RELATIONSHIPS BETWEEN STIFFNESS, PASSIVE FLEXIBILITY, DYNAMIC RANGE OF MOTION AND RUNNING ECONOMY
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Running economy is a characteristic which varies considerably between runners and which has a substantial influence on performance. In some studies, joint flexibility has been found to be a factor which negatively affects economy, however the influences on economy of related characteristics such as leg stiffness and dynamic range of motion during running are not well understood.

Methods: Active university students (N = 26) were recruited for this study in which running economy, kinematic and kinetic characteristics were measured. Based on results from a maximum oxygen uptake test, subjects were tested during treadmill running at speeds corresponding to 60, 70 and 80% of max VO2. During 8 minutes of running at each speed, running kinematics were determined using an 8-camera Qualisys ProReflex system and oxygen uptake was recorded using standard metabolic methods. Based on mass-spring modeling and stance-swing timing, vertical and leg stiffness were determined (Morin et al. 2005). In addition, each runner’s flexibility was assessed by an experienced physical therapist using goniometry. Comparisons were made across speeds using repeated measures analysis of variance and inter-relationships of these characteristics were evaluated using Pearson correlation.

Results: Running speeds at 60, 70 and 80% of max VO2 were 2.7±0.3, 3.2±0.3 and 3.6±0.3 m/s with oxygen uptakes of 31±3, 36±3 and 41±4 ml O2/kg/min. Vertical stiffness (Kvert) increased systematically with speed (p<.01) while leg stiffness (Kleg) remained constant. Dynamic range of motion (ROM) at hip, knee and ankle increased with speed (p<.01). Both Kvert and Kleg were significantly related to hip dynamic ROM (r = -.77 and -.62) but only weakly to knee and ankle motion. None of the stiffness nor dynamic ROM characteristics were significantly related to economy. Passive flexibility measures were only moderately related to economy (ankle: r = .46 and hip ext rotation: r = .35) but were in some cases more strongly related to Kvert (hip int rotation: r = -.66).

Discussion: Based on previous studies (e.g. Craib et al., 1996) a positive relationship between flexibility and economy was expected. Also anticipated was an inverse relationship between flexibility and running stiffness, however this did not result in a clear connection of leg or vertical stiffness to running economy. This is contrary to the findings of Dalleau et al. (1998) where a strong association (r = -.80) was observed between cost of running and leg stiffness. Methodological differences may explain these conflicting results.