, age at which subjects were exposed to OCP, and outcome measurements. Nevertheless, there are individual variations in response to OCP use and these should be taken into account and monitored. Female athletes should be counselled about the range of potential benefits and disadvantages in order to make informed decisions based on their individual circumstances.

Andrew Harrison

References

1. *Br J Sports Med 2003; 37: 315-320*
2. *Sports Med; 1993; 16: 400-430*
3. *Eur J Appl Physiol 1998; 78: 565-572*
4. *Br J Sport Med 1996; 30: 36-40*
5. *Med Sci Sports Exerc 1992; 24: 434-441*
6. *J Appl Physiol 1991; 70: 1817-27*

Female athletes who are obsessed by food and body weight can develop anorexia athletica

If you're an athlete aiming to optimise performance in your sport, you can obviously reap benefits from paying attention to what you eat. However, for some people this interest develops into an unhealthy obsession with food, calories and body weight. They worry continuously about what they are going to eat, when and where they're going to eat, how much weight they'll put on if they go out for a meal with friends, how many hours they'll have to exercise to burn off those calories, how they can avoid eating 'banned' foods, and so on. Such an obsession with food and body weight is termed an eating disorder.

Eating disorders appear to be on the increase in the population as a whole. For example, the number of people seeking treatment for anorexia and bulimia in one London hospital has increased by 360% over nine years. Experts have argued that one factor is a fashion ideal of the perfect body which has become progressively thinner over the last 40 years. Such media-based pressure used to apply predominantly to women, but in recent years use of the male 'body beautiful' in advertising has increased, leading to growing concern among men about whether their body conforms to the ideal. Increased awareness and diagnosis may have also made an impact on the statistics.

Research has identified a number of other factors thought to contribute to the development of eating disorders. Studies of twins indicate that genetic factors may play a part. Biological factors such as imbalances in neurotransmitters in the brain may be involved. Various psychological factors have also been proposed. Here, the eating disorder is seen as a reaction to one or more of the following: being brought up in a family which has difficulty in resolving conflict and expressing emotions; actual or feared sexual abuse; difficulty in coping with stress; low self-esteem (leading to a need to bolster self-esteem by external approval). Overly simplistic diagnoses of causes should be avoided, however, as individuals will vary with respect to the primary causes.

Increased risk of eating disorders for athletes

Studies have shown that athletes are far more prone to developing eating disorders than non-athletes. In addition to all the factors outlined above, athletes face additional pressures related to performance and, for some, aesthetic demands. For some athletes, such as distance runners, sprinters and swimmers, low bodyweight is thought to confer a competitive advantage. On the other hand, competitors in sports where a subjective judging element is involved, such as gymnastics, diving, skating and dancing may feel that their body size will influence their score. And certain sports where weight categories are involved, such as wrestling and rowing, can lead to cycles of weight gain followed by sudden weight loss.

'The highest prevalence of eating disorders is in female athletes competing in sports where leanness and/ or a specific weight are considered important for either performance or appearance'

Athletes, too, often have heightened body awareness, making them more prone to body image concerns. Finally, perfectionism, compulsiveness and high achievement expectations are personality traits thought to be advantageous for the competitive athlete; however these very traits are commonly associated with the development of an eating disorder.

Thus, as might be expected, the highest prevalence of eating disorders is in female athletes competing in sports where leanness and/ or a specific weight are considered important for either performance or appearance. Males also suffer from eating disorders, but at a lesser rate – the estimated proportion is one male for every 10 females.

Anorexia, bulimia and subclinical disorders

The eating disorders, anorexia nervosa and bulimia nervosa, are recognised as types of psychiatric illness, and are clinically defined by a set of diagnostic criteria. These go beyond a concern with weight and body image, and also include serious psychological problems. A number of studies have identified a significant proportion of athletes who suffer from one of these disorders. Others, however, will exhibit less severe, or 'subclinical', forms of eating disorders that meet some but not all of the diagnostic criteria. Some experts have proposed that eating disorders are best conceptualised as a spectrum – for example, Fries (Monograph, *Acta Psychiatr Scand* Vol 248(suppl)) has proposed a continuum hypothesis of eating/dieting behaviour which suggests that dieting may lead to disordered eating behaviours, which in turn may lead to anorexia nervosa or bulimia.

The concept of subclinincal anorexia was first examined by researchers in the 1970s. It was later identified in adolescents exhibiting a pattern of growth failure and/or delayed puberty, due to self-imposed calorie restriction arising from a fear of becoming obese.

Using case-study information, another researcher adapted the concept of subclinical anorexia to athletes. The 'subclinical anorexic' was described as a young male athlete strongly committed to his sport, who underwent extreme weight loss as a means of improving his chances of success. Eventually, the dieting and maintenance of an unrealistically low body fat were no longer the means to an end (ie, athletic success), but became the end in itself (Smith, 'Excessive weight loss and food aversion in athletes simulating anorexia nervosa', *Paediatrics* Vol 66(1), pp139-142). More recently, a Norwegian nutritionist has proposed a set of distinguishing features of a form of subclinical anorexia she refers to as 'anorexia athletica' (Sundgot-Borgen, 'Prevalence of eating disorders in elite female athletes', *Int J Sport Nut* Vol 3 pp29-40).

Attempts to define anorexia athletica

Sundgot-Borgen defines anorexia athletica in terms of absolute criteria (which must be present) and relative criteria (may be present). These are:

Criteria that must be met:

Weight loss, gastrointestinal complaints, absence of medical illness or affective disorder explaining the weight reduction, excessive fear of becoming obese, restriction of calorie intake.

One or more of the following:

Delayed puberty, menstrual dysfunction, disturbance in body image, use of purging methods, binge eating, compulsive exercising.

Researchers from Arizona State University have claimed that these criteria are somewhat ill-defined and indiscriminate (Beals and Manore, *Int J Sport Nut*, Vol 4, pp175-195). They suggest that more research is needed to further delineate and define the unique characteristics of those with subclinical eating disorders, such as anorexia athletica. They make their own suggested list of absolute and relative diagnostic criteria, with the caveat that the number of criteria needing to be met remains to be determined. Their list is summarised as follows:

Absolute criteria:

● Preoccupation with food, calories and body shape
● Distorted body image
● Intense fear of gaining weight or becoming fat even though moderately or extremely underweight
● Over at least a one-year period, the athlete maintains a body weight below 'normal' (5-15%) for age and height, using one or a combination of the following: a) restricting energy intake b) severely limited food choices or food groups c) excessive exercise (ie, more than necessary for success in sport or as compared to athletes of similar fitness levels)
● Absence of medical illness or affective disorder explaining the weight loss or maintenance of low body weight

Relative criteria:

● Gastrointestinal complaints
● Menstrual dysfunction
● Frequent use of purging methods (self-induced vomiting, or

use of laxatives or diuretics for at least one month)
- Bingeing (at least eight episodes a month for at least three months).

Causes?

There has been considerable speculation about why athletes are at such increased risk for eating disorders (clinical and subclinical). It's hard to pin down which comes first – is it a predisposing personality or life circumstances which lead both to athletic participation and an eating disorder, or does participation in certain sports cause the onset of the eating disorder? It seems likely that there will be some interaction.

A comprehensive study of elite female athletes undertaken in Norway sought to identify risk factors for eating disorders, along with trigger factors responsible for precipitating their onset or exacerbation (Sundgot-Borgen, 'Risk and trigger factors for the development of eating disorders in female elite athletes', *Medicine and Science in Sport and Exercise*, Sept 1993 pp414-419).

An initial screening questionnaire was sent to all elite female athletes in Norway (defined as one who qualified for the national team at junior or senior levels, or was a member of a recruiting squad for these teams, aged between 12 and 35). The 522 athletes responding represented six groups of sports: technical, endurance, aesthetic, weight dependent, ball games, and power sports. The Eating Disorder Inventory was used to classify individuals at risk for eating disorders (*Manual of Eating Disorder Inventory*, Odessa, Fla: Psychological Assessments Resources Inc, 1984).

One hundred and seventeen (22.4%) were thereby defined as at risk, and 103 of these agreed to being given a clinical interview to diagnose eating disorders. A comparison group was also interviewed, consisting of 30 athletes chosen at random from a pool not at risk (ie, they were found to have low scores on the initial Eating Disorders screening questionnaire). These control subjects were matched to the at-risk subjects for age, community of residence and sport.

Ninety-two of the at-risk athletes met criteria for anorexia nervosa, bulimia nervosa, or anorexia athletica. All of these athletes were asked if they had any suggestions as to why they had developed an eating disorder. Eighty-five per cent of these gave reasons. Information collected during the interviews was then combined with the specific reasons given by the athletes to define possible trigger factors associated with the development of eating disorders.

The results showed that athletes competing in the aesthetic and endurance sports were leaner and had a significantly higher training volume than athletes competing in other sports. The prevalence of eating disorders was significantly higher among athletes in aesthetic and weight-dependent sports than in other sport groups.

Risk factors for eating disorders in athletes

Several risk factors were identified. Dieting at an early age appeared to be associated with the onset of an eating disorder. A significant number of athletes who began dieting to improve performance reported that their coach recommended they lose weight. For young and impressionable athletes, such a recommendation may be perceived as a requirement for improved performance. Other researchers have reported a similar syndrome – for example, finding that 75% of female gymnasts who were told by coaches that they were too heavy used unhealthy weight-control measures.

The results of the Norwegian study also suggested that the risk for eating disorders is increased if dieting is unsupervised. Athletes with eating disorders may not seek supervision for fear their disorder will be discovered. In addition, many athletes have little knowledge about proper weight-loss methods and receive their information in haphazard ways, from friends, magazine crash diets, and so on. Such diets are unlikely to account for the high-energy requirements resulting from training, or the fact that maturing females have special nutritional requirements. Unsuitable crash diets may appeal to athletes if they feel that rapid weight loss is necessary to make the team or to remain competitive. Finally, the restrictive diets and fluctuations in body weight that accompany these efforts may also increase risk for eating disorders.

