Training for
ENDURANCE

A SPECIAL REPORT FROM

PEAK PERFORMANCE

The research newsletter on
stamina, strength and fitness

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From the editor

Endurance – or stamina, or aerobic fitness – is the attribute athletes need to maintain a vigorous pace throughout a distance event and still have enough left in the tank to produce a final competitive surge at the end. It is also increasingly recognised as important for players of a variety of sports – particularly those involving running (eg football) and lengthy matches (eg tennis).

The old wisdom was that endurance was developed solely through endurance activity. But nowadays there is a growing awareness that training intensity is as important as duration, that strength training has an important role to play in boosting endurance performance and, further, that other factors like self-belief and even thought processes also have a bearing on the outcome.

This special report, prepared for you by PP's expert team of writers, considers endurance performance from a variety of angles, from training schedules (three brilliant ways to quantify and evaluate your training) to cultural conditioning (could you be an unwitting victim of 'stereotype threat'?); from concurrent training (is the perfect sports conditioning partnership in danger of breaking up?) to psychology (what's better, attention or distraction?); and from the example of Kenyan athletes (pointing the way to peak 10k performance) to the effects of exercise on the heart (is there a link between cardiac fatigue and cardiac damage?).

We hope you enjoy reading this special report and find it helpful in preparing you to perform at the very top of your game.

Isabel Walker
Editor

Three ways to quantify and evaluate your training – and make sure you are achieving what your coach has planned for you

Coaches are good at planning training schedules: indeed, most of the ones I know are very thorough – even mathematical – in the detail of their planning. Typically, a coach will plan and add up the amounts of training at different intensity levels and modes required to produce the ideal programme for a given athlete.

Training variation, progression and recovery will be planned within or between weekly programmes to maximise the fitness effect. For example, an endurance coach will plan how best to organise five sessions at steady pace, three interval sessions at high intensity, one complete rest day, three runs at threshold pace and one conditioning session to make the best training week.

Athletes (most of them at least) use diaries to record their training. Commonly, these diary entries will contain session details for each day and may include comments. For example, 'Tuesday am – 30 minute run steady. Felt good. Tuesday pm – 8 x 800m, 2 mins rest. Average time 2min 40s. Legs felt crap.'

By contrast with the rigorous planning of their coaches, athletes' recording of training is often subjective, lacking in particular any information that can be used to calculate the training load of the session. The coach will have planned exactly when the hard, moderate and easy training sessions should take place, yet the athlete does not record information that can be used to determine whether this, in fact, occurred.

Perceptions of the level of training may also differ between coach and athlete. For example, an athlete may find a ‘circuits’ session hard, but the coach may assume that it is moderate and place it in the weekly plan accordingly. The resulting weekly programme may therefore lack the recovery element needed to maximise fitness benefits.

In order to help coaches and athletes plan and then monitor the effects of training more precisely, physiologists have attempted to devise quantifiable methods for recording training load. These methods enable athletes to record training load in terms of numbers, thus making sessions objectively comparable.

‘If the training load is too heavy or too monotonous, the athlete will not experience optimal improvement’

Training load may be defined as the stress placed upon the body as a result of the training session. It has both a fitness and fatigue effect (1), but in order for the cumulative training programme to result in improved fitness, the former must outweigh the latter. If the training load is too heavy or too monotonous, the athlete will not experience optimal improvement.

In this article I will describe three different methods of quantifying a training load, each with its own merits and limitations. I will also demonstrate the potential usefulness of Excel spreadsheets in helping coaches and athletes summarise their training loads in graphic terms.

The basic TRIMP method

First proposed by Bannister *et al* in 1975, this method is a very simple way of calculating what is termed TRaining IMPulse (TRIMP). TRIMP is defined as training volume x training intensity and is specific to endurance training as it uses heart rates or heart rate zones. Initially the researchers proposed simple methods of calculating the TRIMP of a session, such as the following:

- TRIMP = training time (minutes) x average heart rate (bpm). For example, 30 minutes at 145 bpm. TRIMP = 30 x 145 = 4350.

This method, involving simple maths, makes a great deal of sense in terms of calculating a ‘dose’ of aerobic training, and I would recommend it to the average adult exerciser. For adults looking to improve basic cardiovascular fitness by means of simple training sessions, such as continuous pedalling on an indoor bike, or an aerobics class, this calculation gives them a great monitoring tool to analyse their progress and adherence to training.

A week's training could be tabulated and calculated in Excel, as shown in table 1, below. Weekly TRIMP totals could be used as targets for general CV fitness goals or to encourage increased activity.

Table 1: a week's training using the TRIMP method

Session	Time	HR	TRIMP
Monday X-trainer	25 mins	130	3,250
Wednesday bike	40 mins	120	4,800
Saturday BodyPump class	50 mins	140	7,000
		Total	15,050

The disadvantage of this system is that it does not distinguish between different levels of training, which would be a problem for a more advanced exerciser or elite athlete. For example, 30 minutes at 145 bpm gives a TRIMP score of approximately 4,500, as does 25 minutes at 180 bpm, although clearly these are very different levels of training. Assuming a max heart rate (HR) of 185 bpm, this means that one session takes place at 78% of max HR and the other at 97%. The latter will be very demanding, involving high lactate levels and a greater training load than the former.

TRIMP training zone method

To overcome this limitation, subsequent researchers refined the basic TRIMP concept, using heart rate zones to weight intensity in the calculation(2). Foster *et al* split intensity into five zones, as follows(3):

1. 50-60% max HR
2. 60-70%
3. 70-80%
4. 80-90%
5. 90-100%

The zone number is used to quantify training intensity; TRIMP is calculated as the cumulative total of time spent in each training zone.

To express a similar example to that above in these terms:

- 30 minutes at 140 bpm. Max HR = 185 bpm. %max HR = 140/185 x 100 = 76%. Therefore, training intensity = 3.
  TRIMP = training volume (time) x training intensity (HR zone). 30 x 3 = 90.
- 25 minutes at 180 bpm. Max HR = 185 bpm. %max HR = 97%. Training intensity = 5.
  TRIMP = 25 x 5 = 125.

As you can see, this method finds that 25 minutes of working at a very high heart rate results in a higher training load score than 30 minutes at a steady state heart rate.

The zone TRIMP calculation method can distinguish between training levels while remaining mathematically simple and I would recommend its use to serious exercisers and elite endurance athletes, especially as it can be used for quantifying interval sessions with variable heart rates. To calculate the TRIMP for the interval session, simply add up the time spent in each zone, as in the following example:

- 5 x 3 minutes at 95% max HR with 3 minutes easy jog at 70% max HR recovery.
  TRIMP = 15 x 5 + 15 x 2 = 105.

‘The limitation of the TRIMP heart rate zone method is that it can only quantify aerobic training’

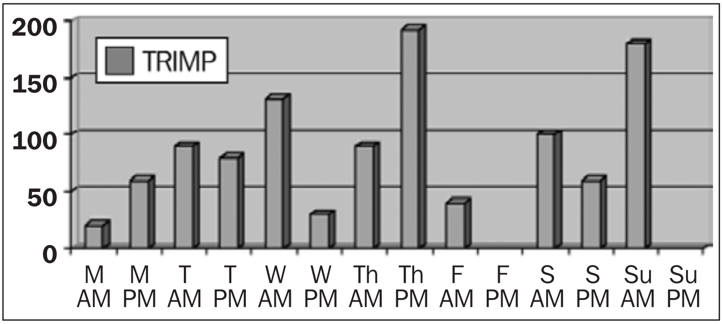
The table and accompanying bar chart opposite describe a hypothetical example of a week’s training for an elite runner, using Excel to calculate and plot TRIMP across the week. Tuesday and Thursday are interval sessions. For example, 8 x 2min 30s reps in zone 5, with 2min recovery in zone 2.

The graph shows quite clearly where the peaks in training load occur during the week, and it would seem that this hypothetical schedule spreads the training load sensibly, including days of relative rest between the hard sessions.

The limitation of the TRIMP heart rate zone method is that it can only quantify aerobic training. Strength, speed, anaerobic

Table 2: a week's training for an elite runner using TRIMP training zone

Day	Time	HR Zone	HR TRIMP	Time	HR Zone	HR TRIMP
Monday	30	2	60	45	2	90
Tuesday	40	2	80	8x2.5/2	5/2	132
Wednesday	30	1	30	30	3	90
Thursday	30	2	60	6x6/1	5/2	192
Friday	40	1	40	–	–	–
Saturday	25	4	100	30	2	60
Sunday	90	2	180	–	–	–



and technical sessions, which do not involve high heart rates but are nonetheless intense, cannot be calculated accurately by these means. Thus the method is suitable only for evaluating endurance training.

Session RPE method

Foster *et al* developed a method of evaluating training using a variation of the Borg Rating of Perceived Exertion (RPE) scale *(see table 3, overleaf)*, which is designed to measure subjective perception of effort (3).

To calculate the TRIMP, the time of the session (in minutes) is multiplied by the RPE scored. For example, for 60 minutes of weight training, rated as very hard (RPE = 7), TRIMP = 60 x 7 = 420.

Table 3: the Borg Rating of Perceived Exertion scale

Rating	Descriptor	Rating	Descriptor
0	Rest	6	–
1	Very, very easy	7	Very hard
2	Easy	8	–
3	Moderate	9	–
4	Somewhat hard	10	Maximal
5	Hard		

(Note, however, that it is not advisable to compare TRIMP scores calculated by different methods. The scores are arbitrary and comparisons are useful only within the same method.)

Foster and his team studied the reliability of this TRIMP method, asking subjects to rate various types of aerobic training sessions performed on a bike, 30 minutes after the session had finished (3). They claim that, while this use of the RPE scale is unconventional, it is not influenced by momentary changes in intensity, which are proven to influence ratings.

The subject provides a 'global' rating of the session, known as 'session RPE', which allows for better comparisons between different types of training, especially sessions that are not dependent upon heart rate.

Foster's study showed that session RPE was a more reliable indicator than heart rate data for evaluating the intensity of endurance training. And, more recently, other researchers have confirmed its reliability for evaluating the intensity of strength training (4).

For example, a session of strength exercises involving sets of 4 reps at 90% of rep max was rated higher than a session involving sets of 15 reps at 50% of rep max (rep max being the highest weight possible for that exercise and defined as 100% intensity for strength training).

