Comparing Centre of Mass Excursion in Individuals with Varying Levels of Anterior Reach Asymmetry

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Summary

The Lower Quarter Y-Balance Test (YBT) measures dynamic balance. YBT anterior reach (AR) asymmetry greater (>) than 4cm is associated with injury; however, it is unknown how center of mass (COM) excursion changes with AR asymmetry. This study determined that greater levels of AR asymmetry resulted in more anterior/posterior (AP) COM excursion and AR asymmetry level and limb side effects medial/lateral (ML) COM excursion.

Introduction

Dynamic balance refers to the maintenance of COM over a base of support (BOS) [1], which is important for injury reduction. The YBT measures dynamic balance while pushing a reach indicator outside the BOS; YBT AR asymmetry > 4cm is associated with injury [2]. One prior study noted a correlation between posterior sway amplitude and YBT posterior reach with no correlation found in YBT AR; however, participants were not group based on AR asymmetry [1]. The purpose of this study was to examine COM excursion using markerless motion capture technology in individuals with varying AR asymmetry levels.

Methods

This secondary analysis used YBT AR data from 23 (12 males; 11 females) participants ages 18-35. AR trials were recorded (Fs = 50Hz, Sony Handycam HDR CX405) and processed in FreeMoCap.org (open-source pose estimation) computing AP/ML COM and joint coordinate data. MATLAB® (MathWorks, 2024) generated a three-dimensional (3D) scatter plot of the YBT AR (Figure 1). Data were filtered (low-pass Butterworth, 2nd order, LP = 6Hz) and time normalized (0-100%) using the Euclidean distance of the toe marker to calculate COM excursions ($|$max-min$|$) from 'start-to-reach' (SR) and 'reach-to-return' (RE) of the AR on both limbs. Participants were categorized into 3 groups based on YBT AR asymmetry ($|$right-left$|$): <1cm (G1), 2-3cm (G2), and >4cm (G3). A two-way ANOVA examined differences in AP/ML COM excursion by limb side and AR asymmetry group for SR/RE ($p < .05$), separately. Pairwise comparisons were conducted if significant main effects or interactions were present (IBM SPSS v.29).

Results and Discussion

There was significantly greater AP COM excursion during RE in G2 ($p = .02$) and G3 ($p = .02$) compared to G1. There was a significant interaction between limb side and AR asymmetry groups ($p = .01$) with significantly greater ML COM excursion in G1 ($p = .05$) and G3 ($p = .008$) compared to G2 for the left limb during the RE.
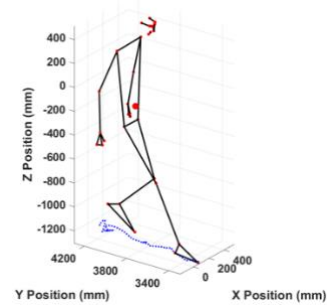
Figure 1: 3D reconstruction of AR (red dot = COM; blue dotted line = Euclidean distance of the toe marker).

Conclusions

Individuals with greater YBT AR asymmetry demonstrated increased AP COM excursion when performing the YBT AR. YBT AR asymmetry may influence ML COM excursion during the RE differently across limbs; this may suggest a limb dominance effect. These findings suggest that those with YBT AR asymmetry have a reduced ability to maintain AP COM over their base of support during a dynamic balance task, which may play a role in injury risk.

References

[1] Phyaklikhit et al. (2023). *Heliyon,* 15:e17318; 911-919
[2] Plisky et al (2006*). J Ortho Sport Phys Ther*; 36: 911-919

Table 1. Mean ± standard deviations for AP/ML COM excursion in SR and RE (R= right limb; L = left limb)

	SR: AP (cm)	SR: ML (cm)	RE: AP (cm)	RE: ML (cm)
G1 ($n = 6$)	R: 19.18 ± 13.32 L: 18.03 ± 7.36	R: 9.84 ± 5.16 L: 12.25 ± 8.42	R: 13.99 ± 5.16 L: 12.91 ± 7.10	R: 7.65 ± 3.91 L: 10.13 ± 8.07
G2 ($n = 9$)	R: 21.63 ± 8.08 L: 25.09 ± 9.98	R: 11.77 ± 4.78 L: 7.67 ± 4.82	R: 19.97 ± 10.28 L: 22.71 ± 11.16	R: 10.66 ± 5.18 L: 5.09 ± 3.67
G3 ($n = 8$)	R: 23.65 ± 10.58 L: 21.82 ± 10.17	R: 8.51 ± 4.29 L: 13.21 ± 7.26	R: 21.57 ± 6.71 L: 21.32 ± 7.68	R: 7.28 ± 2.87 L: 11.74 ± 4.99