Specialised training

PNF stretching and plyometrics

Mike Murray looks at two training methods that are a common focus of exam questions

Gymnasts do plyometric exercises to help them develop the power they need for maximum lift at take-off

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Proprioceptive neuromuscular facilitation (PNF) and plyometrics are two types of specialised training. Past exam questions on these two training methods have focused on:

- descriptions of the techniques involved
- explanations of the physiology behind them

PNF stretching

Passive stretching is where your stretched position is held by a partner or object, or with some other part of your body. Static stretching involves the resistance of muscle groups through isometric contractions (with no movement) of the stretched muscles. During an isometric contraction, because the muscle remains in a stretched position, the stretch reflex is disengaged.

Increasing flexibility

When a muscle is stretched, the muscle spindles within it are activated and send a message back to the muscle telling it to contract (Figure 1). This contraction prevents the muscle from over-stretching and tearing. The signal that tells the muscle to contract also tells the muscle spindle's intrafusal muscle fibres to shorten, increasing the sensitivity of the stretch reflex. This allows the muscle spindles to habituate to a further-lengthened position.

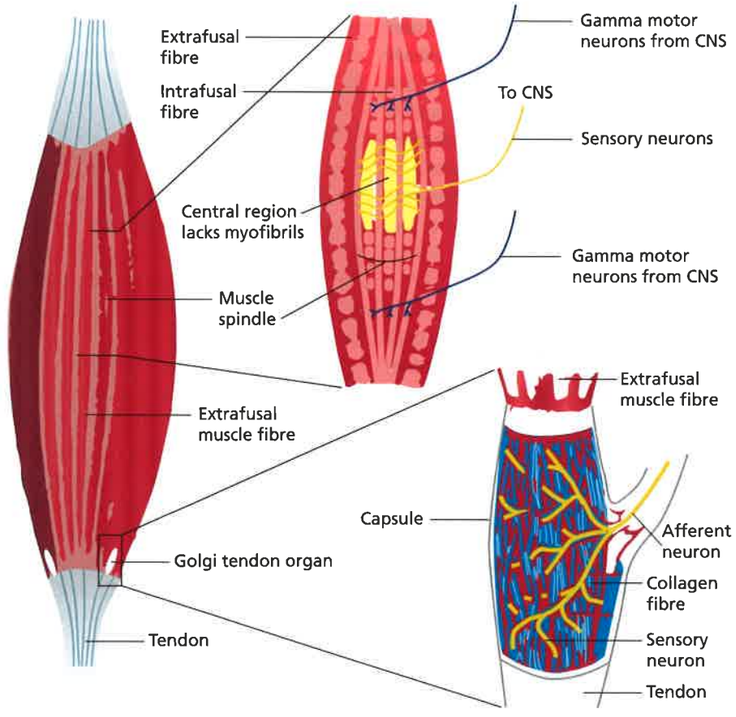

Figure 1 Muscle spindles and Golgi tendon organs within a muscle

Key term

Proprioceptive neuromuscular facilitation (PNF) stretching
A combination of passive and static stretching that is an effective way to increase flexibility.

Test your understanding

1 Training programmes often include exercises to improve flexibility. Describe the method involved in proprioceptive neuromuscular facilitation (PNF) stretching. (4 marks)

2 Using your knowledge of muscle spindle apparatus, explain why PNF stretching tends to produce better results in terms of increased flexibility than other forms of stretching. (3 marks)

3 Outline the method involved in plyometric training that can help a gymnast to achieve maximum lift at takeoff. (4 marks)

4 Explain how plyometric training helps gymnasts develop their power. (3 marks)

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Remember: the **all or nothing law** tells us that when a muscle is contracted, the muscle fibres either contract fully or not at all. So in a contracted muscle some of the fibres are fully contracted and some remain at rest. More fibres are recruited if more strength is required.

Similarly, when a muscle is stretched, some of the fibres are elongated and some remain at rest. During an isometric contraction, some of the resting fibres will be pulled from both ends by the contracting muscles, so some of those resting fibres stretch (Figure 2).