Early start of sport-specific training was also associated with disordered eating. A higher percentage of athletic controls than of eating-disorder athletes participated in other sports before choosing their preferred sport. An individual's natural body type usually steers the athlete to specific sports, and body type dictates in part whether the athlete will be successful. Beginning training for a specific sport before the body matures might have hindered these athletes from choosing a suitable sport for their adult body type. This could provoke a conflict in which the athlete struggles to prevent or counter the natural physical changes precipitated by growth and maturity.

Extreme exercise in itself has previously been cited as a potential causal factor in anorexia nervosa. In the Norwegian study, many of the athletes who did not give specific reasons for the onset of their eating disorder reported a large increase in training volume and a significant weight loss associated with the increased activity. Athletes who increase their training volume may experience relative calorie deprivation, possibly because of not realising that they need to eat more to meet the increased energy demand, or perhaps due to reduced appetite produced by changes in endorphins.

This calorie deprivation may create a biological or psychological climate in which eating disorders are more likely to develop. It has been observed previously that starvation itself can bring about symptoms of eating disorders – eg, obsession with food and hyperactivity (*The psychology of eating and drinking,* AW Logue, Freeman, NY, 1986, p156).

Finally, the loss of a coach occurred in some athletes with eating disorders. These athletes described their coaches as vital to their athletic careers. Other athletes reported that they developed eating disorders at the time of injury or illness, which left them unable to train at high levels. Thus, the loss of a coach, injury, or illness must be seen as traumatic events that become trigger events for the onset of eating disorders.

Prevention

Prevention is the key to addressing the problem of disordered eating, and education is a necessary first step. Athletes, parents, coaches, athletic administrators, training staff and doctors need to be educated about the risks (as detailed above) and warning signals of disordered eating. Mimi Johnson, in 'Disordered Eating in Active and Athletic Women' (*Clinics in Sportsmedicine* Vol 13, no.2, pp357-369, April 1994) identifies the following checklist of warning signs:

✓ A preoccupation with food, calories and weight
✓ Repeated expressed concerns about being or feeling fat, even when weight is average, or below average
✓ Increasing criticism of one's body
✓ Secretly eating, or stealing food
✓ Eating large meals, then disappearing, or making trips to the bathroom
✓ Consumption of large amounts of food not consistent with the athlete's weight
✓ Bloodshot eyes, especially after trips to the bathroom
✓ Swollen parotid glands at the angle of the jaw, giving a chipmunk-like appearance
✓ Vomiting, or odour of vomiting in the bathroom
✓ Wide fluctuations in weight over short periods
✓ Periods of severe calorie restriction
✓ Excessive laxative use
✓ Compulsive, excessive exercise that is not part of the athlete's training regimen
✓ Unwillingness to eat in front of others (eg team mates on road trips)
✓ Expression of self-deprecating thoughts following eating
✓ Wearing layered or baggy clothing
✓ Mood swings
✓ Appearing preoccupied with the eating behaviour of others
✓ Continuous drinking of diet soda or water.

If you are concerned that someone you know may be suffering from an eating disorder, you need to go softly in approaching them about it. People who are truly anorexic or bulimic will often deny the problem, insisting that there's nothing wrong. Share your concerns about physical symptoms such as light-headedness, chronic fatigue or lack of concentration. These health changes are more likely to be stepping stones for accepting help. Don't discuss weight or eating habits directly. Avoid mentioning starving/ bingeing as the issue and focus on life concerns. Offer a list of sources of professional help. Although the athlete may deny the problem to your face, she may secretly be desperate for help.

'If you are concerned that someone you know may be suffering from an eating disorder, you need to go softly in approaching them about it'

Getting help

Ask your GP about eating disorder clinics at hospitals in your area. Both medical and psychological help may be required, and therapy may need to involve the whole family. Other potential resources are:

The Eating Disorders Association, 103 Prince of Wales Road, Norwich, Norfolk NR1 1DW. Telephone (01603) 621414. An umbrella organisation which coordinates a network of local groups (many run by people who have suffered anorexia or bulimia) and provides information, telephone help and a newsletter. Send an sae for details of local groups.

Overeaters Anonymous, PO Box 19, Stretford, Manchester M32 9EB. A self-help organisation for men and women with eating disorders that uses a '12 steps' recovery programme modelled on that of Alcoholics Anonymous. They can put you in touch with the nearest of more than 100 groups nationwide.

Diagnostic criteria for anorexia nervosa

1. Refusal to maintain body weight at or above a minimally normal weight for age and height (eg, weight loss leading to maintenance of body weight less than 85% of that expected; or failure to make expected weight gain during a period of growth, leading to body weight less than 85% of that expected).

2. Intense fear of gaining weight or becoming fat, even when underweight.

3. Disturbance in the way one's body weight or shape is perceived;

undue influence of body weight or shape on self-evaluation, or denial of the seriousness of the current low body weight.
4.In females who have begun menstruation, the absence of at least three consecutive menstrual cycles.

Subtypes:
Restricting types
Do not regularly engage in binge eating or purging behaviour (self-induced vomiting or the misuse of laxatives or diuretics).
Binge eating and purging types
Regularly engage in binge eating or purging behaviour (self-induced vomiting or the misuse of laxatives or diuretics).

Diagnostic criteria for bulimia nervosa

1. Recurrent episodes of binge eating. An episode of binge eating is characterised by both of the following:
a. Eating in a discrete period (eg, within any two-hour period) an amount of food that is definitely larger than most people would eat during a similar period of time and under similar circumstances, and
b. A sense of lack of control over eating during the episode (eg, a feeling that one cannot stop eating or control how much one is eating).
2. Recurrent, inappropriate compensatory behaviour to prevent weight gain such as self-induced vomiting, misuse of laxatives, diuretics or other medications, fasting, or excessive exercise.
3. The binge eating and inappropriate compensatory behaviours both occur, on average, at least twice a week for three months.
4. Self-evaluation is unduly influenced by body shape and weight.
5. The disturbance does not occur exclusively during episodes of anorexia nervosa.

Subtypes:
Purging type
The person regularly engages in self-induced vomiting or the misuse of laxatives or diuretics.

Non-purging types

The person uses other inappropriate compensatory behaviours, such as fasting or excessive exercise, but does not regularly engage in self-induced vomiting or the misuse of laxatives or diuretics.

Janet Stansfeld

A sports physiologist explains why iron and calcium are essential for female athletes

National advice for female athletes is a growing area of interest, and indeed concern, for dieticians and sports nutritionists. Much of the concern is centred on the various subclinical eating disorders discussed in the last article. However, a rather more subtle, yet no less important issue arises when one considers the often limited dietary intake by female athletes of two specific minerals – namely iron (Fe) and calcium (Ca) – especially when heavy training loads are undertaken.

Levels of iron in the various body compartments – collectively known as ‘iron status’ – are of particular importance to the athlete given iron’s role in enzyme function, and especially considering the fundamental role of iron within haemoglobin and myoglobin (the muscle tissue’s equivalent of haemoglobin). Oxygen transport from the lung interface with the atmosphere to the muscle capillaries and subsequent delivery to the mitochondria within the muscle cells, removal of waste products including carbon dioxide, and the buffering of the metabolic acidosis (due to hydrogen ions) built up during intense exercise are all roles performed by haemoglobin and myoglobin. These chemical substances contain individual atoms of iron, each one of which can combine with one molecule of oxygen.

Logically, one might think that simply consuming more iron in the diet would increase haemoglobin levels, but unless a severely inadequate diet has been the norm for a number of months or years, or in certain diseased states, this is not the case.

However, an athlete's iron status may be compromised, and the body stores may be far below the normal desired levels without producing a reduced haemoglobin level or even reducing performance capacity. The problem is, however, likely to appear as reduced performance in the future if the situation is allowed to get worse, when eventually the functional iron stores of certain enzymes, myoglobin and haemoglobin will be affected. So the aim of the serious athlete should be to maintain full iron status through adequate nutrition so that the possibility of worsening performance through lowered functional iron stores does not occur.

One complication for athletes is that their dietary iron requirements appear to be slightly higher than those of the general population, yet for some endurance athletes, those in events where bodyweight must be strictly controlled, and for females athletes in general, total energy and therefore other nutrient intakes may be habitually low (Hawley and co-workers, 'Nutritional Practices of Athletes: Are they Sub-optimal?', *Journal of Sports Science*, 1995, vol 13, Special Supplement, ppS75-S87). Various scientific investigations, especially in the 1980s, discovered low iron intakes among female endurance athletes in particular. One such study conducted in Canada found that 91% of female distance runners did not consume adequate amounts of iron in their diets (Clement and Asmundson, 'Nutritional Intake and Haematological Parameters in Endurance Runners', *The Physician and Sportsmedicine*, 1982, vol 10, no 3, pp37-43).

Why might an athlete need more iron?

Increased iron needs of athletes may be due to several factors, some of which have been backed up more than others through rigorous scientific investigation. Each of these may contribute to iron loss, and the type of athlete mentioned above, the female distance runner, may find many of the potential causes relevant to her own situation. It should be noted, however, that any athlete involved in heavy training can be affected. The factors include:

● Internal gastrointestinal bleeding
● Minor damage to the wall of the bladder
● The physical breakdown of red blood cells, literally through being squashed between bone and an external object (eg, the floor) during high-impact activities
● Over-frequent blood donation (the Good Samaritan Syndrome). At least one report shows that athletes donate more blood than the general population
● Increased iron loss through heavy sweating (although relatively small amounts).

