NEURAL ACTIVATION AND PERFORMANCE IN POWER EVENTS

By Warren Young

All field events and the sprints require a significant power output for successful performance. Therefore it is of interest to coaches and athletes to find ways to develop power, speed-strength or explosiveness through training, as well as to unleash maximum power output in competition.

In 1988 following the Olympic Games in Seoul a Canadian strength coach suggested that Ben Johnson was known to perform heavy squats prior to racing in an attempt to “activate the nervous system” to increase explosiveness. Coaches from the Soviet Union have used this concept in a method described as complex training. This involves lifting heavy weights to elevate the “excitability of the central nervous system” and therefore increase the explosiveness and speed of movement of the legs (Fleck and Kontor, 1986). The notion of “warming up” the nervous system by performing very intense contractions to augment power output seems an appealing strategy. This article is concerned with the concept of “neural activation” and the possibility of the central nervous system (CNS) functioning to “drive” the muscles to increased levels of power output in explosive events. The design of a pre-competition warm-up to activate the nervous system for improved performance is also explored.

THE NERVOUS SYSTEM

The strength and power output of a muscle is largely determined by its cross-sectional area as well as the extent to which it is activated. It is well accepted that many of the adaptations to resistance training occur within the nervous system (Sale, 1988). For example when strength gains are larger than the accompanying increases in muscle size (hypertrophy), it is thought that improved motor unit activation (MUA) is responsible (Moritani and De Vries, 1979). The way in which the nervous system influences force and speed of contraction in a sports event is perhaps less well known. Motor unit activation refers to the extent and timing of MU firing, and is made up of:

1. *Recruitment* — this refers to the number of MU’s that are active or firing. The more MU’s that are recruited, the greater the force of the muscle contraction.

2. *Rate Coding* — this refers to the firing rate or frequency of neural impulses moving down the motor-neuron which controls a motor unit (Deschenes, 1989). Rate coding may influence force output by affecting the degree of fusion of twitch contraction forces of an individual MU, or the degree of synchronization or simultaneous firing of different MU within a muscle. Whether force output is

controlled more by recruitment or rate coding depends on many factors such as muscle function, size, fiber type composition (Doschenes, 1089), and the firing rate patterns (Sale, 1987). For a given cross sectional area of a muscle, maximum strength and power output would be achieved when MUA is maximized, which is facilitated by a high level of recruitment and an optimum firing rate. This could only be achieved when the neural input from the CNS (the “command center”) is adequate.

So, how is complete MUA accomplished? According to Sale (1987), full MUA of specific muscles requires maximum voluntary effort, and is more likely to be achieved when well trained. However, there is sufficient evidence to suggest that neural inhibitions may prevent *complete* MUA of individual muscles when performing complex multi-joint sport movements. Firstly, a phenomenon known as bilateral deficit refers to a situation where the sum of individual muscle forces when each limb is working on its own is greater than the combined forces produced when both limbs work simultaneously (bilaterally). To use a weight training exercise as a possible illustration of bilateral deficit, the sum of the elbow flexor forces when performing a dumbbell bicep or arm curl with one arm at a time is greater than the combined forces of both arms when performing a barbell bicep or arm curl. Since the bilateral condition is associated with decreased electrical activity in the prime mover muscles (Vandervoort et al., 1984), it is an indication of inhibited MUA.

Secondly, when an agonist muscle contracts, a certain degree of co-contraction of the antagonist muscle may occur. For example, if an athlete wanted to produce a powerful contraction of the triceps brachii (agonist) to produce elbow extension, any significant co-contraction of the elbow flexor muscles would inhibit, via reciprocal inhibition, the effect of the agonist contraction.

Thirdly, golgi tendon organs (GTO) that are located in tendons, are stimulated by relatively high tension contractions. Once activated, a reflex is initiated that ultimately acts to inhibit the force of contraction, thereby serving as a protective mechanism to prevent excessive damage to the musculo-skeletal system (Mathews and Fox, 1976).

