SHOCK ATTENUATION AND QUADRICEPS MUSCLE FATIGUE IN DOWNHILL RUNNING

The short report presents the new interpretations of old data. The suggestion is based on the relationship between the increased MPF of quadriceps EMG and the decreased shock attenuation (sacrum/shank ratio) during prolonged downhill running.

Paul et al (1978) suggested that the muscles play a major role in the shock attenuation (SA) of the strike-induced shock accelerations. McMahon et al (1987) shown that in running with increased knee flexion so-called “Groucho running” the increased SA was associated with the increased oxygen consumption and, consequently, the increased muscle activity. Collins and Whittle (1989) discussed that the increased shock propagation and the decreased shock attenuation along the musculoskeletal system initiated with foot-ground contact during human locomotion can be associated with the progression of two pathological conditions – osteoarthritis and low back pain. Few studies have examined the effect of the muscle fatigue on SA in human running (Voloshin et al 1998, Mizrahi et al 2000, 2001, Derrick et al 2002, Mercer et al 2003). The mechanism of muscle SA of the heel strike-induced shock acceleration is still not clear (Mizrahi et al 2001).

Muscle fatigue is defined as a failure to maintain the required or expected force (Edwards 1981). The muscle fatigue is associated with increased integrated electromyogram (iEMG) and decreased mean power frequency (MPF) of EMG for a given performance (Edwards 1981). In order to limit a physiological condition, quadriceps muscles EMG in downhill running was only observed due to specific relationship between muscle morphology and EMG parameters during fatigued load (Wretling et al 1997).
The aim of the present study is to provide a current update of the relationship between quadriceps muscle fatigue and quadriceps muscle shock attenuation in downhill running. In downhill running there is a combination of two negative factors first, exercise-damaged quadriceps muscle performance due to eccentric exercise (Clarkson and Hubal 2002) and second, heel strike induced high-frequency impact acceleration along the musculoskeletal system (Mizrahi et al 2000).

Dick and Cavanagh (1987) used 40 min downhill running with running speed equal 66% of peak O$_2$ consumption which was determined during the level running test. Mizrahi et al (2001) used 30 min downhill running with running speed where the anaerobic threshold (AT) was exceeded in level running (only by 5%). AT was determined in level running test. The prolonged sub-maximal downhill running was associated with significantly increased iEMG (Dick and Cavanagh 1987, Mizrahi et al 2001), significantly increased MPF of EMG and significantly decreased SA between tibial tuberosity and sacrum levels (Mizrahi et al 2001). Despite the fact that MPF of quadriceps EMG significant increased the quadriceps muscle was determined by Mizrahi et al (2001) as fatigued muscle. Jansen et al (1997) shown that the relationship between EMG power frequency and the muscle fatigue development, as observed in isometric protocols, cannot be simply applied in dynamic exercise. It has been reported that the higher median frequency during eccentric contractions may be explained by selective recruitment of fast-twitch motor units (McHugh et al 2000).

It is suggested that an increase of the MPF of EMG of quadriceps versus downhill running, as reported by Mizrahi et al (2001) is reflected the compensatory inclusion of the fast-twitch motor units in order to support the performance in the downhill running.
It was hypothesized that in the downhill running a decrease in the SA of quadriceps muscle is associated with selective disturbance in muscle fibers which is recurred by mean of slow-twitch motor units. Armstrong and Taylor (1993) reported that the running downhill caused structural damage in deep slow-twitch extensor muscles of the limbs. In order to support the assumption in further work is needed to use both high-intensity eccentric repetitive load and high-frequency impact acceleration along the musculoskeletal system. The jump-plyometric load with sub-maximal intensity and with jumping frequency equal step rate in running up to quadriceps fatigue development can be used to examine the trend of MPF of EMG of quadriceps. The load will be done by means of recruitment of fast-twitch motor units. The fatigued load will be associated with the decreased MPF of quadriceps EMG. However, the change of SA in jump-plyometric cannot be simply predicted such as SA not only the function of muscle attenuation properties but also the function of change in joint stiffness of the leg due to different strike pattern between jump pyometric load and running (Butler et al 2003).

References