In addition, female athletes in general are likely to have a higher rate of iron loss than men, and also a higher daily requirement, largely because of blood loss through menstruation. Pregnancy and childbirth can also tax iron stores significantly.

Dietary factors that tend to limit iron intake include:
● Low total energy intakes. Low total amounts of food will lead to susceptibility to dietary deficiencies
● Vegetarian diets. The iron found in meat and meat products is both more plentiful and far more easily absorbed than that found in plant foods, while dairy products and eggs (for those who eat them) do not compensate for iron as they do for other nutrients such as protein
● Natural food diets. Certain food additives such as vitamins and minerals are beneficial; a good example is breakfast cereal fortified with iron
● Fad diets. Diets with a limited range of food choices are unlikely to fulfil basic nutritional requirements, and athletes who follow unusual eating patterns may well be deficient in iron intake.

What is widely regarded as the most reliable single measure of iron status is ‘serum ferritin concentration’. Many laboratories specialising in exercise physiology and sports science support to athletes will be able to determine this measure and provide athletes with an indication of body iron stores. Appropriate action can be prescribed, often through dietary modifications.

How to tackle the problem

Sound nutritional advice with a particular emphasis on enhancing iron status must take into account the two forms of iron found in foods. The first, haem iron, is found in meat, seafood and poultry, and has an absorption rate from the gastrointestinal system of up to 23% (meat sources being the most easily absorbed). While this may not sound very efficient, the importance of this form of iron is clear when one considers that most of the iron in many athletes' diets (and all, in the case of vegetarians) is of the second form, non-haem iron (found in cereals, legumes and vegetables), which has an absorption rate of just 2-8% on average.

'Given the complexity of the situation, the influence of an athlete's dietary pattern and intake is clearly a major factor in producing optimal iron status'

The absorption rate of this form of iron is also that which is most heavily influenced by other dietary factors. For instance, high levels of vitamin C intake at mealtimes will increase iron absorption rates from other foods, as will small amounts of alcohol. Conversely, caffeine, and especially tannic acid (found mostly in tea) will reduce iron absorption rates dramatically.

The RDAs for iron intake in various countries are around 12-17mg/day for females, about 5mg/day more than the male RDAs. Given the complexity of the situation, the influence of an athlete's dietary pattern and intake is clearly a major factor in producing optimal iron status. The take-home lesson for any athlete (whether suspicious of iron deficiency or not) and especially female endurance athletes, can be summed up in six short sentences (modified from Burke and Deakin (editors), *Clinical Sports Nutrition,* 1994, p.188);

1. Increase total intake of iron-rich foods in regular diet
2. If possible, eat at least 90g of lean meat, poultry or fish daily
3. If vegetarian, ensure food choices are iron-dense (includes green leafy vegetables and legumes)
4. Increase intake of bread (especially wholemeal) and iron-enriched cereals
5. Include a good source of ascorbic acid (vitamin C) with each meal – such as salad, fruit or fruit juice
6. Avoid tea or coffee at mealtimes, particularly if plant-food sources of iron are included. Drinking tea at mealtimes is

probably the worst single action an athlete can take for iron status.

Bone mass, menstrual function and calcium

Bone is a body tissue that undergoes continual reformation and modification. The dense outer portions of bones do so very slowly, whereas the 'cancellous' portions of bones (found mainly in the vertebrae, pelvis, flat bones and the ends of long bones) do so more rapidly. Calcium compounds form about 60% of bone matter, so it is not surprising that dietary intakes of calcium can affect bone mass.

Normal bone growth produces a peak in bone mass at around the age of 20, and a decline with age occurs beyond this, causing women to lose about 50% of cancellous bone in a lifetime – almost twice as much as men. Bone mass and density are related to bone strength, and a critical fracture threshold is believed to exist. Stress factors interrupt many athletic careers, and are related to the trauma or stress load experienced by the bones. A reduced bone mass will increase the likelihood of such a fracture.

In general, the greatest stimulus for increasing or maintaining bone mass in adults is weight-bearing exercise. However, a condition of 'osteopenia' has been identified in many amenorrhoeic athletes, ie, a reduced bone mass in female athletes who have menstrual dysfunction (Myburgh and co-workers, 'Low Bone Mineral Density at Axial and Appendicular Sites in Amenorrhoeic Athletes', *Medicine and Science in Sports and Exercise*, vol 25, no 11, pp1197-1202). The beneficial effects of weight-bearing exercise are apparently outweighed by other factors which are related to amenorrhoea.

Menstrual irregularities

Amenorrhoea has a specific definition regarding the absence of a menstrual cycle for at least three months, while the term oligomenorrhoea describes an irregular cycle which does not fit this definition exactly. So 'menstrual irregularities' will be the term used in this article. Young, intensively training female athletes are at much greater risk (at least 15%) of developing menstrual irregularities than sedentary women (2-5%). This suggests a relationship between strenuous training, body type and dietary patterns. This distinction in risk status is polarised when low bodyweights, body fat levels and nutritional intakes are considered in the type of female athlete found to be particularly at risk – that is, distance runners, gymnasts and ballet dancers.

Some research has suggested that menstrual irregularities are related to training volume, especially in distance runners, although the evidence is not yet convincing. More research is needed with a careful control on training intensity before conclusions can be reached in confidence. A more consistent relationship has been shown which links body composition to menstrual irregularities. Every individual may have a personal set-point of body fat, below which she may go only at the expense of normal menstrual function. A tentative parallel in the psychological profiles of some female athletes with those of females with anorexia is made by Bale ('Body Composition and Menstrual Irregularities of Female Athletes: Are They Precursors of Anorexia?', *Sports Medicine*, 1994, vol 17, no 7, pp347-352) with intensive training replacing some of the personal control achieved through dietary extremism. Nevertheless, a very low level of body fat will still be the result, with menstrual irregularity a distinct possibility.

How does irregular menstruation cause osteopenia?

The most likely link between the occurrence of menstrual irregularity and corresponding osteopenia in an athlete is the former's effect on hormonal function. Reduced oestrogen levels are common findings in studies on athletes with menstrual irregularities, thereby producing a similar situation to that experienced by post-menopausal women. The reduced bone mass and bone strength (osteoporosis) and increase of bone fractures for these individuals is well-known and feared. This undoubted link between low oestrogen levels and loss of bone mass means that the athlete with menstrual irregularities (or the athlete who trains intensely but has not yet observed such an effect) can no longer be complacent.

One research study found that the occurrence of stress fractures in female distance runners with menstrual irregularities was almost twice that of similar runners with normal cycles (Barrow and Saha, 'Menstrual Irregularity and Stress Fractures in Collegiate Female Distance Runners', *American Journal of Sports Medicine*, 1988, vol 18, pp209-216). Low bone mass produced in athletes when younger may also lead to premature and increased severity of post-menopausal osteoporosis later in life.

What are the options?

Considering that menstrual irregularities can cause a rapid initial loss in bone mass of about 4% a year for the first three years, prevention or early intervention is crucial. In addition, resumption of normal menstruation does not produce a recovery of full bone mass, and the microscopic structure of any full bone mass may be sub-optimal as well. Ideal treatment outcome would be a resumption of normal menstruation to correct the oestrogen deficiency. However, the necessary treatment would vary considerably between individuals, while consisting generally of weight gain and reduced training which no goal-orientated athlete would consider a serious option. An alternative may be oestrogen replacement therapy, although sports medicine practitioners are divided as to the safety and effectiveness of this approach, and they should obviously be consulted. It is certainly not suitable for young athletes (American Academy of Paediatrics Committee on Sports Medicine, 'Amenorrhoea in Young Athletes', *Paediatrics*, 1989, vol 84, pp394-5).

The role of nutrition

Calcium intake in the diet cannot make up for a lack of oestrogen due to menstrual irregularities, but it can be optimised before, during or after the onset of menstrual irregularities. This should at least eliminate another potential factor which can contribute to osteopenia – lack of calcium in the diet and at best prevent the athlete suffering a painful, frustrating stress fracture. Having said this, calcium is a threshold nutrient, and any intake above the body's needs will not produce further effects on bone mass. It is likely that ensuring adequate calcium intake will reduce the rate of bone loss, but not prevent it.

As with iron, calcium intake may be sub-optimal in cases of low energy intake, vegetarianism or fad diets. Calcium loss is encouraged by high intakes of salt, protein, alcohol, caffeine and phosphorous, and these should be kept to reasonable levels. Dairy products provide over half the calcium intake in the typical Western diet, and low-fat dairy products provide the greatest potential for combining various nutritional goals. Myths about dairy foods having 'too much fat and cholesterol', being 'too high in calories' and causing 'mucus in the mouth' should be dispelled forever. However, vegans or athletes with lactose intolerance or a milk allergy can obtain ample calcium from other foods:

- Soya products (especially calcium-fortified varieties)
- Fish (including bones which are an excellent source)
- Some green leafy vegetables
- Some nuts, such as almonds.

A general target of 1200-1500mg/day has been suggested for female athletes (*Clinical Sports Nutrition, p222*), a value of around 150% of most countries' RDAs. Athletes with necessarily low energy intakes (eg, <1200 kcals/day) may benefit from using calcium supplements – typically with about 500mg calcium – taken just before sleep to optimise absorption. Larger doses can cause constipation, and even reduced iron absorption, which is not really the idea at all!

Alun Williams

(See also: 'How to iron out the problems of anaemia', page72)

A fitness specialist shows why this training is vital for female athletes – but you must choose the right programme for your event

A survey of US schoolchildren in 1985 comprising various motor tests showed that the average 18-year-old girl could perform only one pull-up. It also showed that the sit-up-in-one-minute score peaked for girls at 14 years, with abdominal strength endurance declining from then on. The standing long jump test also indicated that on average girls peak at 14 years. In comparison, the average boy scored significantly higher on the test and improved until 18 years old.