The session RPE TRIMP method is very useful for athletes in sports that involve a variety of training modes, especially anaerobic and technical training, *eg* ball games and power sports. Athletes in these sports may train for long periods of time, and while their average heart rate for the session may be low, indicating a light aerobic training load, the overall training load on the body (including anaerobic and neuromuscular work) will be significant and needs to be calculated.

The hypothetical example of a boxer's training programme, set out in table 4 and the accompanying bar chart below, illustrates the power of the session RPE TRIMP method, which can also be calculated and plotted in Excel.

Here we can see how the session RPE method can be used to quantify the training load across different types of training. This makes it a very powerful monitoring tool for many different sports. This hypothetical example shows that, while the Tuesday evening sparring and circuits session looks the most demanding of the week, in fact the athlete perceived Monday evening's 90-minute technical session as more demanding.

Table 4: a week's training for a boxer using the session RPE TRIMP method

Day	Session	RPE	TRIMP	Session	RPE	TRIMP
Monday	30 min run	3	90	90 min technical boxing	4	360
Tuesday	45 min run	3	135	30 min sparring / 20 minute circuit	7/4	290
Wednesday	rest	–	–	90 min technical boxing	3	270
Thursday	45 min run	3	135	20 min sparring / 40 min technical	8/2	240
Friday	rest	–	–	Rest	–	–
Saturday	30 min run	4	120	40 min strength	6	240
Sunday	rest	–	–	50 min technical	5	250

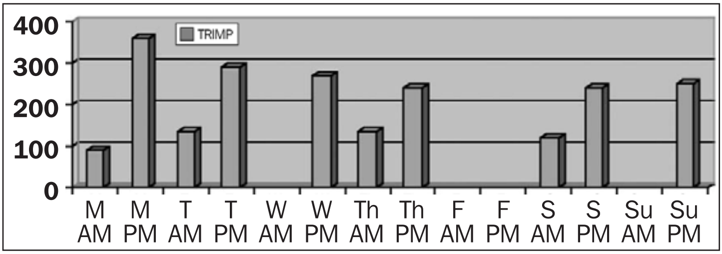
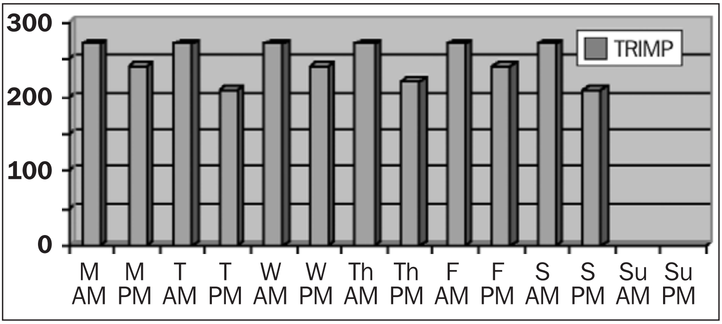


Table 5: a week's training for a tennis player using session RPE

Day	Session	RPE	TRIMP	Session	RPE	TRIMP
Monday	90 min hit	3	270	60 min strength	4	240
Tuesday	90 min hit	3	270	30 min intervals	7	210
Wednesday	90 min hit	3	270	60 min speed	4	240
Thursday	90 min hit	3	270	45 min plyometrics	5	225
Friday	90 min hit	3	270	60 min strength	4	240
Saturday	90 min hit	3	270	30 min intervals	7	210
Sunday	rest	–	–	rest	–	–



This is a useful illustration of how ratings of training load can correct mismatches between what the coach thinks of as hard training and what the athlete actually experiences. Evaluation based on 'actual' rather than planned training will be important for many athletes striving to achieve their best.

The table and bar chart above give a second example of the use of the session RPE method, using a hypothetical tennis training schedule. This illustrates how Session RPE TRIMP can point to monotony in training routines, since the TRIMP plot in the bar chart shows very similar values for all sessions. In the light of this data, coach and athlete could easily make adjustments to either the length or intensity of training sessions to allow for more variation in the weekly programme.

In summary, I have presented three methods for evaluating training load objectively. The first and most simple – basic

TRIMP method – is probably best suited to those training for general health benefits and unable to account for training intensity in training load.

The second – heart rate zone TRIMP method – is a simple tool for monitoring all aerobic training and is excellent for endurance athletes.

The final method – session RPE – is perhaps the most versatile since it can be use to rate the load of any kind of training. It is perfect for games players, power and technical sport athletes.

Raphael Brandon

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Power without mass: how strength and plyometric training can boost endurance running performance

As a middle or long distance runner (or running coach) do you include strength sessions in your weekly training programme? In my experience, as a strength and conditioning coach working with elite athletes, those who don't have either had negative experiences of weight training or hold certain prejudices – *eg* that strength training will lead to increased weight or interfere in some way with running training.

Given my position, it should come as no surprise to learn that I believe strength training is important for middle and long distance runners. However, its beneficial effects, backed up by research, will be experienced only if it is performed in the right amounts, using the correct choices of exercises.

Athletes and coaches should always have an open-minded approach to tweaking and improving their training programmes. At the same time, they should also question the benefits of any new or additional training method. Why is this kind of training good for my event? What is the exact benefit that I will gain from it? How can I successfully fit it into my routine?

For endurance runners, high volume mixed with high intensity running training is essential for success. Recovery between sessions is equally important to avoid staleness; and, consequently, any additional training will not necessarily be beneficial if it adds to fatigue rather than enhancing fitness.

If endurance runners wish to add strength sessions to their training programmes, they need to prioritise, ensuring each exercise in the routine is beneficial. Big weight lifting sessions, involving lots of exercises taking more than an hour to complete, may be useful for a rugby player but wont help an endurance runner.

There are two key principles for endurance runners to bear in mind when including strength training into their programmes:

1. Strength training should be introduced cautiously and progressed very gradually;
2. Programmes must be time efficient and fit into the weekly running programme.

In this article I will describe the kind of strength programmes incorporated into the weekly training routines of two elite middle and long distance athletes throughout a training year: one an 800m runner and the other a 5000m specialist, both competing at senior international level and carrying out the kind of high mileage training you would expect.

For each programme, I will describe not just the content and volume of the exercises but the overall physiological goals of the programme, so that the purpose of each exercise is clear. And let me assure you from the outset that gaining muscle mass is not the main aim.

The 800m strength programme

The aims of strength training for this particular male 800m runner were:

1. to increase the power of the leg muscles;
2. to develop general strength to help prevent soft tissue injuries in the leg muscles.

It is probably fair to say that these will be the two most important goals for all 800m runners. Leg power is important to help promote the high maximum speed required for the event; and general strength in the hamstrings, calf and core help to increase the resistance of soft tissue to fatigue and strain.

These were problems to which this athlete was particularly prone, in common with many other runners.

The exercises included in the programme were selected only if they served one of the above goals. Thus, there were no upper body strength exercises as the athlete did not feel he had anything to gain from increased upper body strength and did not want to risk gaining any upper body muscle mass. The programme was split into three distinct phases: off-season preparation; pre-competition peaking and competition maintenance.

Off-season preparation phase. The main aim of this phase, described in the table below, was to increase maximum leg strength in the powerful gluteal and quadriceps muscles. The front squat and one leg squat were used for this purpose and you can see that increasing the weight lifted was the goal for these exercises. This development of maximum strength lays the foundation for power to be developed later on in the training cycle.

In addition, hamstring, calf and core exercises were included for the purpose of injury prevention. You can see that progress was made in the strength endurance of these muscles with the

‘Big weight lifting sessions may be useful for a rugby player but won’t help an endurance runner’

Strength session: twice a week		
Front squat	4 x 5	Progressed to heavier weights (60-90kg)
One leg squats	3 x 5	Progressed to heavier weights (40-70kg)
Swiss ball hamstrings hip lift	3 x 10	Progressed to single leg, then increased reps
One leg barbell calf raise	3 x 10	Progressed to increased seps
Gluteal bridge (single leg)	3 x 30s	Progressed to 3 x 60s
Side plank	3 x 30s	Progressed to 3 x 60s
Reverse crunch	3 x 20	Progressed to adding weight to legs
The plank	3 x 30s	Progressed to 3 x 60s
Plyometric session: once a week		
30cm drop and catch	3 x 5	Progressed to 30cm drop jump 4 x 5
Power skips	3 x 10	No progression
Ankle hops	3 x 10	No progression
Double hurdle hops	3 x 5	Progressed to 4 x 5
Total foot contacts	75	85

increased reps performed. The one leg squat and one leg calf raise, both performed with barbell on the back, have the additional benefit of developing lateral pelvic stability and gluteus medius strength.

The strength session, completed twice a week, would be unlikely to lead to any significant muscle hypertrophy (increased mass) for two reasons:

- It is a very low volume routine, involving just four main leg exercises, with low repetitions of the two main barbell exercises;
- An endurance runner does so much running that the leg muscles will probably have little spare energy for building additional muscle. Body builders avoid endurance training at all costs so that all their spare energy can go into building muscle.

‘An endurance runner does so much running that the leg muscles will probably have little spare energy for building additional muscle’

Plyometric exercises were performed once a week, introduced with light volume initially (75 foot contacts) and progressed very gradually in order to avoid injury. Plyometrics are very valuable exercises for runners as they are specific to the running action in terms of both movement and velocity. Their benefits include increased recruitment of the fast twitch fibres and greater elastic energy return from the tendons.

It is worth noting here that strength training strengthens tendons as well as muscles. I like to think of weights and plyometrics as enhancing the whole ‘muscle tendon unit’, which explains how this kind of training can play the dual role of improving performance and reducing injury risks in endurance runners.

The whole of the soft tissue adapts to the training and becomes more able to deal with strain and repetitive eccentric contractions, so reducing the risk of injury. In addition, the tendon is able to store and release more elastic energy so that the Achilles and knee tendons can contribute greater mechanical power to running speed.

Pre-competition peaking phase. The main aim of this phase was to develop maximum power of the leg extensor muscles and maintain the strength endurance developed in the hamstrings, calf and core. The sessions described below were each performed once a week, with the core exercises from the previous phase also maintained on a twice-weekly basis.