Fourthly, it has been shown (Ikai and Steinhaus, 1961) that strength can be enhanced by the firing of a starting gun, by shouting, and by a hypnotic condition, compared to conventional conditions of strength testing. Finally, many people have heard anecdotal cases of individuals achieving extraordinary feats of strength under extremely stressful circumstances, which suggests that some neural inhibitions may have briefly been overcome.

It is possible that the inhibitory effect of some of these mechanisms is decreased or eliminated by training, and may in part account for the neural adaptations associated with strength gains. For example, strength training might cause the tension threshold for activation of the GTO mechanism to increase, therefore causing the inhibition to occur only with stronger contractions (Hakkinen and Komi, 1983).

Nevertheless, it seems likely that even a trained athlete would have difficulty achieving *complete* MUA of all individual muscles contributing to an explosive sports movement. Possibly the central nervous input is “shared” by the many muscles activated in a complex sports movement. So it seems that athletes may have a “strength reserve”, and therefore do not achieve the greatest strength and power output that is potentially possible in a sports event. It would be of interest to any coach or athlete involved in power events to be able to uncover this untapped potential.

EXPERIMENTS ON WARM-UPS

To test the possibility that a very intense warm-up might facilitate performance in sprinters, some preliminary experiments were conducted at Ballarat University College. No conclusions can be drawn from the results at this stage, but the basic findings are encouraging and are reported below.

1) Peak power and work output over seconds is measured by a cycle ergometer test was statistically significantly increased when using a warm-up that included heavy squats, compared to a conventional competition warm-up for sprinters.

2) Since performing squats in a warm-up is somewhat impractical due to the difficulty in gaining access to weights so close to a race, a plyometric warm-up was designed. This also resulted in significant gains in peak power and 10 sec work output compared to a conventional sprint warm-up, but only when performed five minutes prior to testing.

3) No significant improvement occurred when the plyometric warm-up was completed 10 minutes prior to testing. This suggests the facilitation is short term and “wears off” with time.

4) Twenty meter sprint time (using blocks) and vertical jump performance were also significantly improved by a plyometric warm-up, providing it was completed two minutes before testing.

These results suggest that there may be a performance enhancing effect by incorporating some intense weight training or plyometric exercises into a warm-up. Possibly neural input to the muscles is increased, or MU excitability is heightened, resulting in recruitment of some high threshold fast MU that would otherwise be inactive. Further study needs to be carried out to determine conclusively if a warm-up can be designed to significantly increase performance, as well as to reveal the possible mechanism related to the nervous system. Some factors that need to be considered are:

1. Choice of exercises used in the warm-up.

2. Volume and intensity of the warm-up.

3. Time, period from the end of the warm-up to the commencement of the performance.

4. The level of performance of the athletes.

5. Applicability to different events.

TRACK AND FIELD

If increased neural activation via a warm-up can be shown to positively influence performance, there would be a significant application to the modification of warm-up methods. Plyometric exercises such as depth jumping or bounding may be useful, and can be done in the warm-up area without specialized equipment. In track events the increased explosiveness would be expected to be most beneficial to the shortest sprints. As the track event increases in distance and time, power becomes a less important quality and other performance factors (e.g. aerobic fitness) become more important. Therefore any benefit expected might be restricted to events up to 400m.

Field event athletes would be expected to gain most from any neuro-muscular excitation acquired from their warm-up. For example, throwers might consider warming up with overweight implements or some other method believed to “shock” the nervous system. In a six round field event competition lasting more than one hour it is possible that stretching and other somewhat passive activities performed between attempts are inadequate for the maintenance of a heightened neuro-muscular system necessary for peak performance. This would suggest that athletes should consider some intense (but non-fatiguing) activities such as plyometric jumps between rounds.

Further experimentation on neural activation in both the laboratory and on the track will be necessary to uncover the potential for improvement in performance for track and field athletes.