COMPARISON OF RIGHT VS. LEFT LEG GRF LANDING SYMMETRY FOR HEALTHY AND OVERUSE INJURY-PRONE RECREATIONAL ATHLETES

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INTRODUCTION

Bilateral performance symmetry during human movement has been suggested as an indicator of the state of health of the lower extremity musculoskeletal system (Schot, 1991). Motor performance outcomes that exhibit consistent and systematic asymmetry are often thought to be abnormal and may denote an unnatural or pathological condition (e.g., muscular strength imbalance, leg length discrepancy, pre-existing injury, etc.) or predispose one side of the body to injury (McCaw, 1989; Schot, 1991). Motor performances that exhibit bilateral symmetry are thought to reflect a normal or natural movement pattern (Schot, 1991). However, inconsistent and non-systematic asymmetry is another performance possibility that could also relate to lower extremity health. Inconsistent asymmetry implies movement variability. Movement variability has been suggested as an internal protective mechanism whereby force magnitudes and temporal characteristics are distributed across a broader range of musculature and bone-cartilage contact areas, thus reducing the cumulative stress to any one structure (James, 1996; McCaw, 1989; Schot, 1991). The predisposition for individuals to chronically experience overuse injuries to the lower extremity during exercise may relate to their inherent lack of movement variability, and thus may also relate to their bilateral symmetry or symmetry consistency. The purpose of the study was to compare right versus left leg symmetry for healthy and overuse injury-prone recreational athletes during an assumed symmetrical bilateral landing task.

METHODS

Twenty recreationally-active subjects gave written consent in accordance with the regulations of the Human Subjects Review Committee at the affiliated university. Landing symmetry was evaluated for each of two groups of subjects (n = 10 healthy; n = 10 healthy, but prone to overuse injuries) by examining vertical ground reaction force (GRF; 1000 Hz) magnitude and temporal variables for each leg while landing from three different heights (50, 100, and 200% of maximum vertical jump, MVJ). Landings were performed from a wooden platform, adjusted to the appropriate height, onto a dual force platform system (Advanced Mechanical Technology, Inc.; one foot per platform). Magnitudes of the first (F1) and second (F2) maximum force values obtained during the impact phase (0-100 ms post-contact) were identified along with the temporal occurrences of these events (T1 and T2, respectively). Vertical GRF pattern consistency varied among subjects and across heights, therefore, when F1 and F2 could not be individually identified the maximum force magnitude and temporal values for the impact phase were assigned to the F2 and T2 variables, respectively. The F2 and T2 values were utilized to evaluate differences between legs (one-way Analysis of Variance, ANOVA; = 0.05) for each group and landing height. Additionally, GRF pattern consistency between legs was monitored for each group by a tally which tracked the number of unimodal (single peak) curves for each landing height.

RESULTS

Mean and standard deviation values for the peak GRF magnitude (F2) and temporal (T2) variables are given in Table 1. Results of the right versus left leg comparisons for each group are summarized in Table 2. ANOVA results indicated no significant right-left side differences for either the GRF magnitude or temporal variables for the healthy subject group. The injury prone ,group exhibited significant (p 0.05) right-left side differences for the 50% MVJ height (right greater than left) and for the 100% MVJ height condition (right greater than left). No right-left temporal differences were observed for the injury prone group.

Results of the descriptive GRF tally for the occurrence of unimodal landing curve patterns (Table 3) suggest that the injury prone group might have been more consistent between legs in producing traditional bimodal GRF-time histories. A unimodal curve was defined as a GRF-time history that did not follow the typical bimodal (F1-toe, F2-heel) landing pattern, suggesting a flat-footed landing style. The 50% MVJ height elicited a right-left unimodal curve count of 21 and 30, respectively, for the healthy group and 19 and 19, respectively, for the injury prone subjects. For the 100% MVJ height condition the healthy group exhibited a total (sum of all subjects) of two right side and three left side unimodal curves, while the injury prone group exhibited no unimodal curves from either leg. No unimodal curves were detected for either subject group while landing from the 200% MVJ height.

