TRAINING FEMALE ATHLETES: GENDER DIFFERENCES

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on stamina, strength and fitness

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From the editor

Since Adam and Eve, it has been nature's biggest distinguishing feature. The male and the female. It all comes down to chromosomes, apparently. And as this mini-report illustrates, it is a distinction that cannot be ignored on the playing fields. Even in the 21st century, with men and women finally on a level playing field in education and careers (disagreements on a postcard please,,,), the physiological differences between men and women cannot be overlooked.

In the first chapter two scientists explain why women will never outpace men in the sprinting events. Perhaps Marion Jones should have considered these facts of life before trying to become super-human. With this fuelling the fire, the following chapter delicately explains why men and women should train slightly differently for sprinting events.

The third chapter encourages women who avoid resistance training to enter the weights room, whilst the final chapter focuses on how menstrual cycles can affect athletic performance.

Whether you are a female athlete or coach female athletes, this mini-report will hopefully enlighten your training ideas.

Sam Bordiss
Editor

Will women ever outpace men?

Will females ever outpace males in running events? Time and again this question has led to fierce debate within the lay and scientific community[1-6]. Performance differentials between men and women are most commonly attributed to such issues as body size and composition, with men tending to be larger than women, with a lower percentage of body fat combined with a higher relative muscle mass. From this perspective, there is not the slightest chance of a female being the fastest human on the planet over 100m or 200m…

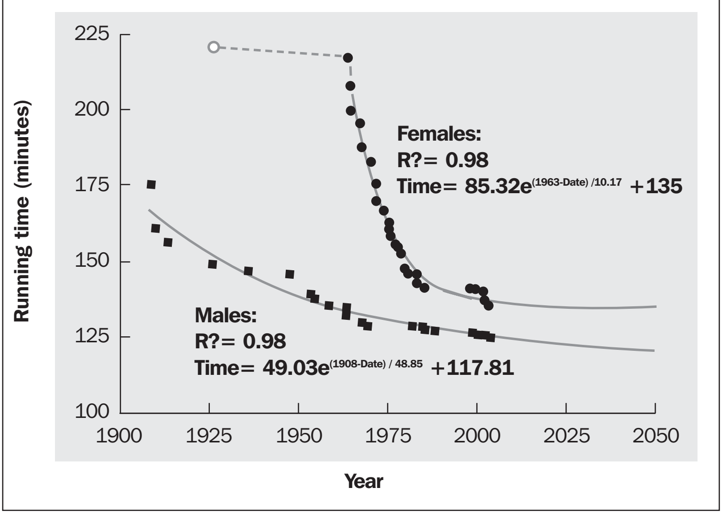
Men also have a higher aerobic capacity and a bigger absolute and relative mass of haemoglobin than women. But, while these attributes appear to give men an advantage in endurance events, their greater muscle mass can be a disadvantage in such events.

Rapid improvements in female marathon performance between 1963 and 1984 *(see figure 1, overleaf)* served to support the idea that women might one day outpace men in long-distance events[4]. However, marathon performances by both sexes are more likely to reflect historical than biological factors.

Male marathoners demonstrated huge improvements during the early years of the last century, after the current marathon distance was established as an Olympic event. After near-stagnant progress between the 1920s and 50s, a new period of rapid improvement was ushered in by scientific progress in coaching and sports medicine, although the rate of improvement slowed down significantly after the 1970s.

The lack of improvement in female marathon performance between 1926 and 1963 can be attributed to the fact that women

Figure 1: graph showing reductions in male and female world-best marathon times from 1908, with projections to 2050. Note that the model implies women will never outpace men in the marathon



could not officially participate in marathon races. In fact, in spite of dramatic improvements in female performance during the 1970s, 80s and 90s, it wasn't until 1984 that the marathon became a female Olympic event.

However, men have always been faster than women over every Olympic distance, and a model applied on all world best results over the marathon distance set since 1908 predicts an endpoint of marathon performance in females at two hours, 15 minutes *(see figure 1)*. This prediction may be a rather conservative if not pessimistic view, particularly in the light of the fact that this time was almost reached (by the UK's Paula Radcliffe) in 2003. However, when applied to males, the model forecasts faster times than previously predicted (1:57:46). Irrespective of whether such a model allows for meaningful extrapolations to the near or far future, it clearly supports the idea of a near-plateau in gender differences at this distance[6,7]. Further analyses supported the idea of a steady gender difference of about 10% in races up to 200km[8]. Nevertheless, there are some important factors that may favour women over very long distances.