These two sessions combine plyometrics and weights exercises into a single workout, mostly because of the athlete's desire to maximise recovery of the leg muscles. The benefits of the workouts were enhanced by using 'complexes' of weights and plyometrics exercises (*eg* front squat and hurdle hop in session 1 and one leg squat and speed bounds in session 2). Explosive strength exercises, like dynamic lunge drives and barbell squat jumps, were included to increase power, while the hamstring and calf exercises were retained from the previous phase for purposes of injury prevention.

Again, this kind of high-quality, low-volume explosive strength programme poses no risk of hypertrophy, given its low levels of repetitions. The main goal is to develop power with minimal fatigue.

Session 1	
Drop jumps 40cm	4 x 5
Front squat + hurdle hop	3 x 5 + 5
Swiss ball hamstrings hip lift	3 x 20 each leg
One leg barbell calf raise	3 x 15
Session 2	
Dynamic lunge drives	3 x 3
Barbell squat jumps	3 x 5 + 5
One leg squat + speed bounds	3 x 20 each leg
Swiss ball hamstrings hip lift	4 x 5

Competition maintenance phase. During the competitive season, when the athlete began racing seriously, his training volume and frequency changed again. The aim of this phase was to simply to maintain the level of power and general strength developed in the previous phases.

During this time, the athlete performed either session 1 or session 2 from the pre-competition phase *(see table above)* once a week, with no sessions performed within 5-6 days of a race.

The weights were reduced slightly during this phase to minimise fatigue while maintaining quality, and the core exercises were carried on as before.

The outcome of this programme was considered successful by the athlete in question, who increased his leg power (as measured by counter movement jump and drop jump performance) by 15% and suffered no significant soft tissue injuries during the training year, thus fulfilling both his training goals.

In addition, by focusing on a limited selection of exercises, using high quality and low volume training, he was able to complete all his running sessions and experienced no gains in muscle mass.

The 5k strength programme

The aims of strength training for this long-distance female runner were also to increase leg muscle/tendon power and reduce injury risk. But the training programme differed because she does not need – and probably can't manage to produce – very high levels of leg power.

Long distance runners need to be very powerful in relation to their own body weight, but not as powerful as sprinters, who are heavier and stronger. In addition, this athlete had a limited strength training history and so needed a lighter programme than the 800m runner to ensure there were no adverse consequences to strength training. Her programme was structured as follows:

The strength session *(see table below)* was used to develop general strength in the leg muscles and tendons to help reduce injury risks and increase resistance to fatigue. The barbell

Strength session – once weekly	
Barbell step-up (40cm box)	3 x 8, progressing weight lifted
Swiss ball hamstring hip lift	3 x 10, progressing to 3 x 20
Calf raise (machine)	3 x 8, progressing to 3 x 15
Standing hamstring hip extension (band)	3 x 10 each leg
Dumbbell press	3 x 10, progressing weight lifted
Dumbbell row	3 x 10, progressing weight lifted
+ Core exercises eg side plank, bridge etc	

step-up, involving the quadriceps and gluteals, was considered the main plank of this routine, and two hamstring exercises were selected as the athlete was particularly weak in this muscle group.

Upper body exercises were also included as she has very little upper body strength and felt that some gains in this area might help promote a more efficient arm action.

Overall, this programme, performed only once a week, is unlikely to result in hypertrophy for the same reasons stated above. An elite long distance runner, training twice a day, probably has very few spare calories available to build muscle. In addition, this low volume session, involving only six exercises once a week, was not enough to promote muscle mass and the athlete did not gain weight.

'An elite long distance runner, training twice a day, probably has very few calories available to build muscle'

The plyometric session *(see table below)* was used to promote leg power. Research has demonstrated that when a similar explosive strength/plyometric programme was added to a 5k runner's weekly programme, maximum speed and 5k performance improved by comparison with a control group who maintained a running-only programme (1).

Plyometric session – once week
1. High knee skip drill, 2 x 20 m
2. Knee pick up drill (using mini hurdles) 2 x 10 hurdles
3. Fast knees-up drill, 2 x 20 m
4. Power skips, 3 x 10
5. Mini hurdle hops, 3 x 8
6. Vertical jumps, 3 x 8
7. 4 x 30m sprints

This performance improvement was independent of any change in VO_2max or lactate threshold, and the researchers concluded that the plyometric exercises had improved the stiffness and/or energy return of the leg tendons so that the runner was more economical as well as more powerful. This study also shows how the neuromuscular system contributes to endurance performance and must not be ignored in the training programme.

Some of you may be surprised to see sprint drills and 30m sprints included in the plyometrics routine. For this athlete, the drills were there to promote sprint technique and served as a useful low impact warm-up before the plyometrics session.

Sprinting is a plyometric action

In fact, the 30m sprint was considered a plyometric exercise in its own right, as sprinting is essentially a plyometric action. The athlete aimed to accelerate as hard as she could during these sprints – a demanding exercise for long distance runners, who have limited acceleration.

The drills and sprints were seen, more specifically, as a means of boosting pace at the end of a race, which is crucial to success at international level. It is known that all members of the Ethiopian distance squad carry out drills and sprints on a weekly basis, and they have proven their ability to produce winning sprint finishes in international competition.

The strength session was usually performed on an easy running day, often the day after – but never the day before – an interval session. The plyometrics were usually performed immediately after a steady morning run, when the athlete was feeling warm but not too fatigued. Again, plyometrics were never performed on the day of – or day before – an interval session.

‘The drills and sprints were seen as a means of boosting pace at the end of a race, which is crucial to success at international level’

These timing provisions were there to ensure that the training was performed in a time-efficient manner, to maximise recovery, without compromising the quality of running training. For similar reasons, no strength or plyometrics session was performed within 5-7 days of a race, unless the race was not considered important and was being used only as a measure of fitness. The athlete ceased strength training two weeks before the major competition of the summer to ensure freshness for racing.

No changes in volume during the season were required for this particular athlete, but an athlete with a long strength training history would probably have been able to perform more work during a training session, reducing the volume as the season progressed.

The results of the programme were positive for the athlete, who succeeded in improving her jump power by around 15%.

The purpose of these two long-ish case histories is to show how strength training can most appropriately be added to an endurance runner's weekly routine. The aim of strength training – which includes both weights and plyometrics – is not to increase maximum strength or muscle mass but rather to boost leg muscle power (power being a different quality to strength), enhance elastic energy release from the tendons and promote general strength in the muscle tendon units and a stable core, with a view to preventing injuries.

A sensible approach, taking account of the volume of running training, is needed to ensure that the programme can be maintained on a long-term basis without compromising the running. I hope the examples above have illustrated how this can be achieved.

Remember, though, that these are individualised programmes for particular athletes I have been working with and that all athletes need their own customised programmes. Feel free to base your weights or plyometrics programmes on these examples, but make sure that any exercises you include are tailored to suit your particular needs and event.

Use these examples as a guide to the kind of training that is effective, not as a definitive strength training guide for endurance runners.

Raphael Brandon

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Weight training and endurance training – the perfect sports conditioning partnership?

Rather like Posh and Becks, weight training and endurance training appear to be two halves of a perfect sports conditioning marriage. But, as with any good relationship, there will always be the occasional conflict and element of discord. This article examines the pitfalls for this partnership and recommends ways to maximise its harmony.

Let's begin with the logical assumption that weight training benefits endurance athletes, by focusing on the sport of rowing. Rowing requires an anaerobic contribution of about 30% to the 2k Olympic race distance. In consequence, rowers often train their lactic anaerobic systems with high-intensity, short duration intervals (lasting from 30 seconds to five minutes), with very short – often 1:1 – recoveries. These workouts target slow and fast-twitch muscle fibres – the latter providing much of the power needed for these turbocharged efforts.

Logic says that weight training these fibres will be beneficial, especially when you consider that the actual rowing race is completed in about six minutes, using 200-240-plus strokes – an amount of 'repetitions' that could easily be accrued in a standard power (70-80% of 1 repetition maximum) weight-training workout, comprising 4x10 repetitions of six exercises.

However, logic does not always apply, and this type of weight training (and indeed other types) may actually offer little direct benefit to rowers when it comes to improving their endurance. Bell and associates looked at the effects of three different weight-training programmes on 18 varsity rowers during their winter training (1). One group performed 18-22 high-velocity, low-resistance repetitions, while another did low-velocity, high-resistance repetitions (6-8 reps) and a third did no resistance training at all. All resistance exercises were rowing-specific and were performed on variable-resistance hydraulic equipment four times a week for five weeks, while the subjects continued with their normal endurance rowing training.

Which group's rowing improved the most? When subjects were tested on a rowing ergometer the researchers found no difference between any of the groups in terms of peak power output or peak lactate levels. So the weight training apparently served no purpose. Similar findings emerged from a US study, when élite male weight-training rowers displayed no increase in VO_2max by comparison with a rowing-only group, who improved their VO_2max by up to 16% during pre-season training (2). So, it looks like our happy couple's relationship is not off to a very good start!

Before we start to consider why this might be, let's take a look at some more research from different sports. Tanaka looked at the effects of weight training on 24 experienced swimmers over 14 weeks of their competitive season (3). The swimmers were divided into two groups of 12, matched for stroke specialities and performance; one group performed weight training three days a week, alternating this with their swim workouts, while the other group did no weight training at all and just continued swimming. Both groups trained for eight weeks.

‘Are our weight-training-and-endurance couple buckling under the pressure of their ill-assorted union?’

Weights – both fixed and free – were selected for their swimming specificity, with the swimmers performing three sets of 8-12 repetitions on lat pull-downs, elbow extensions, bent arm flies, dips and chin-ups. The weights were progressively increased over the duration of the training period, with a tapering period two weeks before their major competition. The result? As with the rowing studies, weight training failed to improve performance, despite the fact that swimmers who combined resistance and swim training managed to boost their strength by 25-35%.

So are our weight-training-and-endurance couple buckling under the pressure of their ill-assorted union, while putting on a brave face and continuing to work together? It looks like divorce is on the cards, especially after a certain Mr Paavolainen's evidence is taken into account. He and his co-workers considered the effects of weight training and other power-training methods on the performance of cross-country skiers – long considered the ultimate aerobic athletes (4).

Seven skiers performed power weight-training exercises (at high velocity against a moderate-to-high loading) as well as plyometric (jumping-type) exercises for three weeks, while another group of eight skiers performed strength-endurance high-repetition training for the legs and arms. Both groups also continued with their normal endurance training. At the end of the study period, the researchers found no difference in measures of endurance capacity, such as VO_2max and anaerobic threshold, between the two groups. In short, the various weight and plyometric training sessions had not enhanced skiing performance power.

