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INFLUENCE OF TRUNK FLEXION ON HIP AND KNEE KINETICS AND ENERGETICS DURING RUNNING

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SUMMARY

The current study found that trunk posture is associated with the biomechanical demands at the hip and knee during running. A more extended trunk posture was associated with greater peak knee extensor moments and greater knee extensor energy absorption. This suggests that individuals who run with a more upright trunk may be predisposed to a higher risk of patellofemoral pain and/or patellar tendinopathy. Moreover, a forward lean trunk posture may be utilized to reduce mechanical demands at knee during running.

INTRODUCTION

The number of individuals who engage in running for health and fitness has grown significantly in the last few decades. Despite the positive health effects associated with running, recent literature has reported a high incidence of lower extremity running injuries (19% to 79%), with half occurring at the knee joint.[1,2]

In an attempt to reduce lower extremity injury risk, popular running techniques advocate the utilization of a more forward lean trunk.[3,4] Although a forward trunk lean has been shown to decrease knee extensor moments during stair ascent and hopping,[5,6] no study has examined the influence of trunk posture on lower extremity biomechanics during running. The purpose of this study was to examine the association between sagittal plane trunk posture and hip and knee kinetics and energetics during running.

METHODS

Twenty male and twenty female recreational runners participated in this study (age: 26.6 ± 6.3 years; height: 1.69 ± 0.1 m; weight: 65.9 ± 9.1 kg; running distance per week: 23.5 ± 15.9 km). All subjects were natural heel-strikers and did not report any lower extremity injury, symptoms or previous history of surgery at the time of testing. Three-dimensional trunk and lower extremity kinematics (250 Hz, Qualisys, Gothenburg, Sweden) and ground reaction force data (1500 Hz, AMTI, Watertown, MA) were collected while subjects ran overground with a self-selected trunk posture at a speed of 3.4 m/s (± 0.1 m/s). The trunk segment was defined by markers placed on bilateral acromioclavicular joints and the highest point of the iliac crests. Trunk orientation was calculated relative to the global coordinate system (vertical axis). Sagittal plane trunk angles and lower extremity net joint moments and power

were computed using Visual 3D software (C-Motion, MD, USA). Variables of interest included the mean trunk flexion angle and hip and knee peak extensor moments and energy absorption during the stance phase of running. Energy absorption of the knee and hip extensors was quantified as the integral of negative power with respect to the time when the internal muscle moment was positive.

Subjects were dichotomized into High-Flexion (N=20) and Low-Flexion (N=20) groups according to their mean trunk flexion angle during the stance phase of running. Group differences in lower extremity kinetics and energetics were assessed using Independent t-test. Associations between trunk posture and kinetic and energetic variables were examined using Pearson correlations using pooled data from all 40 subjects. The level of statistical significance was set at 0.05.

RESULTS AND DISCUSSION

On average, the High-Flexion group exhibited $10.8^\circ (\pm 2.2^\circ)$ of trunk flexion during the stance phase of running while the Low-Flexion group demonstrated $3.6^\circ (\pm 2.8^\circ)$ of trunk flexion (Figure 1).

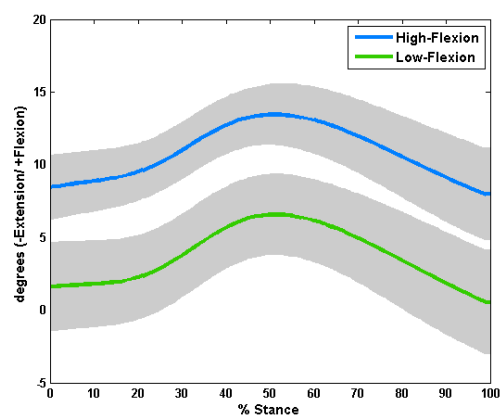


Figure 1: Time-series curves of sagittal plane trunk posture of the Low-Flexion and High-Flexion groups during the stance phase of running.

When compared to the Low-Flexion group, individuals in the High-Flexion group demonstrated significantly lower peak knee extensor moments (2.66 ± 0.30 Nm/kg vs. 2.90 ± 0.30 Nm/kg) and higher peak hip extensor moments (1.77 ± 0.23 Nm/kg vs. 1.48 ± 0.37 Nm/kg)(Figure 2). The High-

Flexion group also exhibited significantly lower energy absorption of the knee extensors (0.60 ± 0.14 J/kg vs. 0.74 ± 0.09 J/kg) than the Low-Flexion group (Figure 3). No group difference in hip extensor energy absorption was found (Figure 3).