Table 1.

Bilateral Mean and Standard Deviation Values for Vertical Ground Reaction Force Magnitude and Temporal Variables.

Group	Height	Statistic	T2 R	F2 R	T2 L	F2 L
Healthy	50% MVJ	M	0.052	20.71	0.044	15.95
		SD	0.018	7.57	0.026	5.98
Healthy	100% MVJ	M	0.046	25.94	0.045	23.24
		SD	0.012	8.51	0.010	7.40
Healthy	200% MVJ	M	0.039	38.81	0.038	38.91
		SD	0.006	8.48	0.007	7.92
Inj. Prone	50% MVJ	M	0.052	21.57	0.043	13.68
		SD	0.018	4.75	0.022	3.90
Inj. Prone	100% MVJ	M	0.051	27.40	0.051	20.20
		SD	0.009	6.44	0.011	5.46
Inj. Prone	200% MVJ	M	0.042	39.65	0.043	37.01
		SD	0.006	7.70	0.007	6.59

Values are 10 subject averages of 10 trial mean values.
Units for GRF magnitude and temporal variables are N kg and s, respectively.
F2 and T2 denote peak force and time to peak force, respectively; R=right, L=left.

Table 2.

ANOVA Results for GRF Symmetry Comparisons.

Group	Height	F2 R vs. E2 L	T2 R vs. T2 L
Healthy	50% MVJ	ns	ns
Healthy	100% MVJ	ns	ns
Healthy	200% MVJ	ns	ns
Inj. Prone	50% MVJ	>>	ns
Inj. Prone	100% MVJ	>>	ns
Inj. Prone	200% MVJ	ns	ns

ns indicates a non-significant comparison ($p>0.05$).
>> indicates right side variable significantly greater (p 0.05) than left side variable.
F2 and T2 denote peak force and time to peak force, respectively; R=right, L=left.

Table 3.

Unimodal Curve Count for GRF Symmetry Comparisons.

Group	Height	Right	Left
Healthy	50% MVJ	21	30
Healthy	100% MVJ	2	3
Healthy	200% MVJ	0	0
Inj. Prone	50% MVJ	19	19
Inj. Prone	100% MVJ	0	0
Inj. Prone	200% MVJ	0	0

Values represent the number of unimodal curves present for all subject-trials in each condition.

DISCUSSION

The functional significance of these results is not clear. However, one might speculate that the asymmetrical GRF magnitude values observed for the injury prone group are related to their injury history, although the cause-effect relationship cannot be determined from these data. One interpretation may be that the presence of the asymmetry predisposed the injury prone subjects to chronic overuse injuries. Alternatively, anticipation of recurrent injuries may have prompted subjects to land asymmetrically in order to protect a specific leg. Interestingly, both observed asymmetries occurred in the same direction (right greater than left) even though the injury history of the injury prone subjects indicated no preferential leg. The absence of asymmetry at the highest height could relate to the imposed performance demands during this condition. Preferential protection of a specific leg or non-volitional asymmetry may not have been a viable movement option for subjects in order for them to successfully complete the task; equal contribution from both legs may have been required.

The number of differences between right and left leg unimodal curves might be related to the amount of movement variability exhibited by each subject group. The fewer total number of unimodal curves and the fewer number of right-left differences suggest less performance variability for the injury prone group. Two possible interpretations are (1) subjects in the injury prone group exhibited more consistent asymmetry (e.g. less variability) because of their previous injuries (e.g. favoring one leg over the other), and (2) the predisposition for subjects to incur chronic overuse injuries results from their consistent asymmetrical performances, as suggested by McCaw (1989) and Schot (1991).

CONCLUSIONS

While further study is needed to assess the cause-effect relationships between landing symmetry and overuse injuries, results from the study support the contention that healthy subjects may exhibit greater bilateral symmetry than their overuse injury prone counterparts. Additionally, these data suggest that musculoskeletal health and performance variability may be positively related.

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