CHANGE IN FOOTSTRIKE POSITION IS RELATED TO ALTERATIONS IN RUNNING ECONOMY IN TRIATHLETES

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INTRODUCTION: Biomechanical factors are likely related to the impairment in running economy frequently observed in triathletes when running after cycling (Millet et al., 2000). Cycling has been shown to interfere with muscle recruitment during subsequent running in some highly-trained triathletes (Chapman et al., 2008), but the implications of this on run performance are unknown. Links between muscle recruitment and running economy have been established during isolated running (Paavolainen et al., 1999), which compel the proposition that any change in muscle recruitment following cycling might be associated with running economy. Stride frequency, stride length and hip and knee angles have been reported to be unchanged after cycling (Quigley & Richards, 1996; Hue et al., 1997), however, muscle recruitment and limb movement have not been simultaneously measured in previous studies that have investigated the relationship between biomechanical factors and running economy after cycling. The purpose of the current investigation was to evaluate changes in neuromuscular control (muscle and movement control) during running after a 45 min high-intensity cycle and their relationships to alterations in running economy.

METHOD: Seventeen moderately-trained triathletes participated. Running economy and neuromuscular control were determined by measuring submaximal VO_2, lower limb electromyography (EMG) and sagital plane kinematics for 4 min at 12 $km.hr^{-1}$ during a control run (no prior cycling) and a run after 45 min of cycling (transition run).
A Pearson's correlation was performed to examine the univariate relationship between changes in EMG, kinematics, and VO_2 for control-transition-run comparisons. Significant univariate variables were retained and entered into a stepwise logistic regression model to determine the most accurate set of variables for prediction of an alteration in VO_2 following cycling. A backward elimination regression analysis was also performed to confirm the contribution of the variables to the model. A significance level of 0.05 was necessary to enter the variable into the model and 0.10 required for the removal of the variable to minimise the likelihood of excluding potentially useful variables.

RESULTS: Eight triathletes demonstrated a clinically meaningful (i.e. > 2.4% change as previously described by Saunders et al., 2004a) increase or decrease in VO_2 during the transition run. Correlation analysis of whole group data revealed that four kinematic variables of knee angle at foot contact, ankle angle at foot contact, total excursion of motion at the knee and minimum excursion at the knee were significantly associated with the change in VO_2 following cycling. Subsequent stepwise linear regression revealed that the change in ankle angle at foot contact was most explanatory, with backward elimination revealing the change in ankle angle at foot contact alone explaining 67.1% of the variance in VO_2 compared to 77.5% for all four variables. The association between ankle angle at foot contact and VO_2 was positive; with an increase in ankle-dorsiflexion (relative to the control run) associated with an increase in VO_2 during the transition run.

DISCUSSION: We found the angle of the ankle at foot contact was most closely related to the change in running economy, explaining 67% of the variance in VO_2. A shift to a more dorsi-flexed ankle and extended knee at foot strike increases vertical ground reaction forces

(GRF) (Gerritsen et al., 1995) and vertical GRF are major determinants of metabolic cost during running (Saunders et al., 2004b). An increase in ankle dorsi-flexion angle at foot contact, or a tendency to heel-strike, reduces conversion of translational energy into rotational energy as most of the energy is lost in collision with the ground (Lieberman et al.,, 2010). In contrast, it has been speculated that landing in a more plantar-flexed position may enhance performance through exploitation of elastic energy storage and conversion (Liebermanet al., 2010).

CONCLUSION: Changes in kinematics at the knee and ankle were most correlated to alterations in VO_2 after cycling, with the angle of the ankle at foot contact being predominant. Therefore ankle position at ground contact may be important for triathlete peformance and training interventions aimed at restoring running kinematics after cycling may benefit some triathletes performance.

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