THE INFLUENCE OF SAGITTAL-PLANE TRUNK POSTURE ON PATELLOFEMORAL JOINT STRESS DURING RUNNING

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INTRODUCTION

Patellofemoral pain (PFP) is one of the most common knee joint problems among runners [1]. A commonly accepted cause of PFP is elevated patellofemoral joint (PFJ) stress [2]. As stress is defined as force per unit area, elevated stress could occur as a result of an increase in the PFJ reaction force and/or a decrease in contact area. In turn, an increase in the PFJ reaction force could occur with an increase in the knee flexion angle and/or an increase in the knee extensor moment.

Recent literature suggests that sagittal plane trunk posture can have a significant influence on knee joint kinematics and quadriiceps muscle activation during landing [3]. Therefore, modifying sagittal plane trunk posture may be a potential strategy to alter PFJ stress during running. As such, the purpose of this study was to investigate whether alteration of sagittal plane trunk posture would lead to changes in lower-extremity biomechanics and PFJ stress during overground running. We hypothesized that increased trunk flexion would result in a reduction in PFJ stress. Conversely, we hypothesized that running with a more erect posture would increase PFJ stress.

METHODS

To date, 5 asymptomatic individuals (2 females, 3 males) have participated in this study. Three-dimensional trunk and knee kinematics and the ground reaction force data were collected at 250 Hz and 1250 Hz respectively (Qualysis, Gothenburg, Sweden; AMTI force plate, Watertown, MA) while subjects ran overground at a velocity of 3.4 m/s. Data were obtained under 3 conditions: preferred posture (Preferred), flexed trunk posture (Flexed) and extended trunk posture (Extended). 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 pelvis. Trunk and knee flexion angles as well as knee extensor moment during the stance phase of running were computed by Visual 3D™ software.

A previously described biomechanical model was used to estimate PFJ stress [2]. The model input variables included subject specific parameters (i.e. knee joint kinematics, net knee joint moment) and data from the literature (i.e. knee moment arms, quadriiceps force/patella ligament force ratios and joint contact area). The model outputs were PFJ reaction force and PFJ stress. Variables of interest consisted of peak PFJ stress and the PFJ reaction force, as well as the trunk and knee flexion angles and knee extensor moment at the time of peak PFJ stress. The Friedman tests with post-hoc Wilcoxon Signed Rank test were used to compare differences in PFJ stress and PFJ reaction force among the 3 trunk conditions.

RESULTS AND DISCUSSION

Peak PFJ stresses for each condition are shown in Figure 1. PFJ reaction force, trunk and knee flexion angles and knee extensor moment at the time of peak stress occurred are reported in Figure 2 and Table 1. Significant differences in PFJ stress and reaction force among the 3 trunk conditions were observed (P = 0.041). Post-hoc analysis indicated a significant difference between the Flexed and Extended conditions (P = 0.043). On average, a 13% decrease in both PFJ stress and reaction force was observed between the Flexed and Extended conditions. The reduction of peak stress in Flexed condition was accompanied by a 9.5º increase in trunk flexion, a 1.3º increase in knee flexion and a 0.45 Nm/kg decrease in the knee extensor moment compared to the Extended condition (Table 1).
Our results indicate that a slight increase in trunk flexion (9.5°) can lead to a significant decrease in PFJ stress during running. Conversely, running with a more erect trunk resulted in elevated PFJ stress. The primary contributor to the change in PFJ stress with trunk orientation was a change in the PFJ reaction force. In turn, the change in the PFJ reaction force was driven by a change in the knee extensor moment as opposed to a change in the knee angle. This is logical as a slight change in trunk orientations can have a significant effect on the location of the center of mass and, therefore, the knee moment.

**CONCLUSIONS**

This is the first study to demonstrate the influence of sagittal plane trunk posture on PFJ stress during running. Our data suggest that running with a forward trunk posture can result in decreased PFJ stress. In turn, running with a backward trunk posture can lead to increased PFJ stress. Future studies need to be conducted to determine whether changes in trunk postures can reduce PFP in symptomatic runners.

**REFERENCES**


| Table 1: Trunk and knee kinematics and knee kinetics at the time of peak PFJ stress. |
|---------------------------------|--------|--------|--------|
| **Trunk posture (N=5)**        | Flexed |Preferred |Extended |
| **Trunk flexion angle (degrees)** | 12.1 ± 5.7 | 6.3 ± 6.5 | 2.5 ± 6.3 |
| **Knee flexion angle (degrees)** | 45.8 ± 6.9 | 45.0 ± 7.9 | 44.5 ± 7.4 |
| **Knee extensor moment* (Nm/kg)** | 2.7 ± 0.3 | 3.0 ± 0.4 | 3.2 ± 0.4 |

*normalized by subject’s body weight