Our perfect weight-training-and-endurance couple seem doomed to disharmony and incompatibility. But could there be some mitigating circumstances? Tanaka introduced weight training into the competitive phase of his swimmers' training cycle – perhaps not the best time. It is possible that, at this stage, the swimmers' performances could have been impaired rather than improved by the added training load.

The relevance of maximum strength

Paavolainen's plyometric power training cross-country skiers did increase their ability to express peak power, although this is not much use to these athletes, whose prime requirement is a highly-developed aerobic system. It may be, as exercise scientist Saziorski suggests, that since cross-country skiing is an ultra-endurance sport, weight training has little direct relevance to performance in the first place (5). Saziorski believes that maximum strength is of little importance in sports with a maximum strength requirement of less than 30%.

The rowing findings are more difficult to explain, but there is a possible answer. It is argued that when an endurance athlete reaches a certain level of performance strength – which can be developed through their everyday CV training or with weights or other resistance training – further improvements in weights-based strength will not bring about further improvements in performance. Since the rowers in the above-mentioned studies were all performing at a high level already, it could be argued that they already had more than enough 'performance' strength, developed through years of correctly-executed rowing technique.

Shepard offers a very succinct explanation for why weight and endurance training can make for poor bedfellows(6). 'Some of the most important and influential factors that result from physical conditioning occur at the cellular level in the muscles, that is, the majority of training effects are peripheral,' he explains. 'The number and size of mitochondria, the amount of myoglobin, the amounts of ATP and CP that are stored, and the concentrations of key enzymes associated with particular energy systems are increased. Training is specific and selective of the types of muscle fibres used. That selectivity will determine the nature of training effects and the type of performance that is improved.'

Essentially what he is saying is that training different energy systems at the same time can produce a confused physiological state – the so-called 'interference effect'. How can pure high-power fast-twitch type IIb muscle fibre be expected to gain in size and power-generating capacity through weight training if it is being relentlessly bombarded in the same training phase – indeed the same workout – by extensive long, slow distance work or intense interval training? Training that, while bolstering its type I slow-twitch counterparts, also causes its type IIa cousins (which generate intermediate power) to defect to the slow endurance side? Depending on the training stimulus, all these muscle fibres can become orientated more towards endurance or power/speed.

So here's the million dollar question: is there any real benefit to be gained from weight training if you are an endurance athlete? To determine this for yourself, you need to look at the specific strength requirements of your sport. If you're a cross-country skier or marathon runner, weight training may not be relevant to improving your performance as you cannot construct a session in the gym that directly replicates what you'll go through in a race.

However, weight training used in combination with other types of resistance training should not be discarded: marathon runners, for example, should expect to improve their performance by improving their foot strike; they can achieve this through plyometric and running drills, and specific weights exercises like the split squat and lunge. The key for them – and for similar endurance athletes – is to construct a training programme that channels their resistance-training gains into strength that will improve their technical performance.

> *'Is there any real benefit to be gained from weight training if you are an endurance athlete?'*

Circuit training for endurance

Circuit resistance training (CRT) has been shown to offer a great deal to endurance athletes as it targets type I muscle fibre, can develop VO_2max and lactate threshold and will also have a limited effect on increasing strength. For best results, use a weight set at 50-60% of 1RM, since this seems least likely to interfere with the development of enhanced endurance capacity.

You may have noticed an apparent contradiction in that some of the studies quoted earlier did actually use CRT-style training, but to no effect in terms of improved endurance performance. This can be explained with reference to the training variables of order and recovery.

The studies by Tanaka and Paavolainen, for example, simply threw all the training ingredients together into the workout mix without taking order and recovery into account.

Taking training unit timing into consideration, Sporer *et al* looked at the effects of weight training on aerobic/anaerobic CV performance in 16 male collegiate athletes (7). The aim of the study was to see whether the type and intensity of aerobic training affected concurrent weight training after four, eight and 24 hours of recovery. One group performed steady state work at 70% of maximum heart rate, while the other performed 95-100% intervals with 40% MHR recoveries. Both groups were then subjected to 1RM maximum strength testing on bench press and leg press.

The researchers found that for both groups weight training gains were compromised by the endurance work unless adequate rest was allowed. More specifically, the participants' leg muscles were negatively affected by their aerobic training in the leg press test, although bench press performance was unimpaired. In consequence, they made the following recommendations for athletes performing concurrent training:

- If you must perform both workouts within a single day, allow at least eight hours between aerobic training and strength training;
- Lower-body strength training should not be performed on the same day as aerobic training.

‘It is almost beyond dispute that weights and resistance training exercises can protect against injury’

Expanding further on these suggestions, you could also consider developing strength in a specific training cycle, removed from your endurance training. This might be particularly helpful at the beginning of the training year, when you could gain most. Such a strategy could reduce the interference effect and provide the optimum conditions for developing stronger, fatigue-resistant muscles. Periodic returns to weight training micro-cycles could then be used to ‘top-up’ strength levels.

Under such conditions, Canadian researchers found that a group of rowers who strength trained for five weeks before five weeks of endurance training were rewarded by a 16% increase in VO_2max and a 27% improvement in lactate tolerance (8). By contrast, rowers who trained in the reverse order boosted VO_2max by only 7% and showed no improvement in lactate tolerance. The explanation? The strength-before-endurance group gained quality rowing muscle without compromise, and were able to use it to row harder and faster, with greater fatigue-resistance, during endurance training. Working out for weight training gains alone may have enabled them to push beyond their ‘normal’ previously conditioned rowing power levels. Finally, if you are an endurance athlete you should use weight training to avoid injury, since it is almost beyond dispute that weights and resistance training exercises can protect against injury by strengthening soft tissue.

John Shepherd

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How elite Kenyan runners point the way to peak 10k performance

The dominance of distance running by East Africans is a well-established phenomenon and there has been much speculation by coaches and pundits about the reasons for this superiority, which has been variously attributed to genetics, sociological factors and altitudinous environment. Recently, French researchers added to the growing literature on East Africans with the first well-conducted study of the physiology and training patterns of Kenyan athletes (1).

The team, led by famous running physiologist Veronique Billat, analysed the training diaries and physiological profiles of 13 male and six female Kenyan 10k runners. The major significance of this study is that the subjects were elite athletes competing on the international circuit. A problem with many previous physiological studies has been that the athletes tested were sub-elite, not training as hard or performing as highly as world-class athletes, and so making it difficult to draw accurate conclusions about what contributes to elite performance. What Billat's study manages to do is highlight some small but significant differences between elite athletes with distinct training habits.

The study focused on training time spent at three discrete physiological paces:

- vLT (velocity at lactate threshold). Billat defines vLT as the pace at which the blood lactate concentration rises by 1 mmol per litre to between 3.5 and 5mmol/L. This is higher than at a steady running pace, when lactate levels would be stable between 2 and 3 mmol/L. Nevertheless, vLT is maintainable, since lactate levels do not escalate rapidly, causing fatigue.

Physiologists and running coaches have identified vLT as the pace conferring optimal aerobic fitness benefit. Training at this pace leads to an increase in vLT, enabling people to run faster without boosting blood lactate levels. Training at vLT is also known as tempo running, and normal run duration is between 30 and 70 minutes;

- vVO_2max (velocity at maximal oxygen uptake). This is a very intense pace that can be maintained for only about six minutes, with blood lactate levels around 8-10 mmol/L. Previous research by Billat has shown that vVO_2max is associated with superior 10k performance and that training at this pace improves both VO_2max and the economy required to maintain pace at this intensity. Training at vVO_2max takes the form of interval workouts – *eg* 20 x 400m or 6 x 800m;
- vD50, the intermediate pace between vLT and vVO_2max, which is, as this study confirms, very close to 10k race pace. Training at vD50 involves long repetition interval sessions – *eg* 4 x 2,000m - with short recoveries.

> *'Physiologists and running coaches have identified vLT as the pace conferring optimal aerobic fitness benefit'*

The Kenyan athletes in this study can be split into three groups, two male and one female, each with slightly different training habits in terms of kilometres run at these three different paces, as shown in table 1, below.

Table 1: Analysis of group training diaries

	M1	M2	F
Total weekly distance (k)	158	174	127
vLT weekly distance (k)	10.9 (6.9%)	25.4 (14.4%)	0
vD50 weekly distance (k)	6.8 (4.3%)	2.4 (1.4%)	10 (7.9%)
vVO_2max (or above) weekly distance (k)	7.8 (5.0%)	0	4.8 (3.8%)

All other weekly distance not specified in the table was run at less than vLT, *eg* 90-minute runs at an easy pace.

M1 was one of two male groups, whose members performed faster-paced interval sessions, with a significant proportion of weekly kilometres run at vD50 and vVO_2max pace. By contrast, members of the second male group (M2) focused on training at vLT, with no interval sessions at vVO_2max and a greater overall weekly training distance. The F (female) group completed significantly shorter weekly distances than the men, but included fast-paced intervals sessions at vD50 and vVO_2max pace.

The physiological profiles of the athletes in each group are summarised in table 2, below. These profiles were determined by means of a step test performed on a running track, at ambient temperatures of 19-22°C and wind speed less than 2 metres per second. The athletes started running at a pace below vLT (F at 14 kph and M1 and M2 at 16 kph) and continued at this pace for three minutes. After 30 seconds' rest, when blood lactate samples were taken, the athletes completed another three-minute run 1kph faster, and so on until exhaustion.

Table 2: Physiological profiles and 10k pbs

	M1	M2	F
Weight (kg)	53.8	56.7	47.8
10 km PB (mins)	28:15	28:54	32:22
10k velocity (kph)	21.2	20.8	18.4
VO_2max (ml/kg/min)	78.4	74.7	68.6
vVO_2max (kph)	22.7	21.6	19.9
vD50 (kph)	21.4	20.8	18.3
VLT (kph)	20.2	19.9	16.8

Oxygen consumption was measured by means of a portable gas analysis system fitted to each athlete, and vVO_2max was taken as the pace at which oxygen consumption did not go up.

It is evident from the table that there were differences between the two male groups in terms of physiological profile and 10k personal best, although it is not possible to say for certain that these differences were due to variations in training. The differences between the male and female groups were assumed to be largely gender related.

