MECHANICAL CONSTRAINTS DO NOT CHANGE THE STRENGTH OF LOCOMOTOR-RESPIRATORY COORDINATION DURING RUNNING

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INTRODUCTION

Coupling between movement and breathing rhythms is thought to be a consequence of mechanical constraints placed on these systems. During locomotion, proposed mechanical constraints have taken the form of a visceral piston resulting from the visceral mass moving relative to the trunk cavity [1], the sagittal plane orientation of the trunk [4], and/or the demands placed on the respiratory musculature in controlling the trunk against perturbations [2]. Currently, little is known about the extent to which these constraints influence locomotor-respiratory coordination (LRC) due to limitations in many methods used to evaluate LRC [3] and because these constraints have previously not been measured.

The purpose of this study was to examine the influence of mechanical constraints that are induced by different uphill and downhill slopes on LRC during running. It was expected that greater constraints in terms of trunk flexion and accelerations of the trunk would result in greater strength of LRC.

METHODS

Thirteen male runners whose mean age was 27.4 (±11) years and ran 49.9 (±15.9) km/week participated in this study. The experimental conditions consisted of running at the preferred speed at level (0%) grade, followed by –9%, -6%, +6%, +9% grades in a random order. During the last 2.5 minutes of each condition, 3D motions of the thoracic trunk and pelvis were recorded (Qualisys, Inc.) along with the timing of right heel strike (tibial accelerometer, Entran Devises) and respiratory volume (respiratory airflow integrated with respect to time, Teem 100, Medical Graphics Corp.).

Mechanical constraints were evaluated at the trunk over 20 randomly selected strides by: 1) sagittal plane orientation, 2) magnitude of peak vertical linear accelerations and 3) magnitude of peak sagittal plane angular accelerations. LRC was obtained by first calculating the relative phase between each heel strike and end-inspiration [3]. The strength of LRC frequency coupling was quantified through return maps and time lags, and was defined as the extent to which the dominant frequency coupling occurred. The strength of phase coupling was quantified by the regularity of consecutively occurring phase relations [3].

RESULTS

Increases in slope resulted in systematic increases in overall trunk flexion from 5.3° during the –9% to 15.1° during the +9% condition (p's <0.0002). Accelerations of the trunk were primarily influenced by the downhill conditions (Figure 1). The peak forward and backward directed angular accelerations (left panel) as well as the peak vertical linear accelerations (right panel) were greater during the downhill grades than during the level and uphill grades (p’s<0.05). Despite these changes there were no consistent changes in the strength of locomotor-respiratory frequency and phase coupling (Figure 2) in response to the imposed uphill and downhill running slopes (p’s>0.05). Correlation analyses showed that the timing of peak angular trunk acceleration was associated with the intra-subject variability of LRC (r=0.32, p= 0.01).

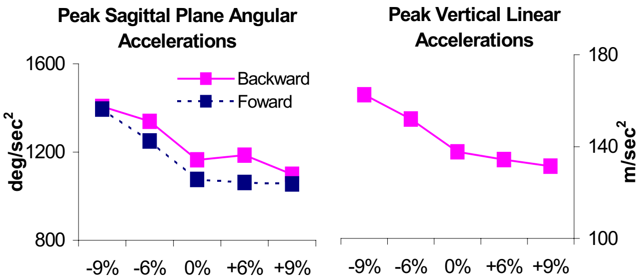

Figure 1: Peak angular and linear accelerations of the thoracic trunk.

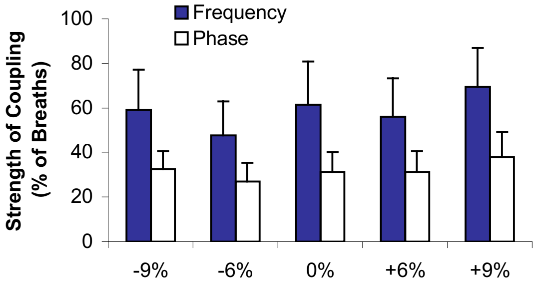

Figure 2: Strength of frequency and phase coupling between the locomotory and respiratory rhythms.

CONCLUSIONS

The results of this study indicate that proposed mechanical constraints do not act to couple locomotory and breathing rhythms in a way that increases the strength of coupling. Results from coupling analyses also suggest that increases in the *variability*, not strength, of LRC may be associated with changes in mechanical constraints. Increases in mechanical constraints imposed may therefore not result in greater coupling between locomotion and respiration, but in enhanced variability in their coordination and decoupling.

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