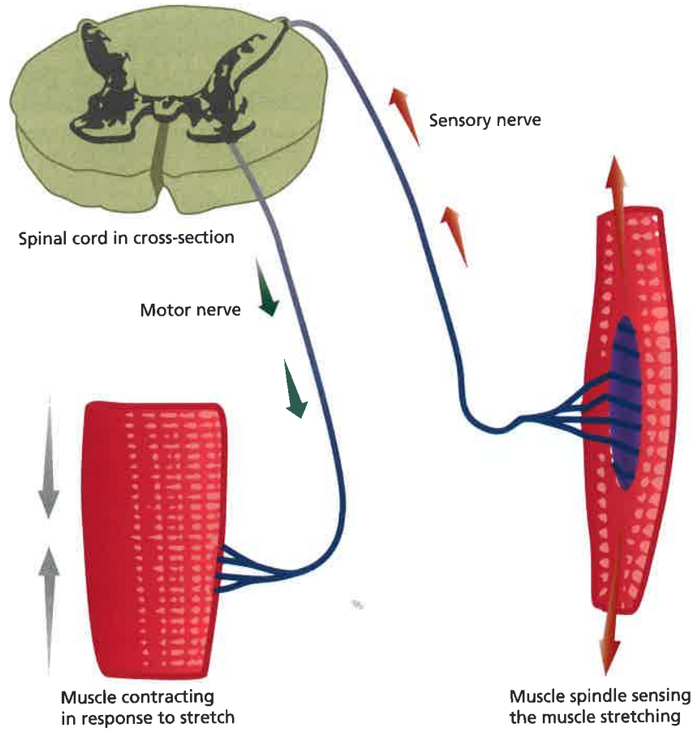

Figure 2 The protective stretch reflex

Normally the number of fibres that stretch during an isometric contraction is insignificant. But when a muscle that is already in a stretched position is subjected to an isometric contraction, some of the muscle fibres are already stretched before the contraction, and, if held for long enough, the initial passive stretch overcomes the stretch reflex, disengaging it.

During the isometric contraction, some of the resting fibres contract, many of the resting fibres stretch, and many of the already stretched fibres stretch even more. When the isometric contraction is relaxed, the stretched fibres retain their ability to stretch beyond their normal limit, the whole muscle is able to stretch beyond its initial maximum, and you get increased flexibility.

Golgi tendon organs

The protective stretch reflex also involves the **Golgi tendon organ (GTO)**. GTOs are attached to the fibres of the muscle tendons. They work to relax a muscle so that the stretch being applied does

Figure 3 An assisted PNF stretch

not cause tearing or overactivity of the nerve fibres.

GTOs are activated when a muscle is stretched or contracted isometrically. They inhibit the development of too much tension in a muscle, allowing the muscle to relax and lengthen. This lengthening during a stretch also helps prevent the tendon or muscle tearing. This process is known as **autogenic inhibition**.

When an agonist muscle contracts concentrically, the antagonist muscle in turn relaxes, allowing the agonist muscle to move a limb through its full range of motion without interference from tension in the antagonist. This is called **reciprocal inhibition**. PNF stretching is mainly concerned with reciprocal inhibition.

CRAC

The most common PNF technique is **contract-relax-antagonist-contract (CRAC)**. It involves two isometric contractions: initially of the agonist, then of the antagonist:

- In the first part of a PNF stretch an initial passive stretch is made to get the joint into a held, stretched position (Figure 3).
- The stretched agonist is isometrically contracted for 6–10 seconds.
- The muscle is relaxed and its antagonist immediately performs an isometric contraction that is again held for 6–10 seconds.
- The muscles are relaxed for 20 seconds before performing another PNF stretch.

As the agonist muscle contracts isometrically, the GTOs are activated, autogenic inhibition occurs and the antagonist relaxes. When the antagonist of the limb being stretched contracts, the agonist muscle relaxes through reciprocal inhibition. These relaxed agonist muscles can be stretched further through repeated cycles of CRAC, increasing flexibility and range of motion. This is helped by the fact that the muscle spindles are disengaged.