M1 athletes were significantly faster than M2 athletes over 10k, a feature that is associated with superior VO$_2$max, vVO$_2$max and vD50. Statistical analysis showed that the superior vVO$_2$max of the M1 athletes was related to their greater weekly distance at vVO$_2$max and also that vD50 and vVO$_2$max were the two biggest predictors of 10k performance.

This important research confirms Billat's previous findings of the importance of training at vVO$_2$max and the association of this intense pace with elite 10k performance. It would seem that for 10k racing vVO$_2$max has a higher currency than vLT, probably because 10k pace is at greater than vLT pace – *ie* at vD50.

Obviously, pushing up your vVO$_2$max will automatically increase your vD50, this being an intermediate point between vLT and vVO$_2$max. Also, by focusing on vD50 and vVO$_2$max you learn to produce the force required to boost economy at race pace, and speed.

Winning in modern international distance racing seems to require a burst of speed at the end of the race, just when you would expect to be slowing down. According to the venerable South African running physiologist Professor Tim Noakes, aerobic training alone cannot prepare distance runners for this feat; instead, training needs to focus on developing the neuromuscular system to produce the running speed required.

> *‘Winning in modern international distance racing seems to require a burst of speed just when you would expect to be slowing down’*

Evidence to support Noakes' theory was found in the current French study. A number of athletes in the M2 group were unable to reach a true VO$_2$max during the step test, as they fatigued too quickly at the fastest running pace. This was probably due to their lack of high-speed training and a consequent failure to produce the muscular force required to run the highest speeds in the test. Clearly, their performance was not limited by oxygen consumption, as this had not yet reached plateau. Thus it was not their cardiovascular systems that failed them.

The lesson here is that to run at your target race pace – and faster – you have to train at these paces rather than simply training your aerobic system. The M2 group ran a greater weekly distance and focussed nearly all of their higher intensity training at vLT, yet they performed worse over 10k than the M1 group, whose aerobic training was relatively neglected.

Nevertheless, the M1 group's vLT did not suffer from this lack of attention, as it was just as high as that of the M2 group. If you glance back at Table 1 you will notice that M1 and M2 completed a similar number of high intensity weekly kilometres – around 27k per week. The key difference was that M1 split the high intensity distance fairly evenly between vLT, vD50 and vVO_2max, while M2 performed almost all of their high intensity training at vLT.

Training at all three paces

It does seem to make physiological sense to train at all three of these paces. vLT training will optimise your aerobic system, vD50 training will help you to be economical at 10k pace, and training at vVO_2max and faster will help you to generate the force required to speed up at the end of races and develop a greater VO_2max capacity.

Interestingly, the Kenyan women in the study trained in a similar fashion to the M1 group but did no training at all vLT. It is possible that their vD50, and therefore their 10k pace, could be boosted by adding in sessions at vLT.

The evidence of this study is that elite Kenyan athletes have very impressive physiological profiles, but previous research suggests that their Caucasian counterparts are capable of developing in a similar way.

In a commentary accompanying the published research, Professor Noakes argues that the 'X factor' of performance is the ability of the brain to produce the force required to run at a given pace required, with the cardiovascular system assuming a secondary importance. The fact that the athletes from the slow training group fatigued at high running speeds before reaching their maximum oxygen uptake during the step test would seem to support this theory.

As that great breaker of barriers Sir Roger Bannister wrote in 1956: ‘Though physiology may indicate respiratory and cardiovascular limits to muscular effort, psychological and other factors beyond the ken of physiology set the razor’s edge of defeat or victory and determine how closely the athlete approaches the absolute limits of performance.’

Raphael Brandon

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Stereotype threat: an alternative explanation for the East African dominance of distance running

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Researchers have long speculated on the factors that contribute to making an elite athlete. When a particular group appears to dominate a given domain, even more speculation and interest is generated. Current examples from sport include the American dominance of basketball and the Northern European dominance of Nordic skiing. An example that has garnered much attention (1,2) is East African dominance of middle- and long-distance running. Although several empirically based positions have been advanced to explain the interindividual variation in performance (3,4), the dominance of black athletes in certain sports has been commonly attributed to factors such as social Darwinism – that is, the hardships of slavery resulted in a degree of genetic selection (5) – and environmental determinism – that is, physiological adaptations associated with living under certain environmental conditions (1).

Hamilton (6) examined empirical evidence for a range of influences that may contribute to East African running dominance, including environmental, social, psychological, and physiological variables. After examining research from various disciplines, he concluded that there was no clear explanation for the East African supremacy. However, Hamilton argued that psychological factors may perpetuate this dominance by attributing differences between African and white running performances to stable external factors, thereby disempowering white runners and empowering East African runners. Regardless of the possible existence of physiological advantages in East African runners, belief that such differences exist creates a psychological atmosphere that can have significant consequences on performance.

Stereotype threat

Recent research in psychology has unveiled insights that are particularly relevant to this debate. It is distinctly possible that what we believe to be true about our genetic make-up may be more important than what is actually true.

Stone *et al*(7) gave black and white students a laboratory golf task that ostensibly measured 'natural athletic ability', 'sport intelligence', or 'sport psychology', depending on how the test was presented. Nothing changed in the test itself, just the perception of what the test measured. Both black and white students scored equally well on the sport psychology control condition. However, black participants outperformed white ones when the task was framed as a test of natural athletic ability, whereas white participants outperformed black ones when the task was framed as a test of sport intelligence. This phenomenon is referred to as stereotype threat and may be of help in explaining the dominance of certain sports by specific groups. Although scientific inquiry into genetic differences between races remains unresolved, previous research suggests that belief in such differences has a large impact on performance. Steele and Aronson (8) introduced stereotype threat as an explanation for the lower scores of black American students on standardised intelligence tests. The authors had been perplexed by the persistent gap in scores between blacks and whites, which endured even if black students came from well educated families of middle-class standing. However, Steele and Aronson found that black students scored just as well as whites on standard intelligence tests when the tests were presented as diagnostic tools that did not measure intellectual capacities. They determined that it was not the test itself, rather the situational pressure surrounding the test, that resulted in poorer scores. Performance decreased when black students were confronted with the possibility of confirming a widespread stereotype about low intelligence in blacks.

Significantly, stereotype threat affects the academic vanguard more than it does the weaker students. A person has to care about a domain in order to be disturbed by the prospect of being stereotyped in it. Good students are generally invested in and have identified with the domain and thus are more prone to the situational pressure that is stereotype threat. Students who did not identify with the domain were remarkably unaffected. Weaker students reduced cognitive effort as soon as the test became challenging, resulting in poor performance, regardless of whether they were under stereotype threat or not(9). Therein lies another key to stereotype threat – the test must be challenging. It is only when one gets to a difficult section, and the possibility arises of confirming the negative stereotype, that sufficient stress arises to impair performance.

‘It is distinctly possible that what we believe to be true about our genetic make-up may be more important than what is actually true’

Oddly enough, a person does not even have to believe the stereotype to be affected by it. Awareness, even at a subconscious level, appears to be sufficient. For example, Levy(10) primed [senior citizens] using subliminal messages and then gave them a memory test. Those who had been primed with negative words associated with old age, such as senile or forgetful, performed worse than seniors primed with positive words like wise and sage.

Spencer *et al*(11) found that stereotype threat was equally applicable to women and maths skills. If women are reminded of the stereotype that they are inferior to men in mathematical ability, their test scores decrease. If the same test is reframed so that women believe it is simply a research tool, they score just as well as men. Current findings indicate that anywhere a stereotype exists, stereotype threat can be invoked and performance depressed. In a related study, white men, selected on the basis of their strong maths skills, performed worse when they were compared with Asian men, a group traditionally thought to excel at maths. A control group not subjected to stereotype threat suffered no such performance decrease (12).

The sporting field also contains its share of stereotypes, particularly when it comes to black-white differences. The perception of the athletic superiority of black people is widespread, with the media contributing substantially to such thinking (2,5). Stone *et al* (13) examined popular perceptions of racial stereotypes by having participants evaluate the abilities of a male basketball player based on a radio broadcast of a college game. Even though participants listened to the same broadcast, they were more likely to attribute talent and natural athletic ability to the player if they thought he was black and were more likely to attribute hard work and sport intelligence to the player if they believed he was white.

‘The widespread societal belief in the athletic superiority of blacks is actually a relatively recent phenomenon’

This widespread societal belief in the athletic superiority of blacks is actually a relatively recent phenomenon. Hoberman (14) notes that during colonial rule blacks were considered inferior sportsmen. In fact, at the dawn of the 20th century there was concern even among black scholars at the lack of physicality of the black race (14). However, the tables have turned considerably in the past hundred years. Impressive accomplishments from black athletes during the first decade of the 1900s – for example, Marshall Taylor and Jack Johnson – followed by the record-breaking performances of black sprinters like Jesse Owens provided the basis for the belief that black athletic superiority is genetic in origin (15). The current dominance of black athletes in a number of high-profile sports has certainly done nothing to dispel this belief. Furthermore, as Hamilton suggests (6), the psychological edge this belief gives black athletes may be the key to maintaining that superiority. Indeed, in stereotype threat we see evidence of the power of such beliefs.

Short-term effects

The poorer performance associated with stereotype threat has been attributed to the anxiety and distress caused by association with a negative stereotype. Blascovich *et al* (16) examined the effects of stereotype threat on blood pressure in African Americans. They found that groups placed under stereotype threat displayed larger increases in mean arterial blood pressure (a measure of somatic anxiety) and performed more poorly on difficult test items than African Americans not under stereotype threat.

In typical models of anxiety(17), the occurrence of a stressor, in this case stereotype threat, creates a state of anxiety *(see figure 1, below)*. State anxiety(18) is manifested either somatically through physical responses, such as sweating and increased respiration, or cognitively through worry or concentration disruption. Each of these manifestations has been linked to negative effects on physical performance(19). Further, whereas a certain amount of physical arousal has been seen as beneficial for sport performance (*cf* the inverted U hypothesis)(20), certain research (21) suggests that any amount of cognitive anxiety is detrimental to performance.

