Aggregating Normative Gait Data Across Centres with Markerless Motion Capture

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Summary

This study compared age-matched normative cohorts collected with markerless motion capture across three centres to assess the potential for data aggregation. Analysis of 155 participants (mean (SD) age: 58 (21) yrs) revealed strong agreement in gait kinematics with minimal variability, demonstrating the feasibility of creating larger, more diverse reference cohorts.

Introduction

Video-based markerless motion capture offers a standardized and automated approach to human body modeling that can help mitigate inter-site measurement variability. This can enable the aggregation of data collected from multiple locations and allow for larger and more diverse reference cohorts that are necessary for normative modeling techniques [1]. The objective of this study was to compare normative cohorts of gait collected from different centres using markerless motion capture.

Methods

Data was collected at two clinical centres following similar motion analysis protocols, with recruitment of asymptomatic participants for normative reference. Each centre records 60 seconds of self-selected walking using eight time-code synchronized video cameras (DSC-RX0M2, Sony, Japan) at 60 fps in 1080p. One centre conducted data collection at two distinct locations, analyzed separately as Centres 2 and 3. Camera configurations were oval-shaped but varied in dimensions and camera height: Centre 1 (14.2m × 7.4m × 2.3m), Centre 2 (9.7m × 6.7m × 1.5m), and Centre 3 (10.0m × 5.7m × 1.6m). Video data were processed using Theia3D (v2023.1.0.3161) with matching preferences (3 DoF hip, knee, and ankle; 8 Hz filter). A standardized Visual3D pipeline calculated joint and segment angles along with temporal distance metrics. Kinematic data between the three centres were compared using mean-based statistics as outlined by [2]. The difference between each centre's mean and the grand mean was calculated, along with the RMS, absolute max, and standard deviation of this *difference*. Principal components (PC) analysis was used to investigate pattern differences with PCs explaining at least 10% variance retained. One-way ANOVAs and pairwise comparisons (α=0.05) were used to detect differences between centres.

Results and Discussion

The cohorts were well-matched with no differences detected in age, quality of life (EQ-5D), or gait speed (Table 1). Lower body joint and segment angles showed good visual agreement (Figure 1). Across all kinematics and centres, RMS was < 1°, with the largest absolute max difference < 1.5°, and standard deviations < 0.6°. Only the first PC of the hip adduction angle was different between Centres 1 and Centres 2 (p=0.03). Compared to previous work [2] using pediatric reference cohorts and marker-based motion capture, our findings demonstrate higher agreement. Additionally, off-plane kinematic outcomes showed improved consistency, highlighting the advantage of markerless motion capture in reducing variability typically associated with marker placement errors. The small difference metrics, along with the overall agreement in waveform patterns between centres, support the viability for data aggregation.

Table 1. Average (SD) demographics and gait speed.

	Centre 1 N = 58	**Centre 2 N=73**	**Centre 3 N = 24**
Age (years)	58.9 (19.1)	57.2 (21.6)	57.4 (24.7)
Male (%))	52%	33%	42%
EQ-5D Score	0.92 (0.06)	0.93 (0.04)	0.90 (0.07)
Gait Speed (m/s)	1.33 (0.15)	1.29 (0.17)	1.27 (0.20)

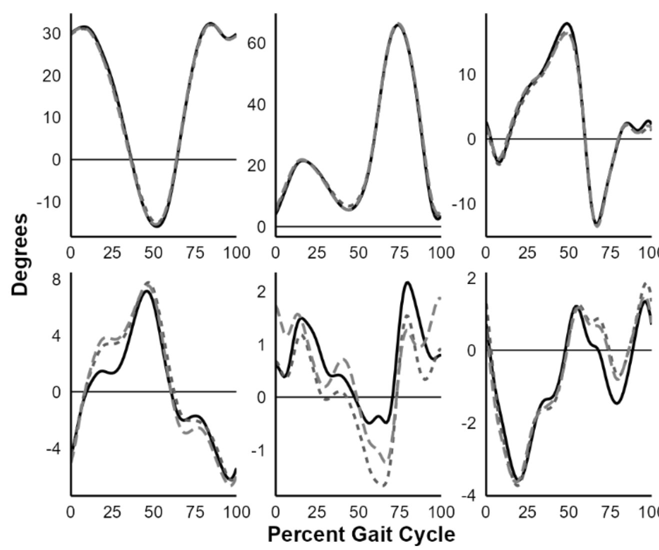

Figure 1. Ensemble average gait waveforms by centres (line type = centres; rows = sagittal (top), frontal (bottom); cols = hip, knee, ankle angle).

Conclusions

Markerless motion capture, when paired with standardized measurement protocols, facilitates the aggregation of data from multiple sites, enabling the development of larger and more diverse reference cohorts.

References

[1] Scott et al. (2023). *NNR*, 37:394-408.
[2] Pinzone et al. (2014). Gait Posture, 40:286-290.