Plyometrics

There are two types of muscle contractions involving movement **(isotonic contractions)**:

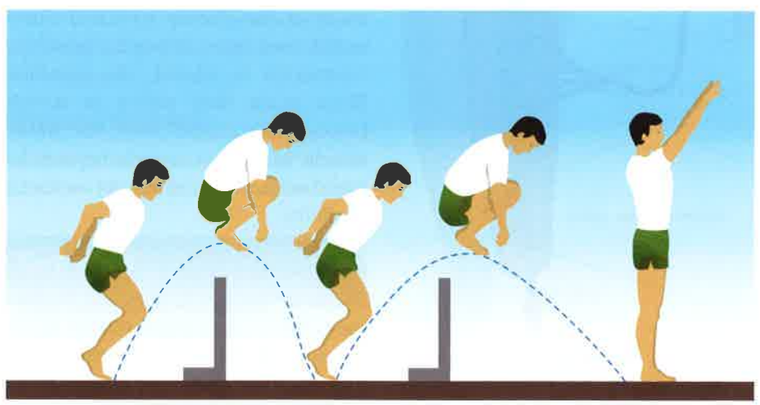

Figure 4 The concentric phase

Key term

Plyometrics A type of power training in which a muscle is loaded and then contracted in rapid sequence to increase the speed or force of muscular contractions. This provides explosive power for a variety of activities.

- **eccentric**, where the muscle lengthens
- **concentric**, where the muscle shortens

Plyometrics involves an eccentric contraction, followed immediately by an explosive concentric contraction. This is accomplished through the **stretch-shortening cycle**. There are three phases involved in the stretch-shortening cycle:

- the eccentric (or loading) phase
- the amortisation (or transition) phase
- the concentric (or unloading) phase

The eccentric phase

The first stage of a plyometric exercise is the eccentric phase, which involves a downwards movement. This eccentric stretch of the muscle activates the muscle spindles and works in much the same way as stretching an elastic band; the muscle is pre-stretched prior to activation. Potential energy is stored in the elastic tissues of the muscle during this loading phase. The less time this phase takes, the greater the stored energy and the greater the training benefit.

The amortisation phase

This phase is the time between the end of the eccentric contraction and the start of the concentric phase. During the amortisation phase the muscle must switch from overcoming the force of the downward, eccentric contraction to imparting force during the upward concentric contraction. The shorter this phase is the better. A rapid switch from an eccentric contraction to a concentric contraction leads to a more powerful response.

The concentric phase

The concentric phase occurs immediately after the amortisation phase and involves an upward concentric contraction, which results in improved muscular performance following the eccentric phase of muscle contraction (Figure 4).

Physiology

Plyometric training uses muscles' elastic properties and proprioceptors (muscle spindles and Golgi tendon organs) to generate maximum force production by increasing the recruitment of muscle in a minimal amount of time.

The elastic properties of muscle

Muscle contains elastic tissue. Muscle action is not like pulling on one end of a piece of string to pull the other end, it is more like pulling on a piece of elastic. If enough tension is applied to the elastic, it will eventually pull on the other end.

The eccentric contraction immediately preceding a concentric contraction significantly increases the force generated concentrically as a result of the storage of elastic potential energy. This extra energy is released as kinetic energy during the concentric phase.

As a simple example, try doing a vertical jump following a squat. The initial squat is the eccentric phase that stretches the elastic tissue and stores elastic energy (amortisation phase). When the jump is performed (the concentric phase) the stored energy is added to the tension produced, leading to a higher jump. The longer you wait in the squat position before performing the jump, the lower the eventual jump height will be due to the inability to recover the stored elastic energy. The amount of stored energy used depends on how short a time is spent in the amortisation phase.

Enhancing performance

There are three mechanisms by which plyometric training improves performance.

Enhanced muscle spindle activity

The muscle spindles detect change in length of the muscle. One role of the muscle spindles is to set the muscle to a preset length. When the muscles are stretched the muscle spindles are also stretched. This causes the spindles to send nerve impulses that result in reflex contraction of the stretched muscle. This reflex enables the muscle to rapidly return to its preset length.

Desensitisation of the GTO

Repeated plyometric exercises desensitise the GTO by increasing the degree of stimulation needed for the GTO to inhibit muscle contraction. This means that the muscle can produce more force.

Enhanced neuromuscular efficiency

Plyometric training may promote better coordination of contracting agonists and synergists, thus improving the efficiency of the central nervous system. Making use of the stretch reflex, inhibiting the GTO, and enhancing the ability of the nervous system to react to the lengthening muscle optimises the force produced by the concentric contraction.

A common error is thinking that plyometrics is only useful for improving jumping performance. The beneficial effects include improved jumping ability, running economy and power output, but not improved strength.

Mike Murray is a senior examiner and the author of a number of teaching resources.