Moreover, athletes performing at elite levels of competition normally adopt a telic, or serious, goal-oriented motivational state. To the elite athlete, performing well is an important outcome. However, researchers(22,23) suggest that adopting a

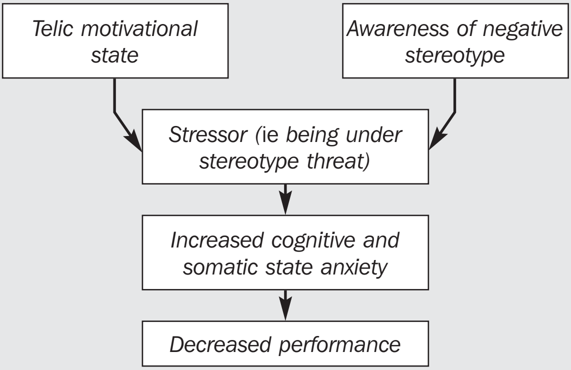

Figure 1: proposed model of stereotype threat effects on sport performance

motivational state that is telic is more highly affected by anxiety than adopting a paratelic – that is, playful, non-serious – motivational state.

Long-term effects

Perhaps the most damaging effects of stereotype threat are long-term, such as feelings of dissatisfaction and ultimately dropout from sport. The benefits of long-term involvement in physical activity are well known. They include increases in physical competence and associated increases in self-esteem (24). However, Steele (25) postulated that, in chronic situations of stereotype threat, individuals become pressured to 'disidentify' with the domain to preserve feelings of self-worth. Disidentification involves a reconceptualisation of one's self-image to remove the value associated with a domain, thereby reducing the impact of negative performance. Stone (26) recently replicated these results in a sport context.

Disidentification, although useful for maintaining self-image, can undermine the motivation required for long-term involvement in an activity. Sustained motivation is dependent on feelings of achievement and accomplishment (27). In a related study, Stone (26) found that stereotype threat was related to the quality of practice performed by participants executing a golf task. Specifically, white athletes who felt they were being examined for natural athletic ability showed less practice effort than white athletes who were not under the threat of confirming racially based stereotypes – that is, poor white athleticism. In addition, stereotype threat only affected athletes for whom sport was an important component of their self concept. Participants who were disconnected from the outcome of the task performed at a level no different from control subjects.

Stone hypothesised that athletes concerned with confirming a racially based stereotype 'self-handicap' – that is, perform less effortful practice – to create ambiguity about the cause of a poor performance. Athletes proactively respond to an anticipated mediocre outcome by withdrawing practice effort, thereby avoiding the confirmation of a stereotype about poor natural athletic ability in white athletes. Although longitudinal studies of the effects of these actions have not been performed, it seems reasonable that decreased practice effort over time would undermine skill acquisition and limit the physiological adaptations necessary for performance at the highest levels of sport competition.

Effects on young athletes

The extent to which athletes choose or opt out of sports based on perceived genetic suitability is an area worthy of future study. Just as negative stereotypes can lead women away from maths-based careers in finance or engineering, there is evidence to suggest that athletes may be choosing their sports based on athletic stereotypes. Coakley (28) notes that young athletes have internalised these stereotypes and are choosing sport participation accordingly. He speculates that this is the reason why white running times in certain events have actually decreased over the past few years; whites are opting out of some sports based on perceived genetic inferiority.

‘Whites are opting out of some sports based on perceived genetic inferiority’

Coaches and support staff need to be aware of ways of dealing with situations involving stereotype threat. Steele (25) presented methods for overcoming stereotype threat in academic settings, several of which are also useful for performance in the athletic environment. Steele (9) theorised that underperformance appeared to be rooted less in self doubt than in social mistrust. Therefore niceness and reassurance on the part of the teachers was not enough. Steele found that emphasising high standards was the key to gaining social trust. For criticism to be accepted across the racial divide in an academic setting, feedback had to be given with the emphasis on high standards, conveyed with the belief that the student could achieve those standards.

Although this research has yet to be replicated in an athletic domain, it provides clear guidance for coaches working in multiracial environments. When dealing with athletes, coaches should consistently emphasise high standards of performance for all, irrespective of race. Evidence suggests in order for stereotype threat to influence performance, the stereotype must be made salient in the particular context, Accordingly, coaches should avoid off-hand comments or jokes suggesting, for example, 'white men can't jump' or 'blacks are better runners', especially before competition. In addition, coaches and trainers should show clear optimism in their athlete's abilities. All attempts should be made to increase the athlete's feelings of self-efficacy – that is, the athletes' beliefs in their abilities to accomplish desired courses of action – before competition. Moreover, these feelings must be reinforced after the event regardless of the results to ensure that stereotype threat has a limited role in future competitions.

Clearly, coaches should also stress the equivocal research findings on race and athletic performance. One method of reducing the negative consequences associated with stereotype threat is by minimising the legitimacy of the stereotype. If athletes are educated as to the lack of consistent findings for racial dominance in sport, the power of the stereotype may be effectively limited.

Research examining the role of stereotype threat in elite levels of performance is virtually non-existent. As a result, the suggestions presented in this paper, although based on strong research with non-elite samples, remain speculative. Future research should consider the role of stereotype threat as a reason for performance differences in racially dominated sports such as middle- and long-distance running. Without indisputable evidence indicating the genetic advantages associated with a specific racial group, researchers should continue to examine alternative explanations for the apparent dominance of one group over another in sport.

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Should distance runners concentrate on their bodily sensations, or try to think of something else?

Distance runners and their coaches recognise the importance of developing an aerobic base and then implementing progressive overload training in 'safe doses' in order to allow the necessary adaptations to occur. Those working in sports medicine, however, acknowledge that problems can arise when the overload principle is applied too rapidly and the loads exceed the athletes' capabilities. This might include overtraining and running too many miles per week, or too much work conducted on hard surfaces. These precursors to injury are quite obvious, although when athletes become so focused on their goals the path towards injury may be recognized only retrospectively.

In this article I will concentrate on runners and the 'attentional strategies' that are used by the recreational and the elite during training and competition. Research on runners has identified two important attentional strategies that are commonly used and, interestingly, found them to be linked with injury rates.

Association or dissociation?

A groundbreaking American study of elite and college distance runners (1) that was mainly concerned with the psychological profiles of athletes triggered a great deal of research by sport and exercise psychologists. This was because of the different types of attentional strategy used by the two groups. The elite runners tended to use a strategy called 'association', which involves monitoring sensory inputs and focusing attention internally on bodily sensations such as muscular strain, breathing *etc* in order to set an appropriate pace and potentially avoid pain.

By contrast, the non-elite runners were more likely to try to direct attention away from bodily physiological signals by distracting themselves. Although many different dissociation strategies exist, the idea is essentially to shift attentional focus from an internal to an external perspective. Dissociation can also happen at an internal level: for example, an athlete may complete a training run while listening to music on a personal stereo system. The music can capture attention and help distract it from inner feelings, such as pain and discomfort.

Following the initial research findings, psychologists have spent many hours attempting to discover whether association is related to higher levels of performance and, as such, is a better strategy for distance runners to use. Although research results have been mixed, the current general consensus is that:

1. Association is related to faster running times than dissociation;
2. Regardless of level of performance, it appears that runners use more association in competition and more dissociation in training (usually conducted at a slower pace);
3. Elite runners seem to have flexible attentional strategies that allow them to change focus during races as required (2). For a more detailed examination of the performance consequences of cognitive strategy, I refer readers to one of my previous articles in *Peak Performance* (3).

Dissociation, pain and injury

Considerable evidence exists to link dissociation strategies with increased pain tolerance during endurance tasks. Essentially, theorists suggest that by attending to an external stimulus, our limited attentional channels become flooded with this information and consequently physiological sensations can be blocked-out temporarily (4). In support of this, many experimental studies that have asked participants for their ratings of perceived exertion (how hard the exercise feels) during sub maximal exercise trials have shown that, at given intensities, lower ratings are found when participants dissociate.

However, since dissociation apparently involves blocking out potentially important warning signals (physical pain) some researchers have suggested it is a risky strategy that could increase the chances of sustaining an injury. In one study, the authors reported on a runner who had sustained fractures to both fibulas and suggested that this could have been avoided if the athlete had not tried to dissociate from the pain (1). Unfortunately, though, such speculation does little to advance our scientific understanding of any relationship between dissociation and injury. Clearly further research is warranted.

Although relatively few research studies have been conducted, there is little support for the notion that dissociation is related to injury. One study found that dissociation scores in both marathon runs and in training did not correlate with history of running-related injuries (5). In contrast to expectations, four marathon runners who stopped running during the race due to injury were actually using association in the miles immediately prior to getting hurt. In two follow-up investigations, no relationship was found between injury rate and dissociation strategies, although injury prevalence was greater in those who ran more races and were more competitive (6,7).

‘dissociation is a limited pain reliever that is most effective in mild and moderately painful situations’

Motivation rather than pain relief

Some elite runners do appear to use dissociation some of the time, but current research involving marathon runners suggests this is safe and unrelated to injury (2). It has been argued that the type of cognitive strategy used has little to do with pain relief and is more closely linked with motivation. Take the example of elite marathon runners who apparently use more association in competitive runs than in training. In competition, runners will be pushing themselves towards the upper limits of endurance and are more likely to experience pain. If dissociation is used for pain relief and blocking out aversive stimuli, one might have expected greater use of this strategy in competitions, but the opposite appears to be true.

In fact, evidence suggests that dissociation is a limited pain reliever that is most effective in mild and moderately painful situations. It seems that when physiological (pain-related) inputs begin to increase towards higher intensities, they demand attention and cause a shift from an external to an internal perspective. Simply stated, although you may temporarily 'switch-off' from pain, as soon as it exceeds a specific threshold (high intensity work) dissociation strategies are no use.

Association, pain and injury

Careful examination of early research suggests that elite marathon runners were well aware of the pain (in fact they associated to it) but chose to continue running (2). This may well be a sign of competitiveness but, interestingly, it has been implicated in relation to injury. Perhaps of greatest significance is one study that assessed attentional strategy and then evaluated its relation to injury after a four-month period (7). Importantly, after taking account of such potentially confounding factors as running addiction, competitive and goal-oriented motivation, history of injury, miles and days of running per week, and number of races and marathons, association still predicted injury while dissociation was unrelated to it.

> *'association, if correctly implemented, can allow runners to ride the thin line between pushing hard and overdoing it'*

Runners may use associative strategies by redefining incoming physiological inputs as a coping strategy, expecting the sensations and focusing directly on them, stripping away the emotional content – a technique which can render the state less aversive. This tough-minded approach can allow the runner to continue running through pain, but the downside would appear to be an increased risk of injury. This finding bolsters previous research that has also linked association with injury rates (8).