Any form of exercise starts a series of acute physiological reactions involving activation of the hormonal and autonomic nervous system. These responses affect, in turn, the conversion of food to energy and the subjective perception of exercise(9). And there is evidence that these effects are highly gender-specific(10).

There is some evidence that women can run aerobically at a higher percentage of their maximal oxygen uptake than men(7). During the early phase of a 90-minute run, women were able to convert more fat to energy than men; and, more importantly, if a carbohydrate drink was provided during the run, they were able to convert a greater relative proportion of it to energy than men.

The implication of this research is that carbohydrate ingestion, which is particularly common in longer events, is likely to be more effective in conserving the body's own glycogen stores in women than in men, which would be particularly conducive to success in races longer than the marathon.

Other research has shown that women are more resistant than men to the potentially damaging oxidative stress that accompanies endurance exercise(11). This is partly because they have more effective mechanisms for breaking down fats into their constituent fatty acids – a process known as 'lipolysis' which acts as a defence against oxidative stress(12).

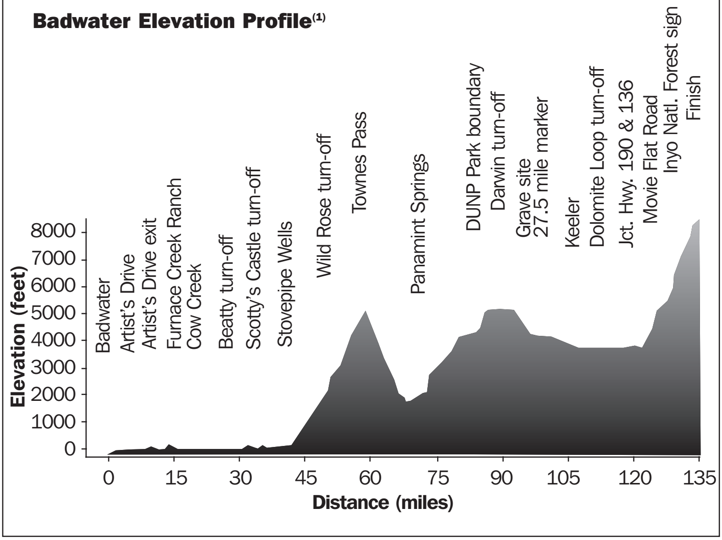
Growth hormone levels increase during acute exercise and are thought to promote positive adaptations to training and recovery. Higher natural levels of growth hormone have been seen in women than in men(13).

Whether or not such findings provide meaningful clues to whether or not women will be able to close the performance gap in races up to 200k, consistent male superiority is already a matter of history in possibly the most challenging ultra-race, the Badwater Ultramarathon. This event, starting in California's notoriously inhospitable Death Valley, is a 216k one-stage race performed at temperatures up to 55°C and bedevilled by challenging uphill and downhill stretches, as illustrated in figure 2 *(overleaf)*.

'Carbohydrate ingestion is likely to be more effective in conserving the body's own glycogen stores in women than in men'

Males dominated this event during the 1980s and 90s. However, despite the fact that women have less effective

Figure 2: elevation profile of the challenging Badwater Ultramarathon



mechanisms than men for regulating their body heat in extremely hot environments[14], in both 2002 and 2003 a female ultra-runner outpaced the fastest male by about 4.5 and 0.5 hours, respectively. Furthermore, in each of the last three years, up to three women have been within the first five finishers – particularly impressive given that this is a race that has always attracted significantly more male than female participants.

Will females consistently outpace males over such ultra distances in the future? That may soon be a matter of fact rather than conjecture.

Professor Ralph Beneke and **Dr Renate Leithäuser**

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Sex in the fast lane: should male and female sprinters train the same?

In an age of gender equality, it's perhaps natural to assume that men and women should following the same kind of training routines for sprint and power sports. However there's good evidence out there that when it comes to sprinting, the physiologies of the male and female body are not equally created.

Introduction

In the eighties it looked like women might creep up on to the heels of men in certain sprint events, such as the 100m. Florence Griffith-Joyner was at the forefront of this charge when she clocked 10.49 sec and 21.34 sec at the Seoul Olympics for the 100m and 200m. These were phenomenal performances and it looked as if women might have a golden era of speed performance ahead of them. If women could develop the power, limb speed and strength that would close the gap between the sexes even further, it seemed as though some old beliefs would have to be challenged.

