CHANGES IN JOINT KINEMATICS AND ASYMMETRY THROUGHOUT A RUN TO FATIGUE IN HEALTHY FEMALE RUNNERS

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INTRODUCTION

Running is a popular form of physical exercise due to its cardiovascular and weight control benefits. It is, however, a high-impact and repetitive activity that results in an annual injury rate of nearly 50% of its participants [1].

A large portion of running injury studies focus on the analysis of data collected in a fresh state. However, it is likely that any injury-related effects are not present until a runner becomes fatigued. Kinematic alterations as a result of fatigue may also result in a more asymmetrical gait, and thus, injury susceptibility on one side. Gait asymmetries have been linked to injuries in both runners [2] and non-runners [3]. However, the link between asymmetry, injury, and fatigue is unclear. Previous studies, which suggest that injury-susceptible runners are not more asymmetrical than runners who remain uninjured [2], where conducted in a fresh state.

The effects of fatigue on lower extremity kinematics have been well documented. Literature has shown changes in lower extremity kinematics following an exhaustive treadmill run [4]. However, no studies have looked at what point during the run are kinematic changes likely to occur. Documenting the progression of changes that occur in normal, healthy runners with fatigue is important for comparison to injured populations.

Therefore, this study looks to examine changes in joint kinematics and kinematic asymmetry that occur over the course of a run to exertion. It is hypothesized that kinematics and asymmetry values would change over time.

METHODS

As part of a normative running database, data from the first six of 100 healthy female runners (32.5years $\pm$7.5, 1.58m $\pm$ 0.9, 56.7kg $\pm$ 4.7) were included in this study. All runners were rearfoot strikers, free from injury and running a minimum of 15 miles/week.

Instrumented gait analysis was performed while participants performed a run to exertion on a treadmill. Video data were collected at 120Hz. All runners wore a laboratory-provided neutral running shoe (New Balance 1062; Boston, MA) with holes cut out of the heel to allow for marker placement directly on the skin over the calcaneus.

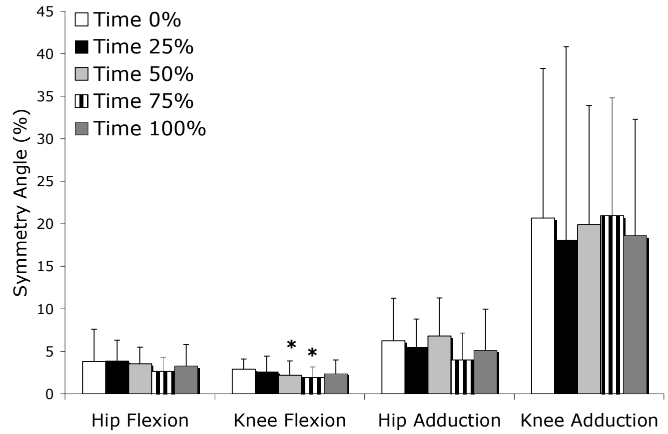

Figure 1: SA values at 0%, 25%, 50%, 75% and 100% of a run to exertion. Significant differences between baseline and a time interval are indicated by (*).

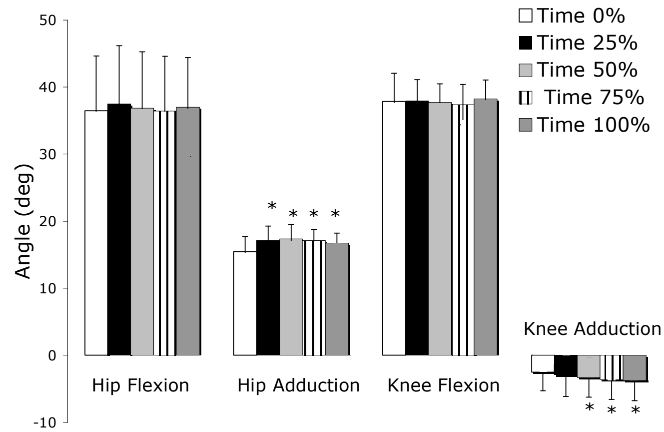

Figure 2: Loading response peak hip and knee angles at 0%, 25%, 50%, 75% and 100% of a run to exertion. Significant differences between baseline and a time interval are indicated by (*).

The run to exertion (23.5 minutes ±5.8) was performed at the individuals' self-selected 5K race pace. Runners were considered exerted when they reached a rating of 17/20 on the Borg Rating of Perceived Exertion Scale. Data were collected every three minutes over the course of the run. Video data were smoothed with a low-pass fourth order Butterworth filter.

Peak hip flexion, peak hip adduction, peak knee flexion and peak knee adduction were measured during the loading response phase of stance. Loading response was defined as the period of time from initial contact to first peak knee flexion. Data from the dominant limb were used for analysis of kinematics. Data from both limbs were used to calculate asymmetry values: the symmetry angle (SA), as described by Zifchock et al [5] was used to quantify asymmetry. An SA value of 0% indicated perfect symmetry, while increasing values were indicative on increasing asymmetry. Peak joint angles and SA values calculated at 0%, 25%, 50%, 75% and 100% of the run were used for this analysis. A one-way repeated measures ANOVA was used to test for differences across time. A significant ANOVA was followed up with post-hoc testing that compared each time period to baseline (0%). Due to the preliminary nature of the study, significance was set at $p \leq 0.10$.

RESULTS AND DISCUSSION

SA value data are shown in Figure 1. There were no significant changes in hip flexion, hip adduction or knee adduction SA values over time. However, there was a significant change in knee flexion asymmetry (P= 0.067). Post-hoc testing revealed significant changes between times 0% and 50% (P=0.099) and 0% and 75% (P=0.039). Other than at 100% of the run, SA values tended to decrease. These findings are contrary to the expectation that asymmetry levels would increase. In fact, SA values at the knee demonstrated decreased knee flexion asymmetry.

Kinematic data are included in Figure 2. These data show significant changes in frontal plane hip (P=0.012) and knee (P=0.002) angles over the course of the run to exertion. During loading response, runners demonstrated significantly increased hip adduction between times 0% and 25% (P=0.033), 0% and 50% (P=0.019), 0% and 75% (P=0.062), and 0% and 100% (P=0.033). Knee abduction angles increased between times 0% and 50% (P=0.05), 0% and 75% (P=0.062) and 0% and 100% (P=0.017). No significant change in knee abduction angle was seen between time 0% and time 25%. There were no significant changes in peak hip and knee flexion angles during loading response. These findings differ from previous research [4] that found increased stance phase peak knee flexion angles following a run to exertion. However, it is unclear whether these changes have occurred as a result of muscular fatigue, or as a means to prevent injury by absorbing shock and minimizing impact forces.

CONCLUSIONS

In healthy runners, there was significantly decreased knee flexion asymmetry throughout a run to exertion. There were no significant changes in sagittal or frontal plane hip asymmetry nor were there significant changes in frontal plane knee asymmetry throughout a run to exertion. Additionally, this study demonstrates that healthy runners had increasingly larger peak hip adduction and knee abduction angles throughout a run to exertion. Future studies will focus on joint kinematic changes and asymmetry changes as a result of exertion in an injured population.

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