Summary and conclusions

The attentional strategies employed by long-distance runners have important implications not only for performance but also for injury risk. Although runners may shift attention during races and training between body monitoring (association) and external / distracting focus (dissociation), the type of focus used does seem to be related to injury, even when other important variables are taken into account. Results suggest that, despite past concerns, dissociation is unrelated to injury while associative strategies appear to predict injury.

The reasons for this are at present unclear, although some researchers suggest it is due to redefining painful stimuli in non-emotional ways and choosing to associate with it, expect it, and thereby reduce negative emotional arousal. Ultimately, the runner decides to continue running in a situation when slowing or stopping would appear to be more sensible.

Further research is needed to confirm these initial findings and allow for greater understanding of the responsible mechanisms. Such strategies may well conform to the 'no pain, no gain' philosophy. The process of changing the focus and behaviours of some runners to reduce injury risks is likely to be challenging, given the importance placed on goal attainment, winning and the links between association and faster running times. The use of dissociation in training has been recommended to avoid compromising safety(2), but association, if correctly implemented, can allow runners to ride the thin line between pushing hard and overdoing it, as long as they listen to their bodies and interpret warning signals correctly. Associating with pain might reduce the responsiveness to warning signals and increase the likelihood of injury.

Lee Crust

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Is exercise-induced cardiac fatigue caused by damage to the heart muscle?

Regular reports of sudden deaths from heart disease during or immediately after prolonged endurance events help to point home the message that the risks of strenuous endurance exercise should not be taken lightly, and that both caution and common sense are needed when training for these types of events.

But before you take fright and swap your trainers for slippers, it is worth noting that the majority of sudden cardiac deaths during exercise occur in athletes with existing cardiovascular disease. In young athletes (under 35), sudden cardiac death is caused mainly by inherited structural and functional abnormalities, while in the over-35s it can be attributed primarily to coronary artery disease (1). Both of these conditions can be diagnosed through screening.

Rather than focusing on sudden cardiac death and unhealthy hearts, the purpose of this article is to inform readers about recent research findings on the effects of prolonged exercise on healthy hearts. We will take a look at current evidence on exercise-induced cardiac fatigue (EICF) and exercise-induced cardiac damage (EICD), along with their clinical implications, and finally home in on what it all means for you as an athlete.

EICF, defined as a reduction in cardiac function following prolonged strenuous exercise, is not a new concept. In a study carried out in the 1960s, athletes were found to exhibit a significant decrease in stroke volume (the amount of blood pumped out by the heart in a single beat) following a bout of prolonged exercise (2). This established a possible link between exhaustive exercise and the potential for a decrease in cardiac function. This is perfectly logical: after all, if skeletal muscle fatigues after a period of extended exercise, why not cardiac muscle too? However, the crucial difference is that the cardiac muscle has the essential job of supplying blood to vital organs and, unlike skeletal muscle, cannot simply 'take a break' during or following prolonged exercise.

Evidence for EICF has come from a number of studies examining cardiac function after prolonged exercise. Decreases in both systolic and diastolic function (blood pressure during and between heart beats) have been reported in ultra-endurance athletes immediately following half and full Ironman triathlons (3,4). More recently, EICF was demonstrated in athletes after the two-day Lowe Alpine Mountain marathon (5). In studies where follow-up assessments of cardiac function have been performed 1-2 days after a race, normal cardiac function has been restored, suggesting that EICF is likely to be a transient phenomenon (3,4).

'There is compelling evidence that cardiac fatigue occurs following a wide range of exercise durations and intensities'

The majority of endurance athletes, however, are highly unlikely to undertake such extreme competition. So what is the relevance of these studies to the general athletic population?

Well, the findings observed following ultra-endurance exercise have been replicated in experiments using less well-trained individuals covering shorter exercise distances. EICF has been demonstrated in healthy subjects following a 20k run (6) and a 60-minute cycle ride (7). It is therefore possible that EICF may affect mere mortals as well as the super-heroes taking part in ultra-endurance events.

It is important to note that the evidence is not beyond doubt since other studies have failed to demonstrate EICF either following (8) or during (9) similar bouts of prolonged exercise. Nevertheless, on balance there is compelling evidence to suggest that EICF does exist and that it occurs following a wide range of exercise durations and intensities in both trained and untrained subjects.

It is worth noting, though, that there is no evidence to support the existence of EICF following periods of intense brief exercise. Indeed, if anything, short duration exercise actually enhances cardiac function in the short-term.

In studies of relatively short periods of endurance exercise (50-150 minutes), EICF has not always been observed. As a result, it has been suggested that exercise duration may be an important factor in determining the onset of EICF, although the existence of a critical 'threshold' has not been established. Other factors, such as temperature and humidity, altitude, hydration status, gender and age, may also be significant, and differences in these variables may account for some of the conflicting findings in the current literature.

There is extensive evidence to support the existence of EICF, but what is actually causing the reduction in cardiac performance? By analogy with the response of skeletal muscle to prolonged strenuous exercise, which is known to generate significant but reparable tissue damage, researchers hypothesised that myocardial damage might be the underlying mechanism in EICF.

New tests for EICD

Testing this hypothesis by obtaining samples of cardiac muscle tissue from athletes would be difficult, impractical and downright unethical. Fortunately, though, highly-sensitive and specific tests to detect blood-borne markers of myocardial cell damage have been developed, and these offer a quick and reliable method of assessing the extent of EICD. Cardiac troponins I and T are regulatory proteins which form part of the cardiac contractile apparatus. Following damage to the cardiac muscle tissue, these troponins are released into the circulation, with the amount released corresponding to the severity of the damage (10).

Evidence of troponin release following prolonged endurance exercise has been reported by a number of investigators (11, 12), although some have failed to find it (13). These inconsistencies may be attributed to some of the confounding variables (climate, gender, age etc) referred to above.

Most of the studies examining EICD have used highly fit individuals who are accustomed to performing extraordinary volumes of endurance exercise in extreme environments. So how likely is it that a person of good physical fitness will exhibit cardiac damage over shorter distances, such as a marathon? The latest data suggests that elevated cardiac troponins (reflecting minimal cardiac damage) are evident even at this level. On completion of the London Marathon, the majority of a sample of recreational runners demonstrated cardiac troponin T values above the upper reference limit for a normal population, although these values were below the level expected after an acute myocardial infarction (heart attack) (14).

The clinical cut-off for diagnosis of myocardial infarction using cardiac troponin T has been established at 0.1 micrograms per litre, with any values above this level indicating the presence of major cardiac injury(15). Since the increases in cardiac troponin T which have been reported following strenuous endurance exercise are substantially lower than those observed after myocardial infarction, and often do not exceed the clinical cut-off, cardiac damage, while present, is likely to be minimal.

‘It is not possible to confirm a link between cardiac fatigue and cardiac damage at present, although research is continuing’

So should athletes be worried about EICD? The current evidence requires careful interpretation, and there are a couple of factors to consider. First, troponin release may be lower in highly trained athletes than in untrained individuals, suggesting that EICD may be part of the normal cardiac adaptation to endurance exercise; secondly, in studies where follow-up samples have been obtained 24-48 hours after exercise, it has been demonstrated that elevated cardiac troponin T levels return rapidly to baseline. This suggests that EICD is temporary, by contrast with myocardial infarction, which results in irreversible damage and, ultimately, cell death (necrosis).

Cardiac necrosis is characterised by a continuous release of cardiac troponins, which originate from the breakdown of the contractile apparatus in the muscle tissue. Cardiac troponin T levels remain elevated for at least seven days after a heart attack, which is much longer than after prolonged exercise. It is probable that these post-exercise elevations are caused by membrane damage of the cardiac cells, resulting in a release of troponin from the cell interior, not by breakdown or necrosis of the entire cell.

Now let's return to the question whether EICD underpins EICF. Studies have shown simultaneous exercise-induced cardiac damage and fatigue following prolonged exercise (9,10), but only limited correlation between these two phenomena has been established. It is not, therefore, possible to confirm a link between cardiac fatigue and cardiac damage at present, although research work is continuing in this area.

In summary, the investigation of EICF and EICD is an important area in which more research is needed to provide a better understanding of the response of the heart to prolonged exercise. Although it is clear that EICF exists, alterations in cardiac function have been shown to be transient in nature, and any cardiac damage that may occur is likely to be minimal and reversible. Thus, there need be no panic about undertaking regular endurance training which will, in fact, ultimately benefit the heart and reduce the risk of major heart disease in the long-term.

However, it is pertinent to remind people embarking on intensive training programmes (especially sedentary older people) that it is advisable to undergo a full cardiovascular screening and to take a sensible approach towards an exercise programme. Progressively building up the number of exercise sessions per week and gradually increasing duration and intensity with time is the best way to improve fitness and cardiovascular health while preventing undue strain on the heart.

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WHAT THE SCIENTISTS SAY

Reports on recent endurance-related studies by Isabel Walker and Nick Grantham

Why long, slow training runs may be best after all

For some time now, experts have been downgrading the value of long slow workouts for endurance runners in favour of briefer bouts of high intensity exercise.

But now a Spanish study, which followed eight well-trained sub-elite endurance runners during the six-month lead-up to their national cross-country championships, has thrown that wisdom into doubt.

The researchers found that the runners spent most of their training time at low intensities (below 60% VO_2max). But they also found evidence to suggest that total training time spent at low intensities was associated with improved performance in highly intense endurance events.

The runners' heart rates were continuously recorded, using a technique called telemetry, during each training session between August and February leading up to the championships, where they competed either in the short race (4.175k) or the long race (10.130k).

The researchers quantified total cumulative time spent by each runner in zone 1 (low-intensity), zone 2 (moderate intensity – 60-85% VO_2max) and zone 3 (high intensity – above 85% VO_2max) and then related these to final race performance. Their two key findings were:

- That these regional/national class endurance runners spent most (71%) of their training time in zone 1 and a mere 8% in zone 3;
- That total training time spent in zone 1 was linked with improved performance time during both races, particularly the long one.

'Our findings suggest,' the researchers conclude, 'that total training time spent at low intensities might be associated with improved performance during highly intense endurance events, at least if the event duration is [around] 35 minutes. Interventional studies are needed to corroborate our findings.'