However, women's sprinting performances have declined significantly across a range of sports since the eighties *(see box, overleaf)*. This article explores the possible reasons for this by focusing on the differences in sprint and power training response between men and women. In particular, it seems that men and women shouldn't train the same and that there are significant 'biological' differences.

Will women ever be as quick as men?

To try and answer this question, Norwegian researchers performed a fascinating piece of research[1]. The team looked at the historical evolution of performances for males and females in anaerobically dominated sprint events in three different sports – running, swimming and speed skating. Specifically, the times of the top six finishers in a total of 283 men's and women's Olympic and World Championship finals held between 1952 and 2006 were analysed.

A strong progression in faster times was identified from the fifties to the eighties, when this trend was halted. This halt is almost certainly because of the increase in drug testing and the number of women having to 'train clean', with a commensurate reduction in performance.

Since then the gap in sprint performance between the sexes has increased. For the events the researchers considered, the closest differential of 10.3% was in the period 1976-88. By the period 2000-05 it had increased to 11.5%. This led the researchers to state: 'Current gender differences in performance and the underlying differences in performance power may now reasonably reflect the true physiological differences between males and females.' It is these 'true physiological' differences we'll consider in the main part of this article.

Sex and sprinting

Ask the majority of coaches what the anaerobic content of the 100m sprint is and they'll typically respond with a figure very close to 100%. Moreover, they probably won't think that there are gender differences. However, according to recent research studies, not only has the aerobic aspect been under-represented for both sexes, there are also gender differences too.

Researchers from Australia looked into the energy system contributions to sprint performance[2, 3]. Advanced methods were used to do this, including in-race measures of VO_2, accumulated oxygen deficit (AOD), blood lactate (La) concentration and the contribution of the high-energy phosphocreatine (PCr) system.

The findings regarding the aerobic content of these events are startling. The researchers conclude: 'While AOD measures are often used to estimate anaerobic energy contribution, at

Table 1: Measuring the specific energy system contributions to the 100, 200m and 400m sprints between genders

Event	Males	Females
Using AOD method	**aerobic/anaerobic**	**aerobic/anaerobic**
100m	21%/79%	25%/75%
200m	28%/72%	33%/67%
400m	41%/59%	45%/55%
Using La/PCr method		
100m	9%/91%	11%/89%
200m	21%/79%	22%/78%

such high exercise intensities (and brief exercise durations) as used in the present study, AOD measures showed larger aerobic energy estimates than expected.'

This could mean a greater emphasis on aerobic training for sprinters than previously thought necessary. However, before sprint coaches get their athletes plodding 'five-milers', it should be noted that most mature athletes will have developed a significant aerobic base level of fitness over years of training, even if they don't realise it. This is because most of their workouts will require elevated heart rates, which are comparable to more steady state aerobic workouts. The aerobic element, especially for the training mature sprinter, is therefore something of a 'hidden' cost, perhaps even more so for women.

The AOD percentages indicate – as mentioned – a greater dependence on the aerobic energy system in sprinting than expected. Research from Brunel University in England looked specifically at elite-level sprinters considering this and other energy system measures[4]. They used a mathematical model of the 'bioenergetics' of sprinting, which enabled them to measure the anaerobic energy metabolism of female athletes competing in the 100m at the 1987 World Championships. Comparisons were made between male and female sprinters. The team found:

- The use of adenosine triphosphate (ATP) and phosphocreatine between males and females was similar;

- The use of the aerobic energy system was higher in females;
- The maximum power generated by female athletes during ATP conversion and glycolysis (the process of creating energy from carbohydrate without oxygen) was only slightly lower than males;
- Females' use of phosphocreatine was substantially lower compared to males.

These findings appear to support those of the Australian researchers that female sprinters run more aerobically than men, and led the researchers to postulate that: 'The lower value for phosphocreatine utilisation might explain the more pronounced fall-off in running speed over the latter stages of a race that female athletes experience in comparison with men.' Phosphocreatine is crucial for short-term high-power muscular outputs; less use of the phosphocreatine system would certainly reduce muscular power output (more later).

More evidence for gender differences

The research presented thus far suggests that men and women may 'sprint differently' in terms of the energy systems their bodies use. To add further credence to this, researchers from Sweden considered another marker of energy provision – glycogen use[5]. This premium grade muscle fuel is derived from carbohydrate and can only be stored in the body in limited amounts (approx 375g).

