The training stimulus

Introduction:

In the previous lecture module you were introduced to the concept of homeostasis. During a training session, energy is used at a high rate and this challenges the environmental conditions of the cell. The body has a range of environmental conditions within which it can operate. If it goes outside this range it doesn't function very well. There are built in mechanisms constantly working to keep the environmental conditions of the cell in the desirable range.

Temperature and acidity are two environmental conditions the body tries to maintain within a set range because they affect enzyme function. Enzymes are critical to the thousands of chemical reactions taking place.

After a training session the athlete will feel fatigued due to depleted resources and damaged components of the cells that temporarily reduced the body's functioning capacity. This is indicated in phase 1 of the chart. During planned recovery periods between training sessions resources are replenished back to normal level. Repair will also be done to damaged cells. The return of the body back to normal functioning requires several hours. If the time between training sessions is long enough the body then enters into a supercompensation phase (phase 3 on the chart) where new structures, enzymes, etc, are built that will increase the athlete's physiological capacity just a little bit. Each time supercompensation occurs physiological functioning improves making it slightly easier for the body to mobilize resources and maintain homeostasis during the next training session.

What you will learn

In this module we focus on the optimal timing for the next training session, discuss the training different types of stimulus variables, and overview methods for measuring the intensity of a training stimulus.

Important terminology

The terms: training stimulus, training effect, training program and training adaptation are often interchanged making their meanings somewhat confusing.

- A training stimulus is an exercise stress designed to motivate cells of the body to undergo changes so they are able to work at a higher capacity.
- Training effect refers to specific changes in muscular, cardiovascular, neural and hormonal systems that lead to improvement in functional capacity as a direct result of the training stimulus. The term is thought to have been coined by Kenneth H. Cooper in the 1960s when he discovered the positive responses of aerobic exercise on the cardiovascular system. The terms training stimulus and training effect are often used interchangeably, but they have different meanings.
- Training adaptation is the sum of changes occurring in the body's cells and organ systems
brought about by systematically repeating certain forms of exercise. These structural and physiological changes depend on the type of training stress the athlete places on their bodies during the training session.

- **A training program** is the planned linking of different types of training stimuli, or training effects, with the goal of producing an improved athletic performances. A training program is beneficial only if it forces the body to adapt so it becomes stronger and more efficient. If the stress is an insufficient challenge then no adaptation will occur. On the other hand, if the stress is intolerable then injury or overtraining may result. Your entire training program design will be based around causing the athlete's body to adapt to increasing stress. The outcome is a stronger body capable of high levels of physical feats.

**Optimal time for stimulus application**

We call this curve the “supercompensation cycle”. Let's go through it again because you will see this curve a lot. Here's where the first stimulus occurs (please refer to the module). This stimulus could be a training session, or a specific stimulus within a training session designed to produce a specific training effect. This axis represents the physiological working capacity of the athlete. This axis here represents time. This line here represents the athlete's current level of physiological functioning.

Phase 1 occurs during the training session. It is showing a depletion of performance capacity due to fatigue and disturbance to homeostasis. Phase 2 occurs during early recovery where homeostasis is returned to normal. Phase 3 also occurs during recovery. It's the supercompensation phase where adaptation takes place. This is happening late in recovery. Phase 4 occurs if there is no additional training stimulus.

Now the question is: When do you apply the next training stimulus?

From a basic theoretical perspective the ideal timing for another training stimulus is at the peak of supercompensation. It is not quite as simple as this, and there will be variations to this basic rule depending on the athlete’s training age. However, for now we will stay with a simple theoretical application.

**Adaptation response to the training stimulus**

Assume you are attempting to develop a newcomer’s endurance capacity. You use a 3-mile run at a comfortable pace as the training stimulus. A beginning athlete will find this workout difficult due to the unfamiliar demands on energy mobilization to the working muscles. This training stimulus produces the recognizable fatigue, followed by recovery. During recovery the cells will replenish energy resources and repair damage. Twenty-four hours later (after the body has built stronger structures, more enzymes, stored more fuel components, etc.)
supercompensation occurs.

At this point the athlete runs a second 3-mile training session at the same pace. This is training stimulus number 2 – once again you see the familiar supercompensation cycle – fatigue, recovery and supercompensation. The athlete probably won’t notice too much difference in effort during the second run because the body has only made itself a little bit more physiologically efficient. However, the run may appear a little bit easier.

A third training run is stimulus 3 and produces the same supercompensation cycle. Then the forth training stimulus occurs and yet another supercompensation cycle. Now the workout will seem a lot easier. And yet another training stimulus and another supercompensation cycle.