They cannot easily explain these unexpected results but suggest that athletes might engage in a form of 'pacing' that occurs over a very long period of time. 'Just as athletes must distribute their energetic resources within a competition… it appears that they must also perform a certain level of pacing over long periods of time, so that the balance of the training stress and training adaptations remains favourable.'
Med Sci Sports Exerc, vol 37, no 3, 496-504

Hill training for endurance

South African coach Abrie de Swardt has come up with some excellent tips for hill training in *The Coach*. Hill training, as you may be aware, offers the following benefits:

- helps develop power and muscle elasticity;
- improves stride frequency and length;
- develops co-ordination, encouraging the proper use of arms during the driving phase and feet in the support phase;
- develops control and stabilisation as well as improved speed (downhill running);
- promotes strength endurance;
- develops maximum speed and strength (short uphill runs).

Abrie de Swardt is a big fan of hill training for endurance athletes and believes it can make the difference between winning and losing. Here are a number of ways to complete hill sessions that will help elevate your performance:

1. Short hills – 5-10 seconds to improve the phosphocreatine system of anaerobic energy production (speed strength) or 15-30 seconds to improve the lactic (glycolytic) power system;
2. Whistle hills – controlled by the coach with a whistle, *eg* sets of 10s, 15s, 20s, 25s flat-out sprints, with an easy recovery jog of one minute between each and 3-5 minutes between sets;
3. Short hills of 30-80m to develop speed strength;
4. Longer hills of 150-200m for strength endurance;
5. Hills of 400-1,000m and hilly circuits over several kilometres for ultra-distance runners;

6. Downhill sprints over 50-80m for increased leg speed;
7. Hill bounding or hops and skipping over 30-80m.

The Coach, Issue 16, Page 18-20

Ephedrine and endurance

The stimulant drug ephedrine, either alone or in combination with caffeine, leads to highly significant performance improvements that would take weeks to acquire through training alone.

That is the clear conclusion of a Canadian military study, which is part of a series set up to clarify the effects of caffeine and ephedrine on physical performance across a broad range of exercise intensities.

A group of 13 healthy active male subjects, all accustomed to resistance training exercises, performed a weight training circuit consisting of three supersets of leg and bench press exercises on four separate occasions, 90 minutes after ingesting one (in turn) of the following in a capsule formulation:

- Caffeine (C) – 4mg per kg of body weight;
- Ephedrine (E) – 0.8mg/kg body weight of ephedrine hydrochloride;
- Caffeine and ephedrine combined (C+E);
- Placebo (P) – 300mg of dietary fibre.

The researchers' theory was that the caffeine-ephedrine combination (C+E) would improve muscular endurance and, further, that the magnitude of the improvement would be greater than could be achieved by ingesting either drug alone.

They were not disappointed in the first supposition: the mean number of repetitions for the first set of leg press exercises was significantly higher for the trials involving ephedrine than for the caffeine-only and placebo trials – 18.5 reps for C+E, 16.3 for E, 13.6 for C and just 12.5 for P. Results for the bench press followed the same pattern, although the improvements were of a lesser magnitude, ranging from 14.3 reps for C+E to 12.3 reps for P.

However, these apparent ergogenic effects were not sustained for the second and third set of exercises. Furthermore, there was no significant difference between the effects of ephedrine alone and ephedrine-plus-caffeine, suggesting that there is no synergistic (additive) interaction between the two drugs.

The researchers comment: 'The magnitude of the effect [of C+E] during that first set is highly significant for this type of exercise, considering that it was induced only 90 minutes after ingesting the C+E. The 48% improvement in the leg exercise and the 16% improvement in bench-press performance would otherwise be expected to require from four to approximately 12 weeks of strength training.'

They believe the most plausible explanation for the observed effects is that the increase in muscular endurance with C+E was mediated by an increase in central nervous system stimulation, which may have delayed or masked the perception of fatigue.

The fact that the improvement occurred only in the first set of exercises may, they believe, have been related to the short rest interval of just two minutes between sets. 'It is tempting to speculate that a more prolonged recovery interval between the [sets] may have facilitated a continuing ergogenic effect of the ephedrine treatments in subsequent sets.'

The researchers hasten to point out that their results should not be taken as advocacy for athletes to use ephedrine as an ergogenic aid. Even discounting the fact that such drugs are banned by the International Olympic Committee, their use poses serious health risks.

For example, systolic blood pressure before exercise was significantly increased with both ephedrine treatment trials by comparison with the other two.

'We acknowledge that there are serious risks…', conclude the researchers. 'However, the fact remains that huge numbers of consumers are estimated to be purchasing and ingesting [ephedrine-containing] products, specifically with a view to enhancing physical performance. This study provides some empirical evidence about the efficacy of C+E and…will perhaps lead to a greater understanding as to why such products are used, in spite of the potential health risks.'

Med Sci Sports Exerc, vol 35, no 6, pp987-994

Risks of long-term detraining

Endurance-trained athletes should avoid long detraining periods because the resultant metabolic changes might prove difficult to reverse. That's the clear message from a French study on rowers – the first to study the effects of long-term detraining in highly trained endurance athletes.

The metabolic adaptations to endurance training are well understood; essentially, it induces a sparing of carbohydrate stores by increasing the contribution of fatty acid metabolism to the overall supply of energy to working muscles through enhanced glycogen creation and increased amino acid availability. These adaptations contribute collectively to enhanced endurance performance.

But what happens when the stimulus to the adaptations disappears not just for a few weeks but for months? That's what the French researchers set out to investigate with 10 male national and international rowers who had announced their intentions of training hard for one year before bringing their sporting careers to a close.

The study started after an off-season of six weeks, during which the athletes were asked to avoid any physical exercise. There then followed a 47-week training period, during which the athletes trained for a total of 1,046 hours (more than 22 per week) undergoing extensive performance and metabolic testing in weeks 1, 24 and 47. After another off-season they embarked on a detraining year, during which physical activity averaged 1.1 hours per week, with testing in weeks 52, 76 and 99.

Key findings were as follows:

- Short-term detraining (five weeks) induced significant changes in the metabolic response to exercise, with decreased fat breakdown during exercise and increased reliance on glucose. These changes did not represent a direct metabolic limit to exercise, with no alterations in acute responses to exercise;
- However, long-term detraining produced more significant and dramatic changes, with lower fatty acid availability giving rise to an even higher reliance on glucose during exercise. Additionally, destruction of red blood cells (haemolysis) was observed during exercise, probably as a result of lower efficiency of the body's systems for protecting the blood against oxidative damage.

'Therefore, endurance-trained athletes should avoid detraining periods longer than a few weeks (notably during off-season)', conclude the researchers, 'since alterations of the metabolic adaptations to training may become rapidly chronic after such a delay.'
Int J Sports Med 2003; 24:320-325

Chinese supplements don't work for cyclists

For endurance performers, the Holy Grail in nutritional terms would be a food or supplement that somehow managed to boost oxygen uptake and thence energy production. Claims like these have been made on behalf of two herbal supplements traditionally used in Chinese and Ayurvedic medicine – cordyceps sinensis and rhodiola rosea.

Indeed, the first of these gained world attention in 1993 following the success of Chinese female runners, who achieved records in 1,500m, 3,000m and 10,000m events and attributed their success to a cordyceps-rich diet.

Were they deluding themselves? That's the question a team of US researchers set out to answer with a study of the effects on oxygen uptake in 17 amateur competitive cyclists of a commercial formula containing cordyceps and rhodiola as its primary ingredients.

The subjects, all male, performed a staged cycling test to exhaustion before and after a 14-day period of supplementation with either the active 'adaptogen formula' or a matched placebo. During the cycling tests, they were monitored for a range of performance variables, including peak oxygen uptake, power output, heart rate and time to exhaustion.

The result? The researchers did not observe any statistically significant difference between or within treatment groups for any of these variables. 'Therefore,' they say, 'it appears that this commercial product confers no ergogenic effect when ingested over a 14-day treatment period.'

They acknowledge a number of limitations with their study: first, they did not have the product independently analysed; secondly, they were unaware of the precise quantities of the active ingredients present in the supplement; thirdly, and perhaps most crucially, it was possible that they did not allow the cyclists to ingest the product for long enough to exert an ergogenic effect, even though they were following the manufacturer's recommendations.

'Whether this formula will prove to have a benefit to exercise when ingested over longer periods has yet to be determined,' they conclude.
Med Sci Sports Exerc, vol 36, no 3, pp504-509, 2004

Sperm changes in long-distance cyclists

Male endurance cyclists may be at risk of significant changes in the structure, if not the quality, of their sperm, according to a new study from South Africa.

Previous studies have suggested that regular endurance training may compromise testicular function. And this may be a particular risk for cyclists, who are exposed, additionally, to mechanical compression and irritation of the testes while performing their sport.

The researchers compared semen samples from 10 long-distance competitive cyclists with those of 10 sedentary controls. The cyclists, who were non-professional, had trained for more than 40 minutes a day on at least three days per week for at least three months before the study began, and none of the subjects had any history of reproductive disorders or were using medication that could have altered sperm production in any way.

No significant difference in volume of samples, motility, viability or sperm count were observed between the two groups. However, the cyclists had a significantly lower proportion of spermatozoa with a normal morphology (structure) than the controls and produced a high percentage of tapered forms of abnormal spermatozoa.

This is contrary to the findings of a previous study of cyclists, which reported no significant alterations in normal morphology. The researchers provide two possible explanations for this apparent contradiction:

1. The cyclists in the previous study were professionals, whose superior cycling techniques may have minimized the mechanical stress associated with the cycling action;

2. The previous study was carried out in the lower ambient temperatures of Europe. The hotter climes of Africa probably resulted in higher scrotal temperatures, which might have had a negative impact on sperm production.

The researchers comment: ‘During training, cyclists are exposed to periodic increases in body temperature and reduction in testosterone levels due to prolonged bouts of exercise. In addition, cyclists are exposed to mechanical compression to the testis, epididymis and vas deferens because of the mode of exercise.

‘These mechanisms could act synergistically in some endurance-trained cyclists and may diminish reproductive function and result in potential problems with fertility.’

Nevertheless, as they point out, although alterations in semen morphology occurred in the cyclists, these remained within the normal range for adults.

‘The morphological alterations may therefore not warrant fertility concerns at this stage,’ they conclude. ‘However, our subjects were still young, and as they grow older the alterations may become clinically significant, particularly if the exercise is continued.’
Int J Sports Med 2004;25:247-251

Notes

Notes