The researchers hypothesised that women's reduction of muscle glycogen content during sprint exercise would be smaller than men's. Even more specifically they thought that women would use up less glycogen in type II (fast-twitch muscle) fibre compared to type I fibre (slow-twitch fibres, which rely more on aerobic metabolism).

The basis for this reasoning was the greater aerobic aspect of female sprinting (as has been indicated), rationalising that if women ran the sprints using more aerobic energy then they would use up proportionately greater amounts of glycogen in their slow-twitch muscle fibres compared to men, and less phosphocreatine. The results were as follows:

- Exercise-induced reduction in glycogen content in type I (slow-twitch, endurance) fibres was indeed 50% smaller in women compared to men, indicating they used these fibres more (*ie* more aerobic activity);
- Blood lactate levels were 22% smaller in women than in men – indicating reduced oxygen independent glycolysis (anaerobic energy production);
- Although there was a major reduction of ATP (50%), phosphocreatine (83%), and glycogen (35%) in type II muscle fibres, this did not differ between the genders.

The hypothesis was partially confirmed. Women did use less glycogen compared to men when sprinting – however, this effect was observed only in type I fibres. The team concluded: 'Fibre-type-specific and gender-related differences in the metabolic response to sprint exercise might have implications for the design of training programmes for men and women'.

As the glycogen reduction was in slow-twitch fibres, it could be argued that women should place a greater emphasis on very short distance flat-out sprinting (30-60m) across the training year, compared to men, so that they can develop the capacity to recruit more fast-twitch fibres, using oxygen independent glycolysis and 'burn' more phosphocreatine.

Some of the researchers from Sweden were involved in a follow-up survey(6). This time they looked at interval training. Fifteen active women and men (average age 25) performed three 30-second sprints, with 20 minutes of rest between each. The researchers took repeated blood and muscle samples. This time they discovered that:

- Glycogen reduction was lower in type I fibres in women (in agreement with their original research);
- Repeated sprints induced smaller reductions in ATP in women than in men in type II muscle fibres over the workout;
- There was no difference in changes of ATP levels and its breakdown products between men and women during the bouts of exercise themselves.

Speed and power training methods – are there gender-specific differences?

If there are energy system usage differences between males and females when it comes to sprinting, are there differences in gender response to training methods used to develop sprint power, such as plyometrics and weight training?

A team of American researchers looked at plyometric training – a key element of sprint and power training[8]. They analysed the effect of a jump-training programme on landing mechanics and lower extremity strength in female athletes involved in jumping sports. They compared these parameters before and after training with those of male athletes. Females are at greater risk than males of suffering anterior cruciate ligament damage. Key identifiable factors include the different strength ratios between the quadriceps and the hamstrings in males and females (which the research considered). Men have stronger hamstrings, for example, and this is seen to add stability to the knee joint, which reduces potential knee damage. The researchers developed a training programme that was designed to decrease landing forces by teaching neuromuscular control of the lower limbs and increase vertical jump height. After training it was discovered that:

- Peak landing forces from a volleyball block jump decreased 22% and knee lateral (side-to-side) movement decreased by approximately 50% among the females;
- Female athletes had lower landing forces than males;
- Hamstring to quadriceps muscle peak torque ratios increased 26% on the non-dominant side and 13% on the dominant side. This, the researchers argued, corrected side-to-side imbalances – reducing injury potential;
- Hamstring muscle power increased 44% with training on the dominant side and 21% on the non-dominant side;
- Peak torque ratios of male athletes were significantly greater than those of untrained female athletes, but, importantly, similar to those of trained females.
- This research seems to indicate that female power athletes need to be introduced to plyometric training more systematically than males.

These findings were explained by the team as follows: 'The smaller levels of ATP reduction in women compared to men during repeated sprinting was created during recovery periods between the sprint exercises – *ie* women possess a faster recovery of ATP …'.

What does this potentially indicate for female sprint training? Possibly that women possess a better ability to recovery between intervals than men in terms of ATP replenishment in both type I and type II fibres. However, males seem better able to get more from their fast-twitch fibres – producing greater power – which mitigates against females' better recoveries (this is indicated by some of the research quoted that shows increased use of phosphocreatine in men's muscles when sprinting).

Having said that, it's worth remembering that neither piece of Swedish research involved highly trained sprinters; trained sprint athletes (regardless of gender) will possess improved ATP and phosphocreatine replenishment capabilities compared to non sprint-trained individuals and should therefore be better able to recruit fast-twitch muscle fibres.