These statistics merely illustrate what everyone knows, that women naturally develop less strength than men. The differences can be explained by the fact that at puberty boys have increased testosterone levels which promotes muscle development and bone growth over the next few years, whereas girls have increased oestrogen which promotes quite fast pelvic bone growth and fat storage around the hips and thighs.

‘Most of the differences in strength between men and women can be explained in terms of differences in lean body mass and muscle and fat distribution’

After puberty, boys’ relative fat mass decreases from 16 to 13%, while girls’ relative fat mass increases from 18 to 26%. Indeed, research has shown that most of the differences in strength between men and women can be explained in terms of differences in lean body mass and muscle and fat distribution. Women have smaller arm girth and greater arm skinfold thickness than men. This different distribution of extra fat and smaller muscle mass accounts for much of the disparity in strength between the sexes, women being about 66-75% as strong in the legs and 50-60% as strong in the arms. Nevertheless, research has shown that normalising for mean body mass, which takes out the overall differences in muscle and fat, muscle pound to muscle pound women are similar in strength to men.

Can women respond to strength training?

In the past, it was believed that strength training was unsuitable for women because they were 'incapable' of improving their strength. But more recent research has put paid to this theory. Professor Jack Wilmore from the University of Texas showed that after a 10-week training programme women showed a 29% improvement on the bench press and 30% improvement on the leg press, compared to a 17% and 26% improvement from men. However, while the men showed hypertrophy (enlargement) in the leg and arm muscles, the women did not. Wilmore hypothesised that the reason for the increased strength in women must be due to an increased ability to recruit muscle fibres and coordinate the movements. Later research has been equivocal – some has shown that women can increase muscle mass significantly, some has not. The tentative conclusion must be that in general most women find it more difficult to gain muscle mass.

Recently an official summary of all the research regarding strength training for women was presented in the US by the Women's Committee of the National Strength and Conditioning Association. They reported that:

1. Women improve fitness, athletic performance and reduce injuries through strength training, just as men do

2. Physiological responses of males and females to the use of weight training and resistance exercise are similar

3. Women should train for strength using the same exercises and techniques as men

4. There is no significant difference between the sexes in the ability to generate force per unit of cross-sectional muscle. Men display greater absolute strength than women largely because they have a greater body size and higher lean-body-mass-to-fat-ratio.

5. Women do experience muscle hypertrophy in response to resistance exercise, but the absolute degree is smaller than in men.

The conclusion to be drawn is that women are equally as strength-trainable as men. If female athletes want to achieve elite performances they must ensure that comprehensive strength training is fully covered in their training schedules. Competitions, unlike laboratory research, do not compensate for lean body mass. It is the fastest who wins, and that's the end of it. If you want to be that winner, you have to optimise your strength. In my opinion, that is a training priority.

What sort of training?

That being said, the next question is, what is the best form of strength training for women? The answer is not a matter of gender but more a matter of the particular requirements of the athlete's event, being the same for both men and women. Looked at from this point of view, any athlete must improve her (or his) strength if their profile is less than the strength demands of their event.

To devise the best strength programme based on the event's requirements, we have to analyse the event in terms of muscle use, the type of contractions each muscle uses, the biomechanics of the movement and whether maximum strength or strength endurance is the goal. This kind of 'needs analysis' should govern the design of any strength programme. As an illustration of such an analysis, let's look at running the 10K.

In the 10K event, the major leg muscles all work dynamically, such as the quadriceps, the hamstrings, gluteus maximus, hip flexors, calf and dorsi flexors. All these muscles are active at some point during the gait cycle and so it makes sense to strengthen them. However, they must all be strengthened in the right way to maximise 10K performance and injury prevention.

In 10K running 97% of the energy for muscle contractions comes from aerobic metabolism. Thus the predominant

'If female athletes want to achieve elite performances they must ensure that comprehensive strength training is fully covered in their training schedules'

muscle-fibre units required at 10K pace will be the aerobic Type 1 and 2a units. The more anaerobic Type 2a and 2b units may only be recruited towards the end of the race as the muscle tire and glycogen is depleted. (Type 2a fibre units can utilise both aerobic and anaerobic metabolism.)

For this reason, the 10K strength programme must have a strength endurance emphasis which targets mainly the Type 1 and Type 2a fibre units. It has been shown that strength athletes who perform a few sets of a few repetitions of very heavy weights, eg, four sets of five reps, have selective hypertrophy in the Type 2b fibres, which wouldn't necessarily benefit the 10K runner, whereas bodybuilders who perform higher volumes of lighter weights, eg, six sets of 12 reps, show hypertrophy in the whole range of muscle fibres.

Although 10K athletes do not want to start bodybuilding, it could be argued that a strength endurance training programme of high repetitions and lighter weights would be most suitable since the Type 1 and 2a fibres will be targeted effectively. To improve strength endurance, 3-5 sets of 12-20 repetitions with 45-second rest periods are recommended.

The choice of leg exercises must reflect the biomechanics involved in the running movement. For example, since most thigh muscle activity occurs when one foot is in contact with the ground, single-legged exercises with the foot in contact with the ground or equipment will be most relevant. Single-legged leg press, lunges or one-legged squats are all exercises of this nature which target the muscles in the thigh and bum areas. The range of movement of the joints is also relevant.

For example, as the foot strikes the ground, the knee joint is slightly bent (about 20 degrees). Then the knee flexes to absorb the impact (to around 40 degrees) and then extends again before toe-off. The quadriceps muscles act to control the shock-absorbing knee flexion movement. Certain strength exercises should be chosen to focus on this range of movement, eg, limited-range leg press, especially to help prevent the anterior knee pain which women are prone to because of a greater femur Q angle causing more inward rotation of the knee.

Don't overlook the trunk and hips

The other major body part that requires strength training for running is the trunk and hip area. Here the major muscles involved during running are the erector spinae (back), abdominals (stomach), obliques (side) and abductors (top of the bum). These muscles are not so obviously involved with running as the leg muscles, yet nonetheless serve a very important role in pelvis and trunk stabilisation and posture control. Biomechanical research has shown that for the legs to work effectively in propelling the body, the pelvis and trunk area must be rigid and supported by its muscles, otherwise the drive from the legs will be wasted.

These hip and trunk muscles must also be trained for strength endurance, for similar reasons. However, since they do not work as dynamically as the leg muscles, the exercises chosen should reflect their more static, supporting role. These muscles are best trained with a combination of isometric or static exercises and slow, controlled dynamic exercises of small, specific range.

For example, lying on one's front over the end of a bench and extending the arms out into a Superman position and maintaining it is an isometric exercise for the back muscles. Three sets of 10 x 10 seconds holding a straight line from the back to the hands will help maintain an upright posture as the muscles must hold the back and shoulder girdle in a rigid extended position.

An example of a slow and controlled exercise which targets a small range is the reverse curl or reverse crunch exercise for the stomach. This involves lying on one's back with legs fully bent. Then, raise the hips an inch off the floor by pulling with the lower abdominals and lower again, keeping the legs completely still. Here the abdominal muscles have to work continually to raise the pelvis and then lower it again, even though it is a small range of movement. This kind of exercise is more relevant to posture control than the more conventional sit-up. After all, when we run we keep our upper bodies still, so being very strong at flexing the trunk forwards is not necessarily related to efficient running.

In general, the hip and trunk muscles must be trained for strength endurance (low resistance/ high volume) using static exercises and exercises with specific ranges of movement for posture control. The choice of exercises must reflect the need to maintain a rigid back with a level pelvis to be able to push off with the legs. Balanced strength in this area also helps prevent lower back and hamstring injuries. In my opinion, the trunk and hip area is very important for 10K strength-training programmes; strong legs will only do so much if the trunk is not a well-supported, rigid structure. Would a motor racing team put a Formula 1 engine in a car with a Formula 3 chassis?

Training the upper body

To complete the strength analysis, we must consider the upper body. This area is less important for 10K running, but for an all-body, balanced strength programme some upper-body exercises should be included. Upper-body strength will also help with posture and an effective, easy-arm action. Once again, I would recommend a strength endurance emphasis.

A practical way to train the upper-body without devoting too much time to it would be to cover most of the major upper body muscles in two or three exercises – for example, seated row together with bench press, or pull-ups together with dips, would target most of the chest, shoulder, upper back and arm muscles.

To summarise the strength training programme for the 10K, all the major muscles involved in running need to be trained with a strength endurance emphasis. The exercises chosen also need to be biomechanically relevant in terms of movement, single-legged and foot-fixed, and any important joint ranges of movement. This will improve the power and efficiency of running action and help reduce knee injury risks.

Training the trunk muscles for endurance, using static and postural specific exercises will increase efficiency by improving the rigidity and support of the trunk. It will also help reduce low back and hamstring injury risks. Exercises covering the upper-body muscles will complete a balanced strength programme that is specifically targeted to the athlete's event.

This kind of analysis can be done for any event or sport. First, the correct muscles and movements have to be pinpointed and the role they play in the sport determined. From this the relevant strength-training exercise protocols can be designed for the muscles involved. Female athletes should definitely use this method as the starting point for their essential strength training requirements.

Raphael Brandon

(See also: 'How training helps women keep their weight down', page 78)

A sports therapist explains why 'the curse' is often lifted for female athletes

Absence or cessation of menstrual periods – technically known as amenorrhoea – is a common problem among sportswomen competing at high levels in any physically demanding sport, whether it be running, swimming, cycling, martial arts or tennis.

