THE WORK AND ACTIVATION OF LOWER EXTREMITY MUSCLES IN EXPLAINING INTERINDIVIDUAL VARIABILITY IN RUNNING ECONOMY

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The purpose of this study was to describe the relationships between RE and the neuromechanics of ground contact. Results of biomechanical studies suggest that more economical runners use different neuromuscular strategies during the stance phase of running. Research in our lab revealed significant, positive correlations between metabolic cost and positive work at the hip and ankle, but significant, negative correlations between metabolic cost and positive work at the knee. Studies focusing on RE and muscle activation patterns show contrasting results. Mechanics may suggest straightforward applications to training and coaching, but further study is required in the area of muscle activation.

KEY WORDS: running economy, mechanics, EMG, activation, coactivation

The work of Conley & Krahenbuhl (1980) provided the impetus for research in running economy (RE). They showed conclusively that among a group of homogenous runners (i.e., runners with similar VO2max), RE was significantly related to race performance. Thus, why some runners are more economical than others, especially when examining runners of similar fitness levels, became an important performance question. Keith Williams completed a comprehensive study in 1980, which spawned several publications, and showed that several biomechanical variables help explain the interindividual variability in RE. The research described in this presentation will focus on how runners interact with the ground during the stance phase of running and the relationships between RE and the neuromechanics of ground contact.

Our work with ground reaction force (GRF) characteristics (Heise & Martin, 2001), was influenced by Kram & Taylor's research (1990). They focused on animals representing a wide range of body mass, whereas we studied a homogenous group of human runners. Kram and Taylor suggested that the force required to support a running animal and the time course of that force determine the metabolic cost of running. We showed that less economical humans (higher metabolic cost) exhibited greater total and net vertical impulses, but other GRF characteristics were not related to metabolic cost. These results, combined with our findings showing significant relationships between RE and lower extremity mechanical work (Heise, Smith, & Martin, 2011), led us to study how runners produce these forces during ground contact and thus we focused on muscle activation patterns. Regarding the results of joint mechanical work during stance, we showed significant, positive correlations between metabolic cost and positive work at the hip and ankle, but significant, negative correlations between metabolic cost and positive work at the knee.

Overall, mechanical results highlighted here, and findings of others, suggest that more economical runners use different muscle activation strategies during the stance phase of running. In two separate samples (Heise, Morgan, Hough, & Craib, 1996; Heise, Shinohara, & Binks, 2008), we showed significant, negative relationships between metabolic cost and select measures of muscle activation and coactivation during stance. In other words, economical runners activated certain muscles (or pairs of muscles) for longer durations during stance. This counterintuitive result had implications regarding dynamic leg stiffness during stance and tissue stiffness in general. Recently, however, Moore et al. (2014) presented results in direct contrast with ours; they found metabolic cost to be positively associated with muscle activation durations. To add further uncertainty to this topic of inquiry, we recently reported no correlations between metabolic cost and muscle activation duration using an approach similar to Moore's group, but we did notice different trends between men and women

(Schornstein et al. 2015). Current research in our lab is addressing methodological differences among researchers which may explain these contrasting results centered on RE and muscle activation during stance.

From an applied perspective, the implications from our work examining mechanical and neuromuscular output of the lower extremity musculature during running may inform training decisions made by distance runners and their coaches. Our research findings on RE and mechanical work at the joints of the lower extremity indicate that more economical runners maximize positive work at the knee and minimize positive work at the hip and ankle during stance. This may lead to a greater strength training focus on musculature crossing the knee, but the contribution of two-joint muscles, especially those that cross the knee (e.g., rectus femoris, medial hamstrings, gastrocnemius) must be considered. Research on muscle activation during stance suggest that neuromuscular solutions to optimal mechanical output may be more individual. Therefore, more focus on these neuromuscular solutions must be pursued.

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