Continuing with the 'energy usage' theme but this time with a more biomechanical slant, researchers from Brunel University considered the energy conversion strategies used in the 100m sprint among men and women(7). They wanted to determine whether the genders reached top speed at different points in races and whether anything could be gained from using different speed strategies – for example, whether delaying the entry into the maximum speed phase of the race would result in potentially faster times, due to less tail-off.

They actually found that there was nothing to be gained from the insertion of a constant speed phase. For elite male athletes maximum speed was reached between 55 and 60m from the start line, and for females between 46 and 53m from the start. In terms of gender training differences, this could require a greater emphasis on speed-endurance workouts for females to mitigate against the inevitable slowing that seems to occur once maximum speed is achieved. A typical relevant speed endurance workout for the 100m sprinter would be 3 x 120m flat-out with full recovery.

'Women also produce testosterone and its levels are elevated in both sexes as a consequence of exercise'

Hormonal response between men and women and speed and power activity

Another factor that can affect performance in power and speed activities is the presence of the hormone testosterone. In terms of sports performance, testosterone can increase aggression (through complex, but not fully understood mechanisms), enabling increased amounts of fast-twitch muscle fibre to be recruited boosting sports performance.

Although testosterone is the male sex hormone, women also produce it and its levels are elevated in both sexes as a consequence of exercise. A team of researchers from the Olympic Medical Institute, Northwick Park Hospital (England) believed that women's naturally lower testosterone levels would mitigate against power development and specifically vertical jump performance[8]. The research was particularly relevant due to the increasing participation of elite-level power athletes (specifically track and field sprinters) in handball, volleyball and football, competing at national and international level. The researchers identified a 'significant positive' relationship between testosterone levels and vertical jump performance.

This sex difference between the athletes would appear to be insurmountable in terms of a legal solution; however, other research has indicated that female athletes can produce similar levels of testosterone during training to men[9]. Additionally, emphasis could be placed on psychological strategies designed to optimise the arousal levels of women before an event, which can boost aggression and help create the right body chemistry for increased performance.

Summary

Recent evidence indicates that there are significant physiological differences between men and women in terms of their biochemical and physical responses to sprint and power training. From the above, it should become apparent that men and women should not train in exactly the same manner. Sprint and power coaches should be mindful of this and develop their training strategies accordingly.

John Shepherd

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Why women avoid weight training – and how coaches can change their minds

Introduction

Female athletes are less likely to perceive weight training as beneficial to their sport compared to their male counterparts, according to a recent study. This may not seem like much of a problem, but weight training is a significant aid to female athletes, not just because it helps improve sporting performance but also because it helps ward off osteoporosis by enhancing bone mineral density (BMD).

Coaches and athletes need to be aware of these benefits as well as the social/cultural barriers that may discourage women from participating in weight training. This article will begin to address these issues as well as offering practical advice on training.

The study referred to above involved 139 male and 165 female student athletes from four US colleges(1). The students, who participated in a total of 11 different sports, including soccer, athletics, lacrosse and basketball, completed two questionnaires:

- The Training Information Survey (TIS), including questions on weight training practice and perception, as well as other sports training and conditioning;
- The Sport Orientation Questionnaire (SOQ), which measures competitiveness, win orientation (where the performer is focused on an objective outcome, *eg* a race result) and goal orientation (focus on personal achievement)(2).

The authors were seeking to identify gender differences in weight training perception as well as differences between more competitive and less competitive athletes.

The key findings were as follows: US

- Female athletes perceived weight training to be less important than their male counterparts, while their coaches considered weight training to be less essential for women than for men;
- The athletes who participated most in weight training activities were those who considered it essential to their sport. Participation was not linked with competitiveness, goal or win orientation;
- Female athletes were less confident about weight training than male athletes;
- The SOQ confirmed previous research that male athletes were more competitive and win orientated than women while female athletes were more goal orientated than men;
- In both groups of athletes, those who were goal orientated and competitive considered weight training equally important for male and female athletes, while those who were win orientated thought weight training was a masculine activity, important only for male athletes.

Leaving aside for the moment the differences between competitive, goal and win orientated athletes, the three main issues highlighted by this study were the perception of weight training as a masculine activity, the finding that participation in weight training is linked to the perception of sport specific relevance and the fact that female athletes are less confident about weight training than males.

Unfortunately, coaches did not appear to be helping matters. And the researchers conclude that coaches need specific education and support in order to promote weight training appropriately to female athletes.