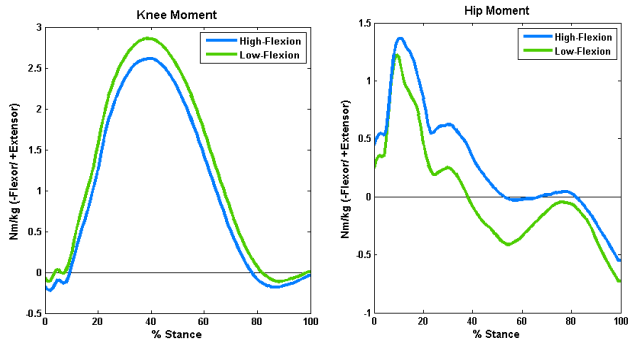


Figure 2: Time-series curves of knee and hip moments during the stance phase of running.

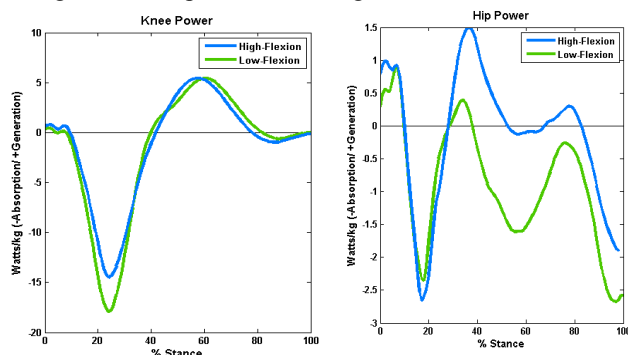


Figure 3: Time-series curves of knee and hip power during the stance phase of running.

Results of Pearson correlations indicated that the trunk flexion angle was inversely correlated with the peak knee extensor moment ($r=-0.55$, $p<0.001$) and knee extensor energy absorption ($r=-0.55$, $p<0.001$) and positively correlated with peak hip extensor moment ($r=0.48$, $p=0.002$). There was no correlation between trunk angle and hip extensor energy absorption.

Our results indicated that a relatively small difference in trunk flexion ($\sim 7^\circ$) was of sufficient magnitude to affect hip and knee kinetics and energetics during running. Consistent with previous studies that examined the influence of trunk

posture on lower extremity kinetics during stair ascent and hopping, a more flexed trunk posture was associated with a greater peak hip extensor moment and a more extended trunk was associated with a higher peak knee extensor moment. In addition, the results of this study also indicate that a more extended trunk posture is associated with higher energy absorption of the knee extensors. Taken together, our results suggest that running with a more extended trunk may predispose an individual to a higher risk of patellofemoral pain and/or patellar tendinopathy. Furthermore, our findings suggest that modifying trunk posture may be an effective strategy to modulate hip and knee mechanics during running. For example, a more forward trunk lean may be utilized to decrease anterior knee pain in persons who are symptomatic.

CONCLUSIONS

Sagittal plane trunk posture was found to be associated with the biomechanical demands at the hip and knee during running. More specifically, a more extended trunk posture was associated with a greater demand on the knee extensor mechanism. Conversely, a more flexed trunk was associated with a lower demand at the knee extensors and a higher demand at the hip extensors. The results of this study suggest that a more extended trunk posture may be related to the development of knee injuries during running.

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REFERENCES

1. van Gent RN, et al., *British Journal of Sports Medicine*. **41**: 469-480, 2007.
2. Taunton JE, et al., *British Journal of Sports Medicine*. **36**: 95-101, 2002.
3. Dreyer D & Dreyer K, *ChiRunning*, 2009.
4. Arendse RE, et al., *Medicine & Science in Sports & Exercise*. **36**: 272-277, 1998.
5. Asay JL, et al., *Journal of Orthopaedic Research*. **27**: 325-329, 2009.
6. Oberländer KD, et al., *Journal of Biomechanics*, **45**: 1387-1392, 2012.