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Asymmetrical Landing Forces Detect Neuromuscular Fatigue

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Abstract

Neuromuscular fatigue decreases performance and increases injury risk, but practitioners lack an easy, reliable method for detecting fatigue. This study determined if ground reaction forces are impacted by neuromuscular fatigue and whether this differed between limbs. Thirty-one female athletes (19.1 ± 1.22 years, 1.7 ± 0.6 m and 63.0 ± 7.7 kg) participated. Each participant had vertical ground reaction force (vGRF) recorded during five trials of a forward jump task immediately prior to and following a competitive soccer season. During each trial, peak vGRF during landing for both dominant and non-dominant limbs and asymmetry of peak vGRF between limbs were calculated. These measures were submitted to a RM ANOVA to test the main effect and interaction between time (*pre vs. post*) and fatigue (*starter vs. non-starter*). A significant two-way interaction for dominant limb peak vGRF (p=0.034) was observed. *Starters* increased peak vGRF (p=0.049) at post compared to *pre* time point, but no difference was evident for *non-starters* (p=0.333). Asymmetry of vGRF (p=0.033) between limbs decreased at the *post*-season time point, but asymmetry did not differ between *starters* and *non-starters* (p=0.360). Ground reaction force data may be an easy, reliable for detecting neuromuscular fatigue.

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INTRODUCTION

Neuromuscular fatigue decreases performance and increases injury risk. Specifically, females exhibit decreased power production and maximal jump height due to muscular fatigue, and larger peak vertical ground reaction forces (vGRF) during landing, which can increase musculoskeletal injury risk. Lower limb asymmetry can further elevate injury risk, as females are more likely to suffer injuries in their non-dominant limb. Detection of increased and asymmetrical landing forces could help identify fatigued players at risk of injury. Yet, coaches and practitioners currently lack an easy, reliable method for detecting neuromuscular fatigue. Thus, the purpose of this study was to determine a vGRF metric that readily identifies fatigue decrements from a competitive soccer season.

HYPOTHESIS

Starters would exhibit larger decrements in performance and greater limb asymmetry for landing forces at the completion of a competitive soccer season than non-starters.

METHODS

Subjects: 31 female athletes participated (**Table 1**). Each was defined as starter or non-starter based minutes played and matches started (starters > 850 minutes played; ≥ 10 games started).

Table 1: Demographics for both starters and non-starters.

	Age (yrs)	Ht (m)	Wt (kg)	N
Starter	19.9 ± 1.0	1.7 ± 0.7	64.4 ± 8.3	12
Non-starter	18.6 ± 1.1	1.7 ± 0.6	62.1 ± 7.3	19

Testing: Each participant completed testing immediately prior to and following (within one week) the completion of a competitive soccer season. During each session, participants performed five successful trials of a forward vertical jump task (**Fig. 1**)

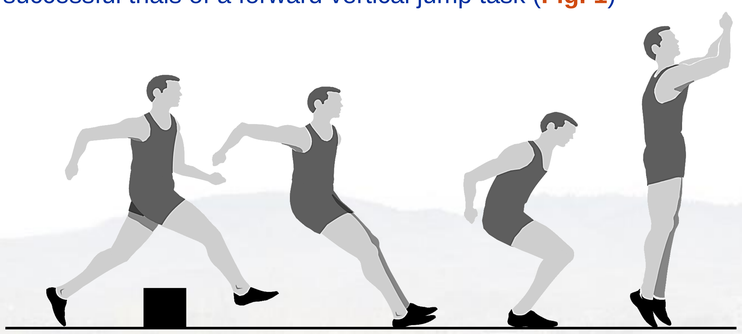

Figure 1. Depicts the forward vertical jump task. For the task, participant were required to jump forward over a 14 cm obstacle, and simultaneously land with each foot on separate force platform and immediately performing a maximal vertical jump.

METHODS CONT'D

Biomechanical Data: During each trial, vGRF was recorded using two force platforms (2400 Hz; OR-6, AMTI, Watertown, MA).

Biomechanical Analysis: During the landing phase of each trial, peak vGRF for both limbs (dominant and non-dominant) was calculated, and symmetry angle (SA) of peak vGRF between limbs were determined according to Zifchock et al. [1] (**Fig. 2; Eq. 1**).