Sportswomen seem to have an adverse perception of weight training, perhaps because they link it in their minds with the image of muscle-bound, testosterone-fuelled bodybuilders. Coaches need to help them overcome this cultural barrier. But in order to do so, they will also have to overcome their own barriers to seeing weight training as essential for female athletes.

As is apparent from this US study, women will weight train if they see it as essential to their sport. So what research supports the sport specific relevance of weight training?

Football training and gender

Let's take football as an example. The physiological requirements of the game are similar for men and women: speed, power and the ability to perform repeated high-intensity sprints, with limited recovery time, over a period of 90 minutes[3]. It follows, then, that training should be similar for both sexes, varying only in accordance with training age, fitness level and the demands of competition.

A recent US study of female high school soccer players sought to evaluate the impact of strength training on various parameters of fitness[4]. One group completed a 10-week in-season programme of twice-weekly training sessions, including 30 minutes of strength training and 15 minutes of plyometrics, while a control group simply carried on with soccer-related activities.

By comparison with controls, the strength training students showed significant increases in their anaerobic power (as demonstrated in an abridged version of the multi-stage fitness test) and fat-free body mass, together with reductions in body fat. These improvements may have been influenced by the untrained status of the players, but the study does demonstrate that a relatively limited intervention, involving 90 minutes of additional training per week, can lead to real improvements.

Gymnastics provides another useful example of the relevance of weight training to women. This is a challenging and difficult sport, since participants need power to tumble and strength to hold positions, but are also marked on form and grace, which call for a suitable body shape.

In a three-year longitudinal study, 20 US college-level gymnasts were tracked as they worked through a periodised resistance training programme. The programme[5] initially worked on baseline strength levels and introduction of techniques, but then progressed to high-velocity movements with the goal of boosting power without increasing body mass.

‘The observation that strength training increases fat-free mass while reducing fat mass is particularly significant for women in terms of osteoporosis’

The movements included in the strength training sessions were designed to be as sport specific as possible, as well as linking in with the participants’ skill training and competition cycle.

Analysis of the results showed year-on-year increases in power and fat-free mass, with a simultaneous reduction in body fat, keeping overall weight constant. Unfortunately, because the authors did not use a non-weight training control group, it is impossible to determine how much of these improvements were down to the strength training programme as opposed to normal gymnastic training. However, it would be difficult to find a control group of similar elite level athletes who did not perform some sort of supplementary training for three years.

The observation that strength training increases fat-free mass while reducing fat mass has particularly significant implications for female athletes in terms of their risk of the bone thinning disease osteoporosis.

Osteoporosis affects as many as 25 million people in the USA alone and, of these, 80% are women[6]. The condition has been linked with a lack of load-bearing physical activity in youth[7] as well as other risk factors, including calcium insufficiency, smoking and use of oral contraceptives.

Sporting participation at high school level as well as current activity levels and percentage of lean body tissue have been shown to be predictors of low bone mineral density (BMD), an independent risk factor for osteoporosis, in a study of 18-39-year-old women[8]. In fact, women who did not participate in high school sports were seven times more likely to have low BMD than their sportier counterparts.

Runners and gymnasts

That study was concerned with general sports participation, but others have been more specific in their attention. In a study comparing the BMD of female cross country runners and gymnasts, the latter were found to have significantly higher BMD[9]. The researchers surmised that this was due to the greater levels of mechanical loading involved in gymnastics, as compared with running.

Table 1: two-monthly weight training cycles for rugby union

Type of exercise	Cycle 1	Cycle 2
Core	Clean and jerk	Clean and push press
Core	Snatch	Dumbbell snatch
Core	Squat	Front squat
Core	Bench press	Dumbbell press
Supplementary	Lunge	Single-leg squats
Supplementary	Russian boxers	Tomahawks
Supplementary	Cheat rows	Pullovers

As well as being affected by particular sports, BMD is influenced by particular types of resistance training. In a study of young women, overloading eccentric contractions performed at 125% of 1 Repetition Maximum (1RM) were shown to be less effective in boosting BMD than submaximal eccentric resistance training at 75% of 1RM(10). The overload group performed three sets of six repetitions of their load, while the submaximal group performed three sets of 10 of theirs.

The researchers were surprised by their results because they had assumed that the higher mechanical loading of the overload group would be most conducive to improving BMD. However, because of the high loading, they avoided load-bearing exercises like the squat in favour of machine-based exercises, which may have affected the response. They concluded that the greater number of reps performed by the submaximal group was the key factor in their enhanced response. This study shows that significant results can be gained without excessive training, allowing for continued sports training and competition.