The yellow line indicates the rate of physiological improvement in response to the same training stimulus that is consistently repeated. In this example, by the 5th training session the athlete’s body has adapted itself almost completely to match this training stimulus. If the athlete continues using the same training stimulus no further adaptation will occur – all that will happen is that the athlete will maintain the new level of physiological functioning. A new stronger stimulus is now needed for any further adaptations to occur. Now, this is just an example. The number of training sessions for complete adaptation to the 3-mile training stimulus will vary from athlete to athlete. A good rule of thumb is 4 to 6 weeks.

**Applying the training stimulus before supercompensation**

What if the next stimulus is applied before supercompensation? For example, let’s assume that the athlete becomes frustrated because a friend is doing much better during competition and decides to run two 5K runs each day. This is a classic example of how the athlete can sabotage your training program design. There will be a gradual decline in physiological functioning because the recovery period is far too short and the athlete will not even recover back to normal levels of homeostasis. Illness, and/or a reduced interest in training usually follows.

The athlete will enter into a deeper fatigued state indicated by the yellow solid line. Over time such an approach to training causes a gradual decline in physiological functioning and can lead to injury, illness or a reduced interest in training

You can’t rush adaptation. It is biologically essential for the athlete to reach supercompensation before the next training sessions *most of the time*. Increasing the training stimulus to a 4-mile run while keeping the 24-hour recovery period is the better approach - not reduced recovery time. Adaptation can only occur if the athlete reaches supercompensation before the next training session.

**Applying the training stimulus too late:**

Can you ever apply a training stimulus too late? Yes you can. This phenomenon occurs when the training sessions are not frequent enough. Injury interrupts training, for example, or you allow too much time to pass without stressing a specific component of the physiological system essential to the athlete’s performance. If the athlete does no training during the off-season, physiological working capacity declines back toward the untrained
level for this reason. The red dotted line indicates how a previously acquired higher level of physiological capacity gradually returns to normal when the stimulus is applied too infrequently. This is referred to as decay or the detraining effect.

I’ve seen this type of situation occur when athletes of different physiological capacities are grouped trained. The workout might be perfect for some of the athletes but not hard enough for others. It’s always better to sort the athletes into groups according to similar levels of physiological functioning.

Recap of key points

Here is a recap of key points regarding the training stimulus and its relationship to homeostasis:

- A training stimulus is designed to stress the organ systems and the environment in which they are functioning. The body’s reaction to stress is to immediately move into action with all the available mechanisms to restore homeostasis.
- Normal homeostasis is the range of conditions in which the cells will work efficiently – especially temperature and acidity.
- How hard the body has to work to maintain homeostasis depends on the type and intensity of the training stimulus, and on the physiological working capacity of the organ systems and cells.
- The timing of the training stimulus is important. The goal is to apply the next training stimulus at the peak of supercompensation. Advanced coaching strategies violate this basic rule but for the beginning and intermediate athlete this is a good rule to follow.

Training stimulus Variables: Introduction

When designing a training stimulus there are five primary variables to consider. They include:

- **Mode or type of exercise.**
- **Volume.**
- **Density.**
- **Complexity.**
- **Intensity.**

A training program design task is to mix and match these variables to produce the right training effect. Each variable stresses the body’s internal environment in different ways, and therefore has a slightly different adaptation effect. As well, the stress induced by each stimulus variable will impact the amount and type of recovery required before the next training session. Let’s briefly take a look at each of these training stimulus variables in a bit more detail.

**Mode or type of exercise**

The first variable is the type of exercise you select – or the mode of training. There are specific and non-specific training stimulus modes. If the exercise is very similar to the type of movement used in competition it is referred to as a *specific training mode*. An exercise different from the movement used
during competition is referred to as the *non-specific mode*. If you want to develop a high jumper’s leg strength, for example, non-specific exercises involve using resistance machines, free weights, or body weight. Jumping exercises would be a specific training mode. All sports intermingle specific and non-specific stimulus modes depending on the skill the coach is trying to develop.

**Volume**

Volume is measured in terms of the number of training hours, distance covered, or weight lifted per unit time. Some sports such as running, canoeing and rowing use distance covered as an assessment of volume. Other sports use load as a measure of volume — weight lifting, or weight training for strength development, for example. Team sports measure volume in terms of time. Frequently, two measuring units are combined. For example, time and distance are frequently combined, as are the number of reps and weight or load lifted.

