Marker set configuration affects hip axial rotation measurement during the ballet turnout

Maria Isabel V. Orselli[1,2], Luciana C. Manfrim[1], Bianca M. Portela[1], Matheus Moutinho[1], Flora M. Pitta[1], Paolo Caravaggi[3], Isabel C. N. Sacco[1]

[1] Physical Therapy, Speech and Occupational Therapy Dept., School of Medicine, University of Sao Paulo, São Paulo, Brazil
[2]Israeli College of Health Sciences Albert Einstein, São Paulo, Brazil
[3] Movement Analysis Laboratory, IRCCS Istituto Ortopedico Rizzoli, Bologna, Italy
Email: icnsacco@usp.br

Summary

No consensus has been reached on how to properly assess larger hip axial rotation (HR), as in the ballet turnout, through skin-marker based measurements. This study aimed at investigating the effect of different thigh tracking protocols for assessing HR during a ballet jump. We compared two rigid-cluster - a conventional rectangular cluster (CC) positioned in mid-lateral thigh and a wedge-shaped cluster (WC) positioned distally on the iliotibial band - to the Vicon's Plug-in-Gait (PIG). An optoelectronic motion capture system and Visual 3D were used to access hip kinematics. The effect of the marker set on HR was tested using Statistical Parametric Mapping. We observed: 1) tracking protocol significantly affected HR; 2) PIG, produced unrealistic results; 3) an offset between WC and CC, due to thigh skin twisting. Despite rigid clusters are more suitable to assess larger HR, cluster longitudinal position should be carefully considered when comparing intra-segmental data.

Introduction

The turnout movement - a large external rotation of the lower limb - is a key element of classical ballet. Understanding the hip biomechanics during the turnout is essential to improve the ballet technique and to prevent injuries. However, skin-markers based measurements of hip axial rotation are limited by the soft tissue artifacts in the thigh. The choice of marker set and the position of the clusters can affect the propagation of tissue artifacts and consequently of hip kinematic measurements [1]. The aim of this study was to compare the effect of three marker sets based on reflective markers, namely the Plug in Gait (PIG) protocol and two rigid clusters from Gontijo et al. [2], on hip axial rotation measurements during the ballet turnout performed in the Assemblé Dessus jump.

Methods

An 8-camera motion capture system (100 Hz) was used to collect lower limb kinematics in 17 female experienced ballet dancers performing the Assemblé Dessus. The study was approved by a local ethic committee and the participants, or their responsible, signed an informed consent form. Subjects were equipped with the Vicon's PIG marker set, a conventional rectangular cluster of markers (CC), positioned in mid-lateral right thigh, and a specifically-designed wedge-shaped cluster (WC), positioned in the distal portion of the right thigh in the iliotibial band [2]. Visual 3D (C-Motion) was used to establish the PIG, CC and WC models, which differed from each other in the markers used to track the thigh. Hip rotations were calculated using Euler angles. Statistical parametric mapping t-test was used to perform pairwise comparisons of the hip axial rotation temporal profiles calculated with PIG, CC and WC models.

Results and Discussion

The PIG protocol yielded significantly smaller lateral hip rotation (figure 1) compared to CC and WC. Notably, the mean hip angle at movement onset estimated with PIG was unrealistic based on our observations (PIG: -3 ± 6 deg; CC: -15 ± 8 deg; WC: -22 ± 8 deg). These findings suggest that the PIG protocol may be less accurate in tracking HR, corroborating the findings of Schache et al. [1]. No significant difference in hip rotations was observed between WC and CC except for the last 10% of the movement. However, the ensemble average for WC was consistently shifted towards greater lateral rotation compared to CC throughout the whole movement (Figure 1). We hypothesized this offset arises from thigh skin torsion due to a constant torsional load, and its magnitude may be influenced by cluster distance, skin shear modulus, and thigh geometry.

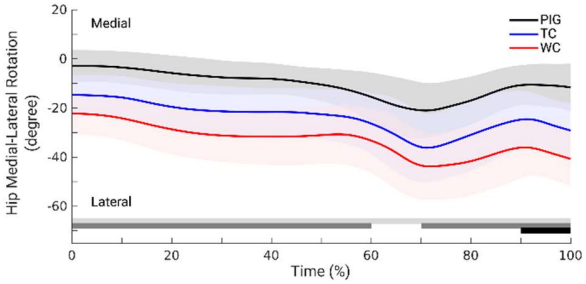

Figure 1: Hip Axial Rotation (mean ± STD) measured using PIG, CC and WC models. Horizontal bars indicates regions of significative differences in SPM's pairwise comparisons: WC xPIG (light gray); CC x PIG (dark gray); WC x CC (black).

Conclusions

We recommend using a rigid cluster protocol for analyzing large-range hip axial rotation, especially in ballet turnout. However, careful consideration should be given to cluster longitudinal position when comparing intra-segmental data.

Acknowledgments

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References

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