Intense training of any kind places immense strains on many of the body's systems. Physical and mental processes that regulate human biological function can be disrupted and may then take the body on a journey it was never designed for. One system which is prone to disruption – in women, at least – is the reproductive one. And when that happens the first sign is usually interference with normal menstruation.

However, I want to stress at the outset that this sort of problem is not an inevitable consequence of strenuous exercise and that reproductive health can be maintained if you know how far to push your body.

The first menstrual period of an adolescent girl is known as the menarche. Studies have proven that intense exercise can delay the onset of menarche by disrupting the hormonal patterns that control menstruation. A girl who has not reached menarche by age 15 would be considered abnormal by most doctors. But this does not necessarily imply that she has a medical problem. She may be a late starter for genetic reasons. Or it could be that her exercise habit has kept her body fat levels below what is needed to trigger menstruation.

A young woman who has never menstruated has what is known as primary amenorrhoea. Girls over 15 with this condition should always be seen by a doctor to rule out any medical abnormalities. Women who have reached menarche and had normal periods that are subsequently interrupted have what is known as secondary amenorrhoea – a condition that is very common among female athletes from all disciplines. Research suggests that between 5% and 20% of female track athletes suffer from secondary amenorrhoea. By contrast, it affects only 2-3% of non-athletic women – usually caused by illness or emotional stress.

Exercise is only one side of the coin

'all women need to be aware of three key factors: exercise, stress and body fat levels, which interact with each other to determine menstrual status'

Intensive exercise has been blamed for secondary amenorrhoea – but it is only one side of the coin. The onset and maintenance of menstruation is controlled by a regulating factor released by the hypothalamus in the brain, known as gonadotrophin-releasing hormone (GnRH). Other factors that affect this highly complex system are stress, body weight and body composition. The main relevant factor in body composition is the percentage of body fat. Providing a woman maintains her body fat levels, strenuous exercise can be taken without compromising normal menstruation. Conversely, a woman who takes no exercise yet has very low body fat levels – an anorexic, for example – is very likely to experience disrupted menstruation.

Thus, all women need to be aware of three key factors: exercise, stress and body fat levels, which interact with each other to determine menstrual status.

It can be difficult to disentangle stress from the other factors: the pressures associated with dieting, competing or juggling heavy training loads with busy lives can disrupt menstruation as much as exam stress or the death of a loved one. Many amenorrhoeal athletes resume normal menstruation as soon as the competitive season ends; release from the tension of preparation for competition may be all it takes to normalise their menstrual patterns.

As far as body fat is concerned, how much is enough? Athletes who train themselves into levels of low body fat for periods of more than three months usually suffer from secondary amenorrhoea, which occurs, on average, when fat levels fall below 20%. However, athletes with fat levels between 20 and 25% are likely to experience an intermediate problem known as oligomenorrhoea, when periods are occasional rather than regular.

Body-builders and long-distance runners sometimes reduce their fat levels to as low as 12-17% – and some go even lower for major events! Such athletes are combining all the risk factors for amenorrhoea, making it very likely that their periods will stop.

Fit women have healthier babies

The good news is, though, that exercise-induced amenorrhoea, whether primary or secondary, is normally reversible, with most women resuming regular menstruation within three months of easing their training load and/or gaining weight. Fertility rates of former athletes are no lower than average – and physically fit women tend to have easier labours and healthier babies.

However, the longer the periods are absent the greater the risk that additional medical complications will be superimposed on the original problem. A woman who has not menstruated for six months or more has chronic amenorrhoea, which can be serious as it is linked with accelerated bone deterioration. The reason for this link is not entirely clear, but one theory is that the low blood oestrogen levels associated with amenorrhoea lead to heightened sensitivity of the bone to parathyroid hormone, which controls blood levels of calcium, an important constituent of bones. The consequent increase in blood calcium levels suppresses parathyroid hormone secretion and this, in turn, impairs conversion of vitamin D to its active form, reducing the body's capacity to absorb calcium.

Difficult though it is to grasp, this theory goes some way to explaining why attempts to compensate for this bone mineral loss by increasing dietary intake of calcium do not appear to work. In addition, some evidence suggests that the increased blood calcium levels caused by low levels of oestrogen speed up the rate of calcium excretion in the urine. Thus chronic amenorrhoea gives rise to a double whammy, in which the body minimises its absorption of calcium while maximising its excretion.

Of course, it must be emphasised that all women are unique and their bodies will react differently to the same stressors. It would therefore be unwise to indulge in sweeping generalisations and hard and fast recommendations. Every woman affected by amenorrhoea needs to examine her own lifestyle and training habits in the light of the issues raised by this article – and elsewhere in this special report.

It is clear that fast weight loss and heavy training loads will almost certainly contribute to either primary or secondary amenorrhoea. But it is also clear that female athletes can indulge in strenuous exercise without risk, as long as normal menstrual function is maintained at least some of the time. Women should never be discouraged from training or competing at a high level because of the potential effects on their menstrual function. Nevertheless, they should be aware of potential problems and give their bodies a chance to recover whenever possible. The best advice I can offer all athletes – male and female – is, listen to your body, and train safely and intelligently.

Carl Fisher

A leading (male) running coach shows how PMT can affect athletic performance, and what to do about it

In 1930, Sir Adolphe Abrahams, who was considered to be an authority on sports medicine, stated: 'One girl has been credited with the ability to run over the marathon course of 26 and a half miles in 3 hrs 40 minutes 50 secs, a feat which I am disposed to doubt.' This attitude prevailed for a further 40 years. No doubt it was reinforced by the fact that a female has only 13.7g/100ml of blood haemoglobin as opposed to 15.8g in men. In addition, the increased fat/body weight ratio and the increased femoral obliquity were considered a disadvantage.

In childhood, there is very little difference between boys and girls with regard to endurance running, and what difference there is favours girls who in development are slightly in advance of boys up to puberty. From late adolescence onwards, the boys rapidly outstrip the girls in physical development.

Female athletes are faced with the tedious business of menstruation and/or premenstrual problems, commonly called PMT. The effects of menstruation on the individual person vary enormously. In some, there appears to be no apparent inconvenience; in others, the changes cause considerable incapacity. The weight gain associated with retention of water during the premenstrual period is clearly a handicap to the endurance athlete. However, it has been clearly shown that physical activity, in the main, enables the female to cope with the physiological changes incurred more easily. But psychological changes can, and do, affect physical performance.

Monitor to find the pattern

In studies of large populations of women between 15 and 55 years, the four days before and the first four days of menstruation reveal that there is an increase in accident proneness, lowering of mental ability, lowered resistance to infection, increased suicide attempts and increased hospitalisation.

It is important to realise that for most women there are rarely more than two or three days when they are at greater risk. It is up to each individual, by careful monitoring, to appreciate her own specific pattern. Those showing variations in sporting performances are advised to record on their menstrual chart the times when they are off peak. But one occurrence, that of increased aggression during premenstrual tension, can lead to improved performance.

Many endurance runners, because of reduced weight, cease their periods altogether. The medical profession is split over this. One view is that it is Nature's way of saying that the female is too thin to have children. Another opinion is that prolonged cessation of the period will lead to infertility. However, I coached a female athlete who went several years without a period and, on retirement from athletics, proceeded to have four children in four years!

So what exactly is PMT?

A lot of uncertainty surrounding PMT over the last 30 years stems from an inability to define the condition accurately. Dr Katherine Dalton, an expert on the subject, defines PMT as: 'The appearance of symptoms in the premenstruum and their disappearance in the postmenstruum'. Unlike most other medical conditions, the diagnosis is based in the cyclical nature of the symptoms rather than on the actual symptoms themselves. An astounding 150 symptoms have been described in PMT. Some women suffer only one but the norm is half a dozen.

Dr Guy Abraham, a specialist in the nutritional aspects of PMT, has divided it into the following four categories:
PMT A: anxiety, irritability and mood swings

PMT B: weight gain, swelling of the extremities, breast tenderness and abdominal bloating
PMT C: headache, craving for sweets, increased appetite, heart pounding, fatigue and dizziness or fainting
PMT D: depression, forgetfulness, crying, confusion and insomnia.

Other symptoms include oily skin, acne, clumsiness and feelings of violence or, in severe cases, even suicide. Of concern to female athletes is that asthma can be aggravated premenstrually.

'Dr Abraham has shown that the majority of women with premenstrual symptoms have a poor nutritional intake compared to those who have no PMT'

About half of women of child-bearing age experience at least some premenstrual symptoms. The other half may feel that their symptoms warrant treatment. Greek and Japanese women have a lower frequency of symptoms, and it is thought that this is due to dietary differences. Increasing age and increasing numbers of children also heighten the chances of PMT. Young women and girls in their teens appear to suffer more from painful periods which often improve as they get older, only to be replaced in many cases by the onset of premenstrual symptoms. The most severe and difficult cases of PMT are found in women in their forties.

Dr Abraham has shown that the majority of women with premenstrual symptoms have a poor nutritional intake compared to those who have no PMT. The former are often found to have low levels of magnesium, which affects blood sugar control and hormonal metabolism. A high intake of salt often aggravates fluid retention and breast tenderness. This also applies to fat consumption, because research reveals that PMT sufferers cannot efficiently metabolise the essential fatty acid, linoleic acid, which is mainly found in good-quality vegetable oils. This barrier is strengthened by the lack of vitamin B6, magnesium, zinc, vitamin C, vitamin B3 and chromium.

Dietary advice for PMT athletes...

1. Reduce the intake of refined sugar, salt, red meat and alcohol
2. Eat fish, poultry, whole grains and legumes

3. Reduce the intake of coffee, tea, chocolate and cola-based drinks
4. Reduce the intake of fats, particularly animal fats, fried foods and hydrogenated margarines
5. Increase the intake of fibre in the form of green, leafy vegetables, legumes and fruits
6. Keep an eye on your weight. If you are 5ft 6in tall (1.676m), don't go beyond 130lbs (58.967kg). Gradually increase your training load to reduce weight.

