exam focus

Principles of training

Heart-rate training

John Dullehan provides an overview of a key topic for the three main exam boards, using the example of an endurance cyclist to illustrate the concept

Exam links

AQA Principles of training: specificity, progressive overload, recovery and reversibility (SPORR).

Edexcel Principles of training: individual needs, specificity, progressive overload, overtraining and reversibility (INSPOOR).

OCR If you are taking the OCR specification, you will be expected to plan personal health and fitness programmes for an aerobic performer, and this 'Exam focus' will assist you with that. The OCR textbook uses the terms specific, progressive, overload, variance, moderation and reversibility (SPOVMR) to guide learners as to the structure of the plan.

For an endurance cyclist to undertake heart-rate training, the performer needs to wear a chest or limb-based heart-rate monitor. Heart-rate data can then be monitored and stored by the performer or coach.

Individual needs

Edexcel and OCR

For heart-rate training to be effective, the cyclist must establish their own heart-rate training zones and target heart rate. These can be identified by either a mathematical calculation or through physical tests.

Following the mathematical route, first, the performer's maximal heart rate is predicted by completing the calculation 220 – Age. Then the resting heart is measured and the results are used to predict heart-rate training zones using Karvonen's theory:

Target heart rate (HR) = ((Maximum HR – Resting HR) × % intensity) + Resting HR

The limitation of the mathematical approach is that age is not the only factor that affects maximal heart rate. An individual's maximal heart rate will differ due to gender, body size, fitness, type of locomotion (bike, run, swim, row) and the individual's history of aerobic fitness.

The assessment of maximal heart rate using exercise is more effective than the mathematical calculation, as it accounts for individual differences. An individual's maximal heart rate can be predicted from sub-maximal assessments or measured through functional threshold tests. These tests are also sensitive to the fact that performers experience the different physiological thresholds at varying percentages of maximal heart rate. Tests can reveal where these thresholds occur and therefore help the performer to establish target heart rates (OCR) or precise boundaries for heart-rate training zones.

Once the heart-rate zones and target heart rate have been established then the cyclist can make their training more effective by combining heart-rate monitoring and the principles of training.

Monitoring heart rate ensures that individual improvements are acknowledged

Specificity

AQA, Edexcel and OCR

When training for the chosen activity it is important to ensure the training drill is appropriate and relevant if specificity is to be achieved. Three aspects of specificity should be considered:

- type of locomotion
- energy systems
- skill action

For example, for a cyclist, the heart-rate assessment and subsequent training should be conducted on a bike.

Once the heart-rate zones and target heart rates are established, training drills can be conducted at the correct intensity to ensure the desired energy system is used and improved. The performer will work at an appropriate intensity (heart-rate zone or target heart rate) for a specific duration. For example, the endurance cyclist might train in a heart-rate zone and heart-rate target where they exercise at the maximum of their aerobic energy system but below onset of blood lactate accumulation (OBLA, 80–85% of maximal heart rate) while completing a 100 km training ride. This would ensure their body is using the appropriate aspect of the aerobic energy system.

Sports also require the performer to be skilful when competing. The skills used when competing must be incorporated into the training drills. For example, endurance cyclists are often required to make skilful manoeuvres around fellow competitors or obstacles. This requires them to train to execute these skills at the same intensity (level of fatigue) as when competing. Heart-rate training can ensure the cyclist is working at competition intensity when undertaking manoeuvring skills and maintaining their streamlined body position.

Progression

AQA, Edexcel and OCR

A progressive training programme is where the performer improves an aspect of their training programme over time. This progression will be identified by an assessment that is typically linked to how the activity, training drill or sport is measured. For example, cyclists undertaking 5 × 1 km sprints with a 3-minute rest between each sprint might expect to see the time taken for each 1 km reduce over time.

A heart-rate monitor ensures that individual improvements are acknowledged, and that the training remains as challenging as when first started. Heart-rate training zones ensure that individuals continue to work at the correct physiological intensity, rather than coasting due to an improvement in their fitness capacity.

Over the short term you would expect heart rate to be comparable when completing the same training drill under the same conditions. Over the long term, it would be expected that heart rate would be lower when completing the same training drill due to adaptations in the cardiovascular system. These adaptations include an increase in the number of mitochondria, capillaries, and aerobic enzymes, increase in concentration of haemoglobin, hypertrophy of the slow oxidative muscle fibres (type 1), and, over years, cardiac hypertrophy.

