Evaluating Runners with and without Anterior Knee Pain Using the Time to Contact the Ankle Joint Complex Range of Motion Boundary

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INTRODUCTION

Excessive ankle joint complex (AJC) eversion is frequently reported as a risk factor in the development of overuse running injuries such as anterior knee pain (AKP)1. Orthotic studies have supported this link, providing evidence that when eversion is controlled, knee pain and function improve2-3. Conversely, prospective and retrospective biomechanical studies have not consistently shown a link between excessive eversion and AKP4-5.

One potential reason for the discrepancy between biomechanical and orthotic studies could be in the definition of excessive eversion. Recent evidence has suggested that evaluating eversion in the context of a subject specific anatomical threshold, such as the joint’s range of motion (ROM), may be more accurate at defining those with excessive eversion6. Using this technique, runners with AKP were found to come within 4.2º of their eversion ROM boundary while healthy runners maintained a buffer of 7.2º. In contrast, no differences in peak eversion were noted between groups. These findings suggest that excessive eversion should be evaluated in a subject specific and anatomically relevant context.

One limitation of this technique however is that it does not consider the velocity at which the joint is approaching its ROM boundary and therefore does not capture the time a runner’s body has to react. In other words, two runners could have the same amount of time before reaching end range but accomplish this differently. One runner could have a large eversion buffer, but evert at a greater velocity. In contrast, a second runner could have a small eversion buffer but evert at a lesser velocity.

Evaluating eversion in this neuromuscular context could provide greater insight into the association between calcaneal eversion and injury. Therefore the purpose of this study was to evaluate eversion using a neuromuscular threshold such as the time to contact (TtC) the AJC’s ROM boundary in runners with and without AKP.

METHODS

Nineteen healthy (10 male, 9 female, 34 ± 10 years, 1.7 ± 0.1m, 65 ± 12 kg) and seventeen runners with AKP (4 male, 13 female, 30 ± 7 years, 1.6 ± 0.1m, 60 ± 8 kg) completed the study. All subjects were running 12+ km per week for 6 months, utilized a heel-strike foot fall pattern and had no history of lower extremity surgeries.

Lower extremity segments were defined from a single barefoot standing calibration with markers placed the greater trochanters, medial/lateral knee, medial/lateral malleoli, sustentaculum tali, and peroneal tuberucle. Dynamic movements were captured using marker clusters attached to the lateral thigh, lower leg and directly to the calcaneus. Passive eversion ROM (Figure 1) and dynamic running trials (2.9 m/s) were both captured (200 Hz) using an eight camera motion capture system (Qualisys, Sweden).

Kinematic data were analyzed in Visual 3D (C-Motion, USA). Marker trajectories were smoothed using a 12 Hz fourth order low pass Butterworth filter. Joint angles were calculated using Cardan angles with an X-Y-Z rotation sequence. The minimum angular distance from the eversion boundary during stance (eversion buffer) and the minimum TtC the eversion ROM boundary were averaged over 10 steps (Figure 1). Statistical
differences were evaluated using a one way ANOVA and 95% confidence intervals.

Figure 1. A runner’s eversion buffer was determined by evaluating the frontal plane position of the AJC over stance relative to the joint’s available ROM (A). The passive ROM of the AJC was measured using a custom built device, which passively everted the AJC using a 10 Nm torque (B). The eversion ROM boundary (A) was then defined by interpolating a virtual line between each measurement. The minimum angular distance between this boundary and the joint’s angle during stance was deemed the eversion buffer (Equation 1). Additionally, the minimum time necessary to contact the eversion ROM boundary was recorded (TtC, Equation 2).

RESULTS AND DISCUSSION

Runners with AKP had significantly shorter TtC (35.63ms vs. 63.96ms, p = 0.03). This shorter TtC was in large part due to having a smaller eversion buffer (Table 1), however, velocity was found to have a substantial influence on the TtC of selected individuals.

A shorter TtC could increase a runner’s risk of injury for several reasons. The reaction time of the AJC to quick inversion movements is, on average, between 54-70ms⁷. Injured runners in this study were found to have TtC’s that were substantially shorter than these reported reaction times indicating that the surrounding musculature may not have sufficient time to react to unexpected perturbations. As a result, it is plausible that the joint could be forced to end range if perturbed, a position that places greater demands on the joint surfaces and surrounding soft tissue, which in turn would increase the risk of injury. Furthermore, functioning at end range could require that kinematic adjustments be made by surrounding joints, such as the knee and similarly increase its risk of injury.

CONCLUSIONS

These results provide evidence that a link between calcaneal eversion and AKP exists when using anatomical and neuromuscular based thresholds to define excessive pronation.

REFERENCES

1. Tiberio D, JOSPT 9, 160-5, 1987

| Table 1. Comparison of time to contact and eversion buffer variables. Mean (SD) |
|---------------------------------|---------|-------------|-----------------|---------|
|                                | Healthy | AKP         | Mean Difference | 95% CI  |
| Minimum TtC (ms)               | 64.0 (46.9) | 35.6 (22.8) | -28.3          | -53.8 to -2.9³ |
| Buffer (°) @ min TtC           | 11.8 (6.3) | 8.7 (5.2)   | -3.2           | -7.1 to 0.8  |
| Velocity (°/sec) @ min TtC     | -204.2 (75.9) | -208.9 (96.9) | -4.6          | -63.2 to 54.0 |
| Minimum Eversion Buffer (°)    | 7.3 (4.3)  | 4.2 (3.6)   | -3.1           | -5.9 to -0.2³ |