... and nutritional supplements

1. Take a multivitamin supplement which contains 100mg of vitamin B6 per day, together with the B vitamins, vitamin C, plus minerals. Optivite is of proven value in treatment PMT
2. 500mg capsules of Evening Primrose Oil, 4-8 per day, taken the two weeks before the period is due
3. Vitamin E, 300-500 International Units per day, is of particular value with premenstrual breast swelling and tenderness
4. 200-300mg of elemental magnesium per day.

The above supplements should be taken for three months before deciding whether or not they are effective. Some hormonal or gynaecological problems can have symptoms similar to those of PMT. If the symptoms do not improve or are very severe, a doctor MUST be consulted.

More about menstruation and performance

1. About one-third of all female Olympic gold medals were won during menstruation. Two-thirds were gained a week after the cessation of the period
2. Menstruation can be adjusted so that the competition dates coincide with the time of maximum efficiency. This might be pre-ovulation (days 9-12) or post-ovulation (days 17-20)
3. Sportswomen whose performances are affected by menstruation and who have a continuous programme of events can have menstruation completely suppressed for a few

months. This requires expert management by a sports physician because some of the drugs (hormones) used for this purpose may be on the list of banned substances

4. Professor Tim Noakes has discovered that bone density declines in non-menstruating athletes, and advises hormone replacement therapy to preserve the health of their skeletal systems.

Frank Horwill

WHAT THE SCIENTISTS SAY

This round-up of recent research from the scientific, medical and sports journals looks at the training, diet and problems of female athletes

Should males and females train differently?

The 'accepted wisdom' on female athletes is that they don't recover from hard training as well as males do. This slur on females does make a certain amount of physiological sense. After all, the primary male sex hormone, testosterone, is a potent bone and muscle builder and connective-tissue construction. Theoretically, after a rugged workout in which heavy stress is placed on muscles, tendons, ligaments, and bones, males should be able to rebuild those parts of the body more quickly.

Taking all this into account, many coaches design training programmes which are quite different for their female athletes compared to their males. The usual difference is for the male schedule to contain more hard, high-intensity interval work, with the female programme more geared to lower-intensity, continuous, non-interval efforts.

For example, Jack Daniels, Ph.D., one of the most successful collegiate coaches in the United States, often has his female charges running 20-25 minute tempo runs at a pace which is 10-15 seconds per mile slower than 10K velocity. Daniels is tremendously well respected by his peers, but other coaches do often contend that his programme works much better for females than for males. Their implication is that males can recover more readily from tougher training routines and need such high-intensity programmes to reach their true potential.

But do male athletes really recover from rugged exertions more quickly? Males pride themselves on their toughness, durability, and resilience, but the scientific evidence supporting quicker male recoveries is actually pretty weak. In fact, recent scientific research suggests that females actually lose less strength than males during the course of a rigorous workout and recover their muscular prowess more rapidly after an exhausting bout of exercise.

In studies carried out at the University of Jyvaskyla in Finland, for example, 10 male and nine female strength athletes (powerlifters and body-builders) performed 20 maximal squat lifts, with three minutes of recovery between each lift. After the 20 lifts, the fatigued leg muscles of both males and females had lost about 20-24% of their maximal strength.

However, various indicators of muscular power favoured the females. For one thing, the 'force-time curve' – an indicator of muscles' ability to contract powerfully and quickly – changed negatively by 28% in the males over the course of the workout but dropped off by only 19% for females. Females also recovered from the 20-lift session more quickly. One hour after the workout, female lifters' leg muscles could generate about 92% as much force as before the session, while male muscles were just 79% as strong.

Why was fatigue greater and recovery slower in males? Part of the problem seemed to be that the male lifters' nervous systems became less responsive over the course of the workout. From the first to the twentieth lift, activation of leg muscles by nerve cells fell by 20-25% in males but held steady for females. While it's not clear why male nerve activation should deteriorate more quickly, it is clear that females lose less of their muscular power during heavy-duty resistance training and seem to recover more rapidly once a tough session is over.

Reference

('Neuromuscular Fatigue and Recovery in Male and Female Athletes during Heavy Resistance Exercise', International Journal of Sports Medicine, vol. 14(2), pp53-59, 1993)

To keep your fat furnace working, concentrate on building muscle mass

A big problem for older, sports-active women is that body fat tends to increase with age. This heftiness interferes with the ability to exercise: each additional pound of fat is a weight which must be lugged across the tennis court, carried around a 10K race route, or dragged through a rigorous, step-aerobics workout. The fat does nothing to enhance performance; instead it raises exercisers' heart rates and makes workouts feel more difficult.

What causes this age-related increase in corpulence? One problem is that 'basal fat oxidation', the rate at which fat is broken down inside the body, tends to drop as individuals get older. As fat oxidation drops, more fat piles up on the hips or the midsection.

What can be done to prevent fat-oxidation rates from dropping? When researchers recently studied a large group of healthy women, aged 18 to 73, they found that the best predictor of fat-burning decline was a loss in muscle mass, not advancing age or a diminishment in aerobic capacity. In other words, losing muscle mass caused fat-burning fires to die down much more rapidly, compared with getting older or losing fitness. In effect, women could check or even reverse the tendency for fat oxidation to decline with age simply by bolstering their muscles. Sustaining high fat-oxidation rates would then make it hard to develop a big tum or 'thunder thighs' and would improve athletic performances.

What's the best way to maintain or increase muscle mass and therefore boost fat oxidation? It's easy! Just report to the gym two to three times a week for 30-45 minutes of strength training – or read the article on page 49 of this special report.

Reference

('Basal Fat Oxidation Decreases with Ageing in Women,' Journal Applied Physiology, vol. 78, pp. 266-271, 1995)

How to iron out the problems of anaemia

As we've already indicated earlier in this special report, iron problems and female athletes are closely linked. In Great Britain and the United States, about 30% of adult women and 40% of adolescent women are iron deficient, while around 6% of both groups suffer from true iron-deficiency anaemia. However, studies of athletes report higher frequencies of iron problems; research indicates that up to 19% of swimmers and runners may be troubled by iron-deficiency anaemia, which can have a strongly negative impact on performance.

Basically, iron difficulties can take two forms, either iron deficiency or true anaemia. Iron deficiency itself has two distinct stages. Stage I, the iron-depletion stage, is characterised by blood-ferritin levels of less than 12 ng/ml, which indicates that iron levels have been significantly reduced. Ferritin, a key protein which latches onto iron, serves as an important mechanism for iron storage within the body. Stage II of iron deficiency involves iron-deficient erthropoiesis, which basically means that newly created red blood cells contain lower than normal amounts of iron.

Stage II iron deficiency can eventually lead to true iron-deficiency anaemia, with abnormally low levels of blood haemoglobin (haemoglobin is the iron-containing compound found in red blood cells which actually carries oxygen to the tissues) and truncated haematocrit readings (haematocrit is simply the percentage of blood which is made up of red blood cells).

In women, the act of training for a specific sport can increase the risk of iron deficiency. Studies with female hockey players uncovered a steady drop in ferritin levels during each of three consecutive seasons, with a return to normal between seasons, and other research with female high school and college athletes detected unusually high frequencies of iron deficiency. Causes of the iron problems were not exactly clear but were thought to be related to iron-poor diets, losses of iron through menstruation, bleeding in the digestive system, poor iron absorption, and losses in sweat and urine.

Experts contend that a paltry intake of iron is the most significant cause of iron deficiency in female athletes. The basic problem seems to be that many female athletes consume only 2000 daily calories (or less) in hopes of becoming leaner, especially for sports like running and gymnastics which emphasise a sinewy physique. That creates a situation in which iron deficiency is almost assured, because the average British and American diet often contains only five mg per 1000 calories. With the recommended dietary allowance for iron set at 15mg per day for women, female athletes would need to eat about 3000 instead of their usual 2000 calories per day to take in enough iron. Many female athletes also prefer a vegetarian diet, which may be low in iron or may contain a form of iron which is difficult for the digestive system to absorb.

For females, the biggest loss of iron occurs during menstruation, with about one-half milligram of iron slipping away each day in the menstrual flow (and more if menstruation is heavy). Women who lose more than 60 ml (about two ounces) of menstrual blood per day are particularly susceptible to iron deficiency. Amenorrhoea (the absence of menstruation), which is more common in female athletes than in the population at large, would seem to lower the chances of iron deficiency, but studies indicate that amenorrhoeic women are actually at greater risk, possibly because their total intakes of calories and therefore iron, are often lower than normal.

Strangely enough, a fairly significant amount of iron can be lost in the faeces. The problem is particularly acute for runners, with up to 85% of runners testing positive for blood in their stools following a strenuous run. In fact, women who run more than about five to six miles per day lose twice as much blood in their faeces as sedentary women. Use of aspirin or non-steroidal anti-inflammatory medications can magnify these iron losses.

Something about exercise also seems to impair the absorption of iron across the walls of the small intestine. Iron-deficient runners, for example, may absorb only 16% of dietary iron, compared with 30% for iron-deficient, sedentary people.

Iron problems can have a big impact on performance. Anaemia, by reducing the oxygen carrying capacity of the blood, can eat away at maximal aerobic capacity (VO_2max), lower endurance, and increase fatigue. However, it's not yet clear whether iron deficiency (without actual anaemia) can curtail exercise capacity. Several studies with runners have shown that apparently non-anaemic but iron-deficient athletes who take iron supplements do improve their performances and lower lactate production during exercise. However, many of these runners may have actually been mildly anaemic (although their haemoglobin levels were still in the normal range, the readings were probably lower than usual for many of the athletes. A female athlete with a usual haemoglobin level of 14 might have experienced a drop to 13, for example, which is still in the normal range for the overall population but below normal for her). If haemoglobin levels don't actually decline during iron deficiency, many experts contend that the effects on performance will be minimal. The problem, though, is that deficiency, if not corrected, will often lead to anaemia.

