THE EFFECT OF FATIGUE ON SINGLE-LEG HOP BIOMECHANICS

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INTRODUCTION: The single-leg hop is a commonly-used clinical test for patients with knee pathology (e.g. ACL injury). There is currently little information in the literature regarding the biomechanics of this test. However, studies of drop-landings have shown that substantial extensor moments are needed at the hip, knee and ankle to balance and support the body upon ground contact. (Decker et al., 2003) Total support moment represents the total extensor pattern of the lower extremity to support the body and has been used previously to measure support and balance strategies during the single-limb stance phase of gait. (Winter et al.,1990) When applied to the single-leg hop, this concept may prove useful in analyzing changes in support strategies due to fatigue or injury. The purpose of this study was to compare landing support strategies of the lower extremity before and after fatigue.

METHODS: We recorded kinetic and kinematic data from the dominant legs of eleven healthy, male subjects as they performed a single-leg hop in both the unfatigued and fatigued states. Using an inverse dynamic model, we calculated sagittal plane joint angles, moments at the ankle, knee and hip for each landing. All joint moments were normalized to body mass.
Subjects performed a maximal single-leg hop to establish a baseline followed by three hops onto the force plate from 80% of this distance. They then completed two sets of fifty step-ups to a height of 32 centimeters until they hopped 80% or less of their original baseline performance. Subjects then hopped onto the force plate three more times from the same distance as the unfatigued trials. The total support moment was calculated for each trial by adding the net moments at the ankle, knee and hip. Paired t-tests were used to compare joint angles and percent contribution of each joint to the maximum total support moment in the fatigued and unfatigued states. P-values less than 0.05 were considered significant.

RESULTS: There was a significant increase in knee range of motion from 46.22 ± 13.60 degrees in the unfatigued state to 58.15 ± 21.15 degrees in the fatigued state ($p = 0.021$). A significant increase in hip range of motion was also observed in the fatigued state ($p = 0.036$). No significant difference was found in the maximum total support moment before and after the fatigue protocol ($p = 0.176$). There was a significant increase in the percent contribution of the ankle to the maximum total support moment from 11.9 ± 8.31 % to 20.17 ± 8.02 % ($p = 0.01$) and a significant decrease in the sum of the knee and hip contributions from 88.40 ± 7.88 % to 79.89 ± 7.94 % ($p = 0.008$).

DISCUSSION: In this experiment, the total support moment represented the extensor pattern used by the lower extremity to decelerate and to balance the body during landing. The results of our analysis of the single-leg hop are analogous to Winter's conclusion that the total support moment during gait remains constant while the contributions of each joint may vary depending on the situation (1990). The step-up exercise primarily fatigued the thigh musculature causing the decrease in extension moment and increased ROM. To compensate for this deficit, the extensor moment at the ankle was increased in order to decelerate the body and to maintain a constant total support moment. The preliminary results of this study show that fatiguing the muscles of the lower extremity changes the support strategy used in landing from a single-leg hop. Biomechanical analysis of the single-leg hop landings may reveal more about lower extremity adaptations in response to injury than simply measuring the distance hopped.

REFERENCES:

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