Eq. 1: $$SA = \left(45° - \tan^{-1} X_{left}/X_{right}\right)/90° * 100\%$$

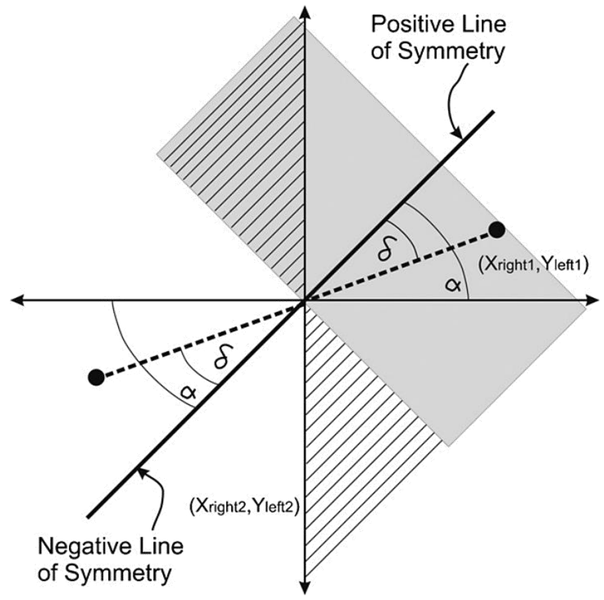

Figure 2. Depicts the quantification of SA for vGRF. Any set of left and right-side vGRF values will form a vector at an angle (α) from the ±x-axis. Asymmetry is represented by a deviation (δ) of the vector from the vector of perfect symmetry. Positive (X_{right1}, Y_{left1}) and negative (X_{right2}, Y_{left2}) values deviate from their respective lines of symmetry.

Statistical Analysis: Each measure was submitted to a RM ANOVA to test the main effect and interaction between time (*preseason vs. postseason*) and group (*starter vs. non-starter*). Alpha was $p < 0.05$.

RESULTS

A significant time versus group interaction was observed for dominant limb peak vGRF ($p = 0.034$) (**Fig. 3**). Starters exhibited a significant increase in peak vGRF ($p = 0.049$) at post compared to the pre time point. But, no significant increase in dominant limb peak vGRF ($p = 0.333$) was evident for non-starters at the post season time point. The non-dominant limb exhibited no significant change in peak vGRF from pre to post season for the starters nor non-starters ($p > 0.05$).

RESULTS

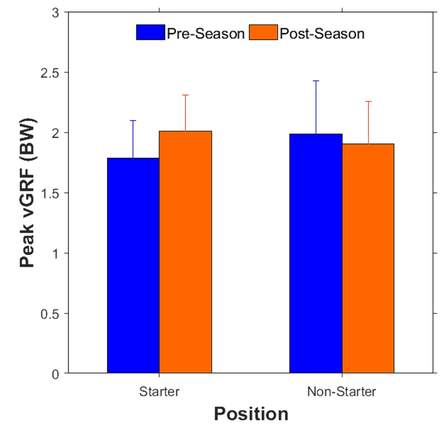

Figure 3. Mean (SD) of peak vGRF of the dominant limb for both starters and non-starters at the pre- and post-season time points.

Asymmetry of peak vGRF ($p = 0.033$) decreased at the post-season time point (**Fig. 4**). But, asymmetry did not differ between starters and non-starters ($p = 0.360$).

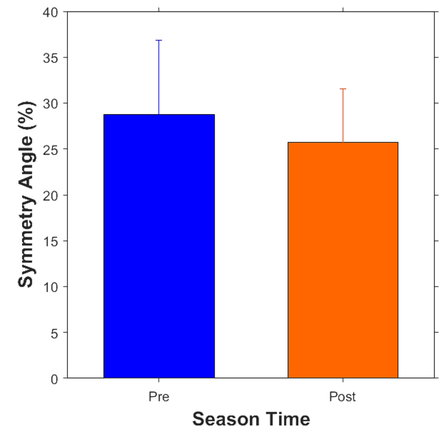

Figure 4. Mean (SD) of SA at the pre- and post-season time points.

CONCLUSION

Ground reaction force data may be an easy, reliable method for detecting neuromuscular fatigue and injury risk. Starters on a female soccer team increased peak vGRF and subsequent injury risk following the completion of their competitive season. But, limb asymmetries in landing force did not further increase at the completion of the season.

REFERENCES

1. Zifchock RA, et al. *Gait & Posture* **27**, 622 – 627, 2008.