So, if we accept that strength training leads to improved fitness parameters that help sporting performance, an increase in fat-free mass, a decrease in fat mass and an increase in BMD that will help prevent osteoporosis, what can coaches do to promote participation by female athletes?

How coaches can help

Remember the findings of the first study mentioned in this article – that female athletes need to understand the benefits of strength training for health and sporting purposes, which tend to be goal orientated and are likely to lack confidence when performing weight training activities?

Coaches can use this information to educate their athletes, provide them with short-, medium- and long-term goals, and create a positive, supportive atmosphere in the weight training facility that helps build confidence.

How can this be achieved? Goal-setting has been covered in depth in sporting literature but coaches need to be aware that this key tool should be applied to conditioning as well as sport specific training and lifestyle.

Role models have been shown to be important in increasing participation by women in sport[11]. And if coaches can involve other female athletes, even from different sports, in implementing and demonstrating weight-training techniques, their own athletes may be more likely to respond.

Coaching in small groups of up to six athletes is also beneficial in that it allows for more individual tuition and creates a less intimidating atmosphere in which to facilitate learning. In my experience, groups of more than six beginners are difficult to coach in the gym, in terms of health and safety as well as technique. People are left either lifting unsupervised or with too much recovery between exercises so that they get cold or bored.

It may be wise to book out the gym for a women-only hour (or even afternoon) for the first five or six sessions, as this will reduce distractions and allow the athletes to lift weights without an audience.

A balance needs to be struck between repetition (to promote familiarity and confidence) and variety (to stimulate minds and bodies). One way to do this is by varying the training environment. For example, aqua-based plyometrics can be used as an alternative to land-based exercises.

This will provide a fresh physical and mental stimulus, may be perceived as fun, and is less likely to result in muscle soreness than land-based training[12]. Follow this up with 10 minutes of water polo or water sprints and you will have created a session that your athletes really look forward to!

I would suggest developing a core set of 4-6 exercises that you consider essential for your sport, then varying supplementary exercises around the core in each session. This will provide both the familiarity and the variety that your athletes need.

Within your core group of exercises, you can then introduce minor variations every 2-3 weeks. For example, in rugby union you could use two cycles over a two-month period, with the four core exercises changing slightly, as shown in Table 1, above. Within each cycle you may have 10-12 individual sessions in which the supplementary exercises would change each time. Within that overall structure, you would then periodise the load, sets and reps, allowing for delivery of 20-24 different sessions.

In summary, by educating themselves and then their athletes, coaches can start to communicate the benefits of weight training for female athletes. By means of goal-setting, individual coaching and good session planning, coaches can encourage, help and stimulate their athletes and then look forward to corresponding improvements in both fitness parameters and sporting performance.

James Marshall

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Cycling proficiency: do the various menstrual phases affect athletic performance?

Introduction

The female body is a complicated system, with hormones playing an important role in its function. Within that system, the menstrual cycle represents a combination of interactive, and sometimes opposing, hormonal actions with the potential to impact upon the health of an exercising female. Therefore, any coach involved in training female athletes needs a clear understanding of the physiology of menstruation and its effects on performance.

Female athletes are often concerned about the number of days in their cycle and the volume of menstrual flow. In fact, the average cycle runs for the oft-quoted 28 days in less than 15% of cases, with normal regular menses encompassing anything from 21-35 days. The duration of menstruation has also been shown to vary widely, with normal flow lasting for an average of 3-7 days.

The cycle, which begins with menstruation, is regulated by a complex interaction of pituitary and ovarian hormones. In the 'follicular phase' (the days leading up to ovulation) oestrogen is the predominant hormone; following ovulation, during the 'luteal phase' of the cycle, progesterone exceeds oestrogen, preparing the uterus for pregnancy.

Researchers have shown that physiological changes occur in both the follicular and luteal phases and that both oestrogen and progesterone can be altered by intense exercise. Therefore, the influence of menstrual phase is important to our understanding of performance and training.

Although no significant changes to endurance performance have been reported in connection with the various phases of the menstrual cycle, a slight decrease in aerobic capacity has been noted during the luteal phase. This phase is characterised by an increased ovarian response, leading to a net fluid retention, with consequent changes in electrolytes and minor increases in haemoglobin concentration, for reasons explained below[1].