Ferritin levels of greater than 20 ng/ml represent adequate iron stores, while ferritin in the 12-20 range indicates that iron stockpiles are minimal. Readings below 12 ng/ml show that iron stores in the bone marrow have become completely depleted (deficiency is present), and that anaemia may be just around the corner.

Technically, anaemia is present if haemoglobin levels fall below 12 g/dl or if haematocrit plunges below 36%. However, remember that 'normal' readings for these two variables may in fact not be normal. A female athlete with a haematocrit of 37% is in the normal range, for example, but if her usual haematocrit is 42, she would actually be mildly anaemic, and her athletic performances would suffer.

Sometimes, low haemoglobin and haematocrit don't represent real anaemia. That's because one of the key physiological adaptations produced by physical training is an expansion of blood volume. For example, a very moderate but regular jogging programme can boost blood plasma by 5%, and the training schedule of a top-level endurance athlete can augment blood plasma by 20 per cent. The upswing in blood volume, although beneficial to the endurance athlete (it increases the amount of blood which can flow to the muscles and skin during exercise; the enhanced skin flow promotes better body cooling) artificially lowers haemoglobin and haematocrit readings, fooling some doctors into thinking that anaemia is present. However, this 'pseudoanaemia' is unlike true anaemia because iron levels are normal. In addition, pseudoanaemia does not respond to iron supplementation.

Since iron deficiency is so common, it's wise for female athletes to have their iron stores checked at least yearly, preferably before the competitive season begins. The treatment to reverse anaemia usually calls for iron supplementation, with a typical dosage of 50 to 100 mg of elemental iron three times a day (150-300 mg total per day). Such an intake should raise haemoglobin by at least 1 g/dl within four to six weeks, but the treatment often continues for six to eight months in order to re-establish normal ferritin concentrations. In the case of iron deficiency, the typical dose is 50 to 100 mg of iron per day, with the supplementation continued until ferritin moves above 20 ng/ml.

Because of superior absorption, the ferrous, not the ferric form of iron, appears to be a better supplement. Ferrous sulphate, which is fairly inexpensive, is usually taken in an actual dosage of 325 mg three times a day for the treatment of anaemia. Experts advise iron supplementers to avoid the sustained release or enteric-coated iron tablets, which may decrease absorption. Also, it's wise to decrease gastrointestinal side effects by increasing the dosage gradually from once daily to three times per day as tolerance increases, and it makes sense to take the supplement along with vitamin C, since the latter enhances iron absorption. Absorption of iron is especially enhanced if the vitamin C-iron combination is taken on an empty stomach (although GI upsets may also increase).

How can you be sure you're taking in enough iron? If your regular diet tends to be a bit low in iron, consider ingesting a daily multivitamin which contains at least 15 mg of iron. Also, try to include more iron-rich foods in your diet. Lean meat, poultry, and fish are excellent sources of iron, and the iron found in such meats is more readily absorbed than the iron in supplements or non-meat foods. If you are a vegetarian, some good high-iron foods include iron-enriched grains, dried fruits, spinach, tofu, and beans.

As mentioned, you should always take in your high-iron foods along with a rich source of vitamin C. In addition, avoid the practice of wolfing down iron with foods which inhibit its absorption: those foods include tea, wheat bran, and high-calcium products such as milk, antacids, and calcium-phosphate supplements. One final trick for getting more iron is to do a lot of your cooking in an iron saucepan. Using an acidic sauce (like tomato sauce) in your iron pan can help to convert your meal into a rich lode of iron.

References

('Helping Active Women Avoid Anaemia', The Physician and Sports Medicine, vol. 23(5), pp. 35-48, 1995)

How sport improves the body image of adolescent girls

We live in a culture which celebrates thinness and excoriates fatness. As readers of this special report know, in young women, the fear of becoming fat develops during adolescence and continues into adulthood, even among thin, active females. These fears can create patterns of over-exercise or under-eating which may have devastating health consequences. Inadequate intakes of food and calcium can lead to osteoporosis (bone-thinning), and a low calorie intake can contribute to amenorrhoea (lack of normal menstruation), which, by lowering the output of the bone-building sex hormone oestrogen, can increase the severity of osteoporosis. Extreme preoccupation with thinness can also lead to anorexia nervosa and/ or bulimia, two disorders which can produce an array of ruinous physical problems.

What's the best way for young women to improve their perceptions of their bodies and hopefully lower their risk of developing amenorrhoea, anorexia, bulimia and osteoporosis? According to researchers at the Melpomene Institute in

Minneapolis, Minnesota, participation on sports is one of the best body-image enhancers. Melpomene investigators studied 152 young women aged 11-17 who were attending YWCA summer programmes in 1994, both in the United States and Mexico. The young women completed questionnaires designed to obtain information about perceived weight, concerns about weight, dieting behaviour, body image, and factors influencing body image.

Researchers also measured each young woman's BMI (Body Mass Index), which is simply body weight (in kilograms) divided by height (in metres) squared. Example: Bess weighs 60 kilograms (132 pounds) and is 1.7 metres in height (5 feet 7 inches). 1.7 X 1.7 = 2.89. BMI = 60 divided by 2.89 = 20.8. Normal BMI ranges between 20 and 25, and a BMI higher than about 27 for women has been linked with an increased risk of diabetes and high blood pressure.

The young women in the Melpomene study reflected their culture's adoration of slimness, tending to overestimate their weight if they were of a normal weight and being happy if they were underweight. For example, women who viewed themselves as too fat actually had a BMI of just 22.3, which is considered a healthy weight /height ratio. Adolescents who had high body image possessed an average BMI of about 18.8, which is considered below-normal.

Sports participation was linked with improved body image. Young women who played on higher numbers of sports teams had better body images, compared to women who played on few or no teams. However, physical activity per se was not a good indicator of body image: 18% of women with medium body image and 26% of those with high body image were active seven days a week, versus 33% of young women with low body image, probably because the latter group was attempting to use exercise to lose weight.

Being black (African-Amercian) also tended to improve body image. About 44% of black young women had a high body image, compared with just 32% of white women and 33% of Native American women. Black women were more realistic about their weight; blacks who said they were 'about right' in weight had a BMI of 20.9, versus 18.8 for whites. Strikingly, 40% of the black young women considered themselves 'attractive' or 'very attractive', compared with just 9% of whites. Similarly, 36% of blacks reported that the statement 'I feel confident about my body and the things it can do' was true for them, versus just 8% of whites. 28% of whites stated that wanting to be attractive to young men was a factor which influenced body image, compared with 0% of blacks. A 'sense of style' was more important than weight in determining body image for blacks.

Aside from sports participation and ethnic background, the content but not the frequency of parental comments were also critical in determining body image. Body image scores of young women who received negative comments from parents were much worse than the self-ratings of women who received positive comments. Overall, women with high body image tended not to look outside themselves to define their body images; inwardly they were able to generate feelings of self-worth which extended to their physical appearances.

Why did sports participation help body image? It's believed that sports-team participation can be a source of self-esteem through approval from peers, parents, and friends. The young women in the Melpomene study also reported that team participation helped make them feel that their bodies were 'capable' and 'competent'. These positive feelings seemed to produce a fairly high level of satisfaction with their bodies.

References

('Adolescent Girls: Factors Influencing Low and High Body Image', Melpomene, vol. 14(2) pp. 14-22, 1995)

How training helps women keep their weight down

Endurance training leads to metabolic changes which favour leanness in women. That is the main conclusion of a Canadian study which compared the thermogenic (energy-burning) response to food and other metabolic changes after eating in 12 endurance-trained and 13 untrained women.

The trained subjects were distance runners or triathletes, who had been training for at least two years and had taken part in provincial and national competitions. Crucially, they and their untrained counterparts, recruited through advertisements, were matched for body size to facilitate analysis of the effect of body composition on metabolism.

Energy expenditure and substrate (glucose and fatty acid) oxidation were measured before and for six hours after an oral test meal and then again after the same meal administered directly to the stomach via a nasogastric tube. The point of delivering the food in these two different ways was to calculate the difference between the 'obligatory' component of the thermogenic response to food (TRF) – the increase in energy expenditure arising directly from the process of digestion, absorption and storage of nutrients – and the 'facultative' component of TRF which is related to stimulation of the mouth and throat. The fact that previous research in this area has been inconclusive may be due to the fact that these two components of energy consumption after eating are not routinely separated.

The researchers point out: 'Understanding the relationships between physical training and TRF is important for the evaluation of long-term benefits of exercise for weight regulation. Although TRF represents a small proportion of 24-hour energy expenditure, a permanent increase in this component of the energy balance equation is likely to be significant.

The objective of this study was, therefore, to measure both components of the TRF in trained and untrained women and to calculate the relationship of these measurements to VO_2max and body fat'.

The two groups were matched for age, weight, height and BMI. Body fat, fat mass and resting heart rate were predictably lower in trained subjects, while fat-free mass, resting energy expenditure and VO_2max were predictably higher. A three-day dietary recall showed higher total energy intake but a lower proportion of energy derived from fats in the trained subjects.