**Density**

Density is the ratio of time of exercise to recovery time. Sometimes only the density of a specific workout is of interest, and other times weekly or monthly density is of interest. Heart rate is often used to assess the length of the rest period. If heart rate has not recovered back to a normal level within a specified period then the density of the workout may be the problem. One way of decreasing density is to increase the amount of recovery.

The formula for density is: Time of training performed – Time of the rest interval divided by the volume of training performed.

If the athlete does 100 mins of total exercise interspersed with a 35 minutes of rest periods then the density of this workout is 65%. Density gives you an idea of intensity of the workout.

**Complexity**

Complexity reflects the stress the training stimulus places on nervous system information processing. It refers to the degree of sophistication of the training stimulus, especially its neuromuscular coordination demands. Endurance running entails a relatively low complexity compared with the stopping and starting and spatial awareness demands of team sports. Hurdling has higher coordination under time pressure and precision demands than sprinting does. Complex skills require a high level of motor program involvement and development and therefore the complexity of the training session can place a mental strain on the athlete. As soon as the athlete begins making mistakes then this indicates the training session may have exceeded the ability of the athlete’s information processing system and it has fatigued.

**Intensity**

Intensity of a training session can involve both high metabolic stress and nervous system stress. The strength of the stress is a function of training load, speed of movement and/or the duration of the intervals versus the rest periods (density).

Another element of intensity is the psychological strain of the exercise and this can be a function of the complexity of the skill.

There is no commonly accepted method for assessing accumulated intensity. Intensity and volume go hand in hand. When volume increases you will need to reduce the intensity.

While measuring intensity is difficult to do there are five methods available for you to use. Simply select one method or a combination of two or three of them and use this method regularly. The five include the rating of perceived exertion (RPE), velocity, power, blood lactate and heart rate. Click each of the intensity button on the screen to review each intensity measure.

**Measuring Intensity**

- **Rating of Perceived Exertion (RPE):** The easiest method for measuring intensity is to simply
ask the athlete to rate the intensity of the training session using everyday language such as easy, hard, extremely hard, etc. The scale is called the rating of perceived exertion. There are many RPE versions available depending on the sport. This one here is designed for endurance runners and is fairly easy for most coaches and athletes to use. Ask the athlete to point to the best description of their breathing during the training session, then record the score matching this breathing description. RPE is a useful tool to use and is fairly reliable. You can easily design your own RPE scale but use the same one consistently.

- **Velocity:** Velocity is a measure of how fast the athlete is moving. Runner refer to velocity as pace and is measured in minutes/kilometer or minutes/mile. Swimmers will usually refer to pace in terms of time per 100 meters. Cycling uses kilometers per hour. Velocity is an OK method of referring to intensity if there are no hills, no wind or the water is calm. Varying conditions during the training makes it difficult to compare workout intensity from one training session to the next. For an endurance runner, a windy day will be a more intense training session than a calm day.

- **Power:** Power is the amount of work performed per unit time. Expressing exercise intensity in terms of watts or power is relatively new, but for some sports it has become an important indicator of intensity. Cycling and rowing are the two endurance sports in which the concept of power is used to assess intensity. It is a reasonably accurate way of reflecting intensity because environmental factors are minimized. The downside is that it relies on expensive technology. The least expensive power meter for a bike, for example, retails for 10 times the cost of a basic heart rate monitor.

- **Blood Lactate:** Lactate is a measure of the acidity levels of the cells and blood and also provides an assessment of the strength of the energy systems. The obvious downside of lactate measurement is that it requires drawing blood. For this reason, it is not a method for assessing intensity on a daily basis. It is more frequently used if a specific training period has focused on buffering, or aerobic energy adaptations, and you want to find out what progress has been made.

- **Heart Rate:** Monitoring heart rate gages intensity of a workout because how fast the heart is beating reflects the body’s response to the energy demands of the workout. Heart rate indicates the level of oxygen and nutrients demanded by the muscles for energy. The heart must beat faster to meet a higher demand. For this reason, there is a close correlation between intensity and heart rate. You can use heart rate to determine recovery time. For example, if you know the athlete’s resting heart rate and the training session consists of repeated bouts of exercise, then you can gage the start of the next bout based on how close the athlete’s heart rate is to resting level.

References

Bompa, Tudor O. Periodization: Theory and Methodology of Training, 1999

Hansen, Anne K., Christian P. Fischer, Peter Plomgaard, Jesper Løvind Andersen, Bengt Saltin, and

Viru, A.A. Adaptations in sports training. CRC Press, 2000 N W Corporate Blvd, Boca Raton, Florida 33431, 1995