Lower Extremity Coordination Changes During a Fatiguing Run

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Introduction

Studies have shown that runners adapt different locomotor strategies with fatigue (Bates et al., 1977). These studies have primarily focused on basic system dynamics such as stride rate and stride frequency. Additional information may be obtained through examining changes in joint co-ordination. Coordination changes have been associated with injury in non-fatiguing conditions (Bates et al. 1978; Hamill et al., 1992). Furthermore, the magnitude of kinematic couplings may also have potential clinical implication due to greater torsional stresses at the knee (McClay et al., 1997). Therefore, the purpose of this study was to examine the changes in lower extremity coordination with fatigue during an exhaustive run.

Methods

Four healthy male runners served as subjects in this study. All subjects were free of injury prior to participation and ran at least 25 miles per week. Each subject ran on the treadmill at their predetermined 10K race pace until volitional exhaustion. Three dimensional kinematic data were collected at 240Hz for 20 seconds every 3 minutes. Triads of markers on a rigid structure were placed on the foot, leg and thigh. Coordination of the ankle eversion (AE) and knee flexion (KF) coupling was defined using a modified Poincaré Section (MPS) of an angle-angle plot at maximum knee flexion during stance. The mean of fifteen strides was calculated for each interval for each subject. A simple linkage cluster analysis was performed on each subject’s mean intervals. A large increase in the distance between two adjacent intervals represents a change in coordination (cophenetic coefficients ranged from 0.8051 to 0.9174). A dendrogram is a hierarchical classification method that was used to determine cluster formations. Two objects in close proximity form a linkage. A collection of small linkages represents one cluster (Figure 1).

Results & Discussion

Each runner displayed unique changes in the knee flexion/ankle eversion coupling throughout the exhaustive run. For example, four distinct coordination patterns were exhibited by subject A with a general decrease in both ankle eversion and knee flexion (Figure 2). All subjects displayed changes in coordination at different percentages of the exhaustive run. The coordination changes for subject A occurred at 23%, 46% and 62% of the run. The linkages formed between these critical points also demonstrate this (Figure 1). For example, a cluster was formed as a result of the links between 0 and 23 % exhaustion.

The results of the cluster analysis on the MPS was sensitive to coordination changes during an exhaustive run. Each subject accommodated to fatigue with different coordination strategies. For example, two subjects showed an increase in magnitude of KF and AE with fatigue while the others showed a decrease in these parameters. This contradicts previous studies that have shown a systematic increase in eversion with fatigue in all subjects (Fromme et al., 1997). Other studies have associated changes in the timing of knee flexion and ankle eversion with injury (Hamill et al., 1992). In addition to examining the timing of this coupling, one should also consider the magnitude of this joint coordination.
The method used in this study was sensitive enough to detect alterations in the strategies subjects used in the fatiguing protocol. The results of this analysis illustrate that each subject utilizes a different strategy in terms of joint coordination throughout the run.

**References**