Testing after the oral and tube-fed meals revealed the following findings:

- Both groups exhibited significantly lower energy expenditure after tube feeding – an expected finding since the facultative component had been removed;
- Trained subjects had higher total TRF (+22%) and higher OTRF (+32%) than untrained subjects, but the facultative component of TRF was similar in both groups;
- Fatty acid oxidation was significantly higher in trained subjects after the oral meal but not after the tube-fed meal;
- OTRF was significantly related to VO_2max but not to percentage body fat;
- Resting metabolic rates were higher in the trained subjects even after adjustment for fat-free mass.

'In conclusion', state the researchers, 'this study shows that trained women have higher resting and postprandial energy expenditure than untrained women of similar body size. The greater TRF in trained subjects is related to a higher cost of nutrient metabolism, and this energy expenditure is correlated with VO_2max. Fat oxidation is also higher in trained women after an overnight fast and postprandially. These findings have important implications for understanding the relationships between physical fitness, body weight regulation and the efficiency of nutrient digestion, absorption and storage'.

References

(Am J Physiol Endocrinol Metab 279: E601-E607, 2000)

How menopause limits women's response to weight training

High-intensity weight training promotes bone growth in older men but is less effective for older women, according to a new US study. The researchers, from Oregon State University, compared the effects of a moderate-intensity seated resistance-training programme with those of a high-intensity standing free-weight exercise programme on bone mass and circulating levels of insulin-like growth factors in healthy men and women in their 50s.

Twenty-eight men and 26 women – all the women being postmenopausal but free of hormone replacement therapy – served as their own controls for the first 12 weeks of the study, when they maintained their normal daily routines and eating habits. They were then randomly assigned to either a high-intensity functional standing free-weight programme or a moderate-intensity seated machine-based programme – both programmes designed to activate all major muscle groups. Training sessions lasting 75 minutes were held three times a week for 24 weeks under the close supervision of personal trainers (one to every two subjects). Bone mineral density (BMD), body composition, muscle strength, hormonal status and anaerobic power were assessed at the beginning, middle and end of the study.

The men in the study experienced significant bone gain at the lumbar spine with high-intensity training and at the greater trochanter (top of the thigh bone) with both types of training. Women gained bone at the greater trochanter with both types of training but did not make significant gains at the lumbar spine with either type.

In women leg lean mass increased significantly in both training groups, but changes were much greater in the high-intensity group (8.1% compared with 3.4%). In men leg lean mass increased to a lesser extent, by 3.2% in the high-intensity group and 1.9% in the moderate intensity group. Surprisingly, improvements in BMD, lean mass and strength were not accompanied by increases in circulating serum levels of insulin-like growth factors in either men or women, suggesting that highly localised factors were responsible for the changes observed.

For women the biggest disappointment must be the lack of significant bone gain at the spine in response to training. 'The fact that women were primarily early menopausal (within 36 months) likely explains the lack of spine response', say the researchers. 'The majority of the women (78%) in the high intensity group were within their first five years past menopause, a time during which there is accelerated bone loss of 2-6.5% per year. In these women training did not offset low reproductive endocrine status.'

However, an interesting related finding was that two women in the study who were more than eight years past menopause showed significant bone gain of 4-5% at the spine in response to high-intensity training. This suggests the need for further research in which women are separated according to their menopausal status. Meanwhile, the researchers conclude that 'resistance training may help off-set musculoskeletal declines associated with aging and is beneficial to both older men and women.

References

(Calcif Tissue Int (2000) 66:399-404)

Women suffer most after strenuous exercise

The theory that women incur less muscle damage than men after strenuous exercise has been exploded by a recent study which suggests the opposite: far from being protected against exercise-induced damage, women seem to be more severely affected, with a relatively reduced range of motion which persists for at least a week afterwards.

Most previous studies in this area have relied on indirect – and unreliable – markers of tissue damage, particularly the muscle protein creatine kinase, and have used small sample sizes and inappropriate exercise tests. The current study is the first to evaluate changes in muscle function in women and men in response to an exercise damage protocol.

A large sample of 83 women and 82 men performed a bout of eccentric exercise of the elbow flexors consisting of 70 maximal repetitions. Isometric strength, resting elbow angle and muscle soreness were measured before exercise, immediately afterwards and then daily for seven days.

The results were as follows:

● Muscle soreness peaked at 32-48 hours post-exercise for both groups, with no significant difference between men and women;

- Both groups experienced a significant and similar loss of strength after exercise, with a similar rate of recovery;
- Men and women showed a similar loss in range of motion up to 48 hours post-exercise, but the women revealed a more pronounced loss at 72 hours, which was still apparent at the end of the week.

'The cause of this difference is unclear,' say the researchers. 'Moreover, the mechanism driving the well-documented decrease in range of motion is not known.' However, the finding is compatible with the theory that loss in range of motion is caused by changes in connective tissue, since women are more prone than men to connective tissue diseases. 'If connective tissue is more susceptible to injury in women, this may have contributed to the more pronounced muscle shortening and reduction in the elbow angle. However, it should be noted that the difference in loss of range of motion between men and women was small.'

References

(J Sports Sci 2000,18,229-236)

There is no major sex divide in sports injuries

As readers of this special report will already know, several studies have shown that sportswomen are at much higher risk of injury to the anterior cruciate ligament (ACL) of the knee than men. But does this perceived gender difference extend to other sports-related injuries? That's the question a Californian research team set out to answer with a 15-year retrospective study comparing sports injuries in men and women.

The study involved 3,767 18-22 year old male and female athletes from California's Pomona College competing in seven sports – basketball, cross-country running, football, swimming, tennis, track and water polo – at intercollegiate level. From the autumn of 1980 through the spring of 1995, all athletic injuries seen in the training room at the college were evaluated by the same head athletic trainer, with injury reports retrospectively compiled and categorised by gender, sport and anatomic site of injury.

Analysis of the patterns of injury demonstrated much more similarity than difference between the sexes. The key findings were:

1. Overall, female athletes had more injuries (52.5 per 100 participant-years) than their male counterparts (47.7 per 100 participant-years). However, this difference was not statistically significant.

2. No significant gender differences were detected in the pattern of injury for the sports of basketball, cross-country, football, tennis and track.

3. Only two sports – swimming and water polo – showed a statistically significant gender difference in their pattern of injury, with female swimmers suffering more back/neck, shoulder, hip, knee and foot injuries than their male counterparts, and female water polo players having more shoulder injuries. However, the higher rate of shoulder injuries for these sports was attributed, at least in part, to the more rigorous training regimen used by the women's coach.

4. Females had more hip injuries in every sport except basketball, although the differences reached significance only in track and swimming. Women also had more lower leg injuries in every sport but basketball, with the differences reaching significance only for track and football.

5. Male basketball players had more back/neck and facial injuries than their female counterparts, while male athletes also had a higher overall rate of thigh injuries, primarily due to an increased rate found in male tennis and track athletes.

6. ACL injuries were twice as common in women than men (nine compared with four), but because of the small numbers this difference did not reach statistical significance.

The researchers conclude: 'Except for some minor gender differences in total injuries for two sports and several differences in total injuries by anatomical location, our data suggest very little difference in the pattern of injury between men and women competing in comparable sports'.

References

(Int J Sports Med 2001 Aug 22(6), pp420-423)

HRT maintains muscle after menopause

Hormone replacement therapy (HRT) after menopause is widely believed to counteract the increased risk of heart disease and bone loss which accompanies the loss of the female sex hormones, particularly oestrogen. And now recent research from Finland suggests that HRT also plays a key role in maintaining post-menopausal muscle performance, which is good news for women in general and female athletes in particular. Even better is the implication that the benefits of HRT combined with high-impact physical training exceed those of either HRT or training alone.

This one-year study of 80 women aged 50-57 is the first randomised double-blind placebo-controlled trial – the gold standard of scientific research – to investigate the effects of HRT on muscle performance and muscle mass. The women were assigned to one of four groups: exercise; HRT; exercise-plus-HRT; and control.

The exercise groups embarked on a 12-month progressive physical training programme that included a twice-weekly supervised circuit training session and a series of exercises performed at home four times a week. The circuit training sessions varied, but all included three or four of the following: resistance exercises for the upper body; chest fly; latissimus pull down; military press; seated row; biceps curl. The home exercise programme was also designed as a circuit training routine, including skipping, hopping, drop jumping and exercises to strengthen the abdominal and lower back regions.

The control group took dummy tablets daily as did the exercise-only group, while the women in the two non-exercise groups were told to continue their normal daily routines without changing their physical activity levels.

Various measures of muscle performance and mass were taken before the start of the study and at six and 12 months. By six months 18 of the original participants had dropped out for a variety of reasons, leaving 62 spread across the four groups. By 12 months that number had been whittled down to 52. Key results were as follows:

1. Over the course of the study lean body mass increased in all except the control group;
2. Women in the exercise and HRT groups showed an increase in maximal isometric knee extension force after six months compared with the controls. But after 12 months of follow-up, only the exercise-plus-HRT group differed significantly from the controls;
3. Slight increases in vertical jumping height – an indication of muscle power production – were seen in both the exercise and HRT groups after six and 12 months when compared with the controls. But the differences were more marked in the exercise-plus-HRT group;
4. After 12 months, women in the HRT and exercise-plus-HRT groups showed increases in the muscle mass of their quadriceps and lower leg in comparison with the exercise-only and control groups. Again, the differences were most marked in the group combining exercise with HRT.

'The independent effect of HRT on skeletal muscle mass and performance is probably the most interesting finding in the present study,' comment the authors. 'The results... suggest that continuous administration of oestradiol/noretisterone acetate [a combined HRT preparation] has beneficial effects on muscle performance, muscle mass and muscle composition in early post-menopausal women.... The results also suggest that the effects of HRT combined with high-impact physical training may exceed those of the two treatments separately.'

References

(Clin Sci (Lond) 2001 Aug 101(2), pp 147-57)

Notes

Notes

Notes

Notes