This same research also failed to identify any significant differences in VO2max, heart rate, cardiac output and stroke volume between menstrual phases, suggesting that the cardiovascular response to exercise is unaffected by the menstrual cycle.

One difference the researchers did discover was that blood lactate was lower in the luteal phase following intense exercise, although this has been disputed by subsequent research[2]. It has been suggested that any observed decrease in lactate production during the luteal phase happens as a result of an altered oestrogen: progesterone balance.

Ventilatory response to exercise has been shown to increase during the luteal phase of the menstrual cycle, which is associated with a reduced oxygen supply to working muscles[3]. The body compensates for this deficiency by boosting the concentration of oxygen-carrying haemoglobin in the blood, and no differences have been reported in either oxygen uptake or time to fatigue between the follicular and luteal phases.

Research into the effects of the menstrual cycle on anaerobic exercise performance is limited and inconclusive. Decreased cycle (Wingate anaerobic power test) and 50m swim test performances have been reported during menstruation, while an increase in high intensity/low duration work has been noted during the luteal phase of the menstrual cycle[4]. More recently, investigators demonstrated no significant difference in maximal cycling or leg power during any of the menstrual phases[5], although it has been suggested that premenstrual and menstrual syndrome symptoms, such as joint, muscle and back pain, may have a negative effect on anaerobic performance, possibly by influencing the stretch shortening cycle of the tendons and ligaments.

Common menstrual disorders

Menstrual disorders are very common among athletic women, with amenorrhea (cessation of periods) occurring in up to 40% of some athletic groups by comparison with 2-5% of women of reproductive age in the general population[6]. Amenorrheic athletes show no monthly follicular and luteal phase variations, resulting in ovarian suppression.

Bone density generally relates closely to menstrual regularity and the total number of menstrual cycles. Reduced bone density from long-term amenorrhea often occurs at multiple sites, including bone areas subjected to increased force and impact loading during exercise. Persistent amenorrhea that begins at an early age blunts the benefits of exercise on bone mass and is also linked with increased risk of musculoskeletal injury, particularly repeated stress fractures during exercise.

'Reduced bone density from long-term amenorrhea often occurs at multiple sites, including areas subjected to impact loading during exercise'

Disturbances in menstrual function can be seen in the form of primary amenorrhea (absence of menstruation by age 18), secondary amenorrhea (absence of menses for three or more months in a woman who was formerly menstruating) or oligomenorrhea (a menstrual cycle lasting more than 36 days).

A high incidence of secondary amenorrhea has been reported for athletes in sports associated with heavy training levels, while girls who begin athletic training before puberty often experience delayed onset of menstruation (menarche).

The menarche can also be delayed on account of inadequate caloric intake which, in many cases, is related to issues of weight control and aesthetic appearance. Attempts to control weight are associated with disordered eating which, in turn, can lead to reproductive dysfunction. It has been suggested that a minimum percentage of body fat is required for the onset of menstruation and the maintenance of a regular cycle, based on the hypothesis that an energy reserve is essential to sustaining a pregnancy.

Even in regularly menstruating competitive athletes, lower-than-expected progesterone levels during the luteal phase have been observed. Over time this can lead to impaired fertility and/or an increased susceptibility to osteoporosis.

A proactive approach

The American College of Sports Medicine (ACSM) has taken a proactive approach to menstrual dysfunction in athletes, recommending intervention within three months of the onset of amenorrhea. Their guidelines recommend a non-pharmacological behavioural approach, together with diet and training interventions, as follows:

- Reduce training level by 10-20%;
- Gradually increase total energy intake;
- Increase body weight by 2-3%;
- Maintain daily calcium intake at 1,500mg.

Skin blood flow and the sweating response during rest and activity are also influenced by the menstrual cycle. Scientists have found that a significantly higher core temperature is required to initiate sweating during the luteal phase(7). Although this change in thermoregulatory sensitivity does not affect the ability to exercise, it is worth taking account of menstrual cycle phase when evaluating thermoregulatory dynamics during exercise and thermal stress.

In summary, then, the majority of published studies agree that neither menstrual phase (follicular v luteal) nor menstrual status (menstruating v non-menstruating) significantly alters or limits exercise performance.

However, the combination of intensive exercise (particularly during the pre-pubertal years) and under-nutrition can have an adverse impact on reproductive function and sexual maturation, leading to either primary or secondary amenorrhea.

If an athlete does become amenorrheic, medical treatment should be considered in order to maintain long-term health and reduce the risk of fractures.

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