These changes cause an increase in a-VO_2 difference (see pp. 18–21), lactate threshold and VO_2 max. Due to these adaptations of the body, it is necessary to re-assess performers' heart-rate training zones to ensure that training is at the correct intensity.

Overload

AQA, Edexcel and OCR

Overload occurs when the body is stressed to a degree that it becomes damaged, and then repairs itself, becoming bigger and stronger. This process of adaptation will result in the body being able to cope with similar future stress without damage.

Overload is based on the idea of 'no pain, no gain'. But how much pain is appropriate? Too much could cause injury and too little will reduce the effectiveness of the training. Heart-rate monitors can ensure that individuals train at a level that will help achieve this balance and keep the performer in their *Goldilocks zone* (not too little, not too much).

Heart-rate monitors allow assessment of the amount of time the performer has been working at a high percentage of their maximal heart rate. These real-time measurements allow coaches to modify training sessions to ensure performers do not damage themselves or undertrain and not experience overload.

Recovery

AQA

Recovery is the process by which the body returns to the state of rest. The length of recovery depends on the fitness of the individual, and the duration and intensity of exercise. In some activities, recovery may take place during as well as after exercise. This occurs when activities have periods of lower intensity that allow the performer to partially recover.

Heart-rate monitors can be used to assess low-intensity bouts (relief intervals) as well as high-intensity periods (work intervals). The relief interval might not be planned as a specific period of time, but as a target heart rate. For example, it could be expected that an endurance cyclist would complete 10 × 4-minute work intervals at 85% of maximum heart rate, but each one is started when their relief interval heart rate is below 50% of maximum heart rate for 1 minute.

In this example, heart rate is being used to monitor the fast component of excess post-exercise oxygen consumption (EPOC). By ensuring the performer heart rate declines to less than 50% of maximum heart rate, the coach and cyclist are intending for the fast component of EPOC to be complete. This means that the myoglobin is re-saturated and ATP/PC is re-synthesised.

Moderation

OCR

Moderation means ensuring that training is appropriate to the performer so that they can adapt. If the performer is not allowed adequate recovery time or does not experience overload, then the body will not adapt correctly. The Goldilocks zone of heart-rate training ensures that moderation is achieved.

A cyclist must consider their lifestyle (sleep, diet, stress) and their training demands if they are to ensure that their body adapts appropriately.

Overtraining

Edexcel

If the performer is still showing an elevated resting heart rate hours after exercise, it might be an indication that the cardiovascular system is being used to recycle the energy stored in the blood lactate and repair tissue (slow component of EPOC).

It is common for elite endurance cyclists to monitor their resting heart rates daily to ensure that they have recovered from the previous day's training in order to avoid overtraining.

Exam-style questions

Modern technologies such as motion sensors and heart-rate monitors are often used by performers in training and performance.

Using your knowledge of training principles, explain how effective heart-rate monitors are in preparing an endurance cyclist for a major event. (4 marks)

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Training in different heart-rate zones can prevent boredom, as can exercising with others

Reversibility

AQA, Edexcel and OCR

Reversibility is often referred to as *detraining*. This is when injury or extreme fatigue prohibits effective training and therefore fitness is lost. The general calculation is that 2 weeks lost from training takes the fitness of the performer back to where they were 3 weeks before the incident.

Injury prevention is of significant concern to athletes. This is one of the reasons why it is so important to monitor the intensity of exercise during training in terms of work interval, so that the desired recovery occurs during the relief interval.

Ensuring the performer is not unduly fatigued during the session can reduce the chance of traumatic injury due to loss of concentration. Excessive fatigue may also hinder training in subsequent sessions.

Post-training heart-rate monitoring can ensure the performer experiences enough recovery and avoids excessive training fatigue. An elevated resting heart rate might serve as an early warning signal that the performer has not fully recovered and might need to modify their training schedule or lifestyle. This modification of their training programme might prevent underlying health issues developing into more serious illness, which may limit future training and performance.

Variance

OCR

Overuse injuries and boredom can be an issue in training. Heart-rate monitors cannot be used to identify overuse injuries, but they can be used to increase an individual's motivation. Boredom may be reduced by setting new training goals based on percentage success in achieving target heart rate.

If the endurance cyclist has never used a heart-rate monitor, then the introduction of this technology would add a welcome break from the monotony of prolonged endurance training. Heart-rate training would offer the opportunity to set new SMARTER goals. This variation of training ensures that specificity is maintained. It is important to note that when varying the training sessions, the performer should not create a training programme that fails to deliver specificity.

John Dullehan is a senior examiner for A-level PE.