The Relation Between Reactive Strength Index and Running Economy in Long-Distance Runners

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Introduction: There are several physiological factors that affect long-distance running performance, which include maximal oxygen uptake (VO_{2max}), running economy (RE), lactate threshold, and velocity at VO_{2max} (Basset Jr., & Howley, 2000; Beattie et al., 2014). Running economy is defined as the energy demand at a given velocity of a submaximal workload (Bassett Jr & Howley, 2000). Given this definition, factors such as leg-spring stiffness (k) can reduce energy demand (VO_2) during running due to superior elastic energy return, meaning increased stride length and decreased ground contact times. Furthermore, evidence has shown a positive relationship between reactive strength and k (Brazier et al., 2014). Reactive strength reflects the effectiveness of an individual's stretch-shortening cycle (SSC) (Flanagan, & Comyns, 2008). Reactive strength can be measured using the reactive strength index (RSI), which is derived as the ratio of jump height (JH) to ground contact time (CT) during a drop jump (DJ). Additionally, a modified RSI (RSI_{mod}) is a reliable measurement that evaluates any vertical plyometric movement, such as a countermovement jump (CMJ) (Ebben, & Petushek, 2010). An individual's RSI is a reliable measure of their explosiveness, or how quickly they can produce power (Flanagan, Ebben, & Jensen, 2008). Therefore, an increased RSI score is beneficial to athletes, as that reflects increased k, which may reflect superior metabolic efficiency in distance runners. To date, research has not examined the relationship between RSI and RSI_{mod} and the oxygen cost of running. It is therefore the aim of this study to determine which RSI measurement, if any, correlates best with VO_2.

Methods: Fifteen competitive middle-to-long distance runners (female n = 12; age 29.2 ± 10.2 years; height 169.1 ± 8.1 cm; mass 60.5 ± 10.2 kg) were recruited to participate in this study. All athletes were competing at local club level or NCAA Division III cross-country running events. All participants gave written informed consent and attended the lab on three separate occasions for familiarization and testing.

Treadmill testing involved the completion of 5-8 three-minute stages with increasing workload. Heart rate (HR), VO_2, rating of perceived exertion (RPE), and blood lactate (B_{Lac}) were recorded at the end of each stage. Strength testing involved the assessment of participants' three repetition maximum (3RM) back squat performance along with their CMJ and DJ (box height of 30-cm) performance. Participants completed three repetitions for both the CMJ and DJ (assigned randomly) and received 2-min rest between each repetition. All jumps were performed on an AMTI force plate. Participants' maximum RSI and RSI_{mod} were calculated as JH divided by CT (Flanagan, Ebben, & Jensen, 2008) and JH divided by time to takeoff (Ebben, & Petushek, 2010), respectively. Participants' 3RM back squat performance was assessed using the procedures of NSCA protocol (Baechle, & Earle, 2008).

Statistical analysis. Normality assumptions were tested using scores for skewness and kurtosis as described by Field, (2015). Pearson's correlation test was used to examine the relationship between RSI and RSI_{mod} and the oxygen cost of running at 12 and 14 km.h^{-1} (i.e. RE).

Results: Data showed a significant negative correlation between RSI and VO_2 at 12 km.h^{-1} (R^2 = 0.29; $p \leq 0.05$) and 14 km.h^{-1} (R^2 = 0.37; $p \leq 0.05$). R^2 values showed RSI explained 38% of variance in VO_2. No significant result was found between RSI_{mod} at 12 km.h^{-1} and 14 km.h^{-1}.

Discussion: Results show that participants exhibiting higher RSI used less energy while running at 12 and 14 km.h^{-1}. Thus, participants exhibiting higher RSI were more efficient while running at submaximal workloads relative to those with lower RSI scores. These results provide further support for the influence of strength characteristics on distance running performance. Changes in RE following strength training may be due to increases in lower extremity stiffness, and therefore reactive strength (Brazier et al., 2014). The findings of this study suggest that strength and conditioning practitioners should consider implementing both strength and plyometric exercises into training programs for long-distance runners. These types of training can improve reactive strength, which is shown to reduce ground contact time during running, and therefore improve running economy (Brazier et al., 2014; Flanagan, & Comyns, 2008; Saunders et al., 2006). Future research should focus on identifying the mechanisms responsible for changes in RE following resistance training.

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