Segment Length Agreement Between Pose Estimation and Anthropometric Measurements

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Summary

This research sought to determine the relationship between measured anthropometric segment lengths and estimated segment lengths captured through FreeMoCap open source markerless motion capture. This study suggests markerless motion capture may detect larger segment lengths better than shorter segments with more complex joints. After adjusting for errors, FreeMoCap may be a suitable alternative to gold-standard (GS) methods for deriving segment lengths automatically without the need for manual palpation.

Introduction

Segment lengths are an important measurement to estimate lever arms in musculoskeletal biomechanical models. The GS method of collecting segment lengths is with manual palpation (tape measure); however, this can be time consuming for researchers [1,2]. Markerless motion capture systems can derive segment lengths through machine learning techniques. The purpose of this research was to determine the relationship between GS and derived segment lengths.

Methods

This secondary analysis used data from 21 participants, ages 18-35 (males = 9; females = 12). A tape measure (Hoggan Scientific,) was used for GS lower extremity segment length (leg, thigh, and shank) measurements while lying supine. Standing trials were recorded using three HD cameras (fs = 60Hz; Sony Handycam HDR CX405) and processed in FreeMoCap.org (MediaPipe™ pose estimation) to compute a three-dimensional (3D) scaled point cloud of joint coordinates during the standing trial pose (Figure 1). Following pose-estimation, data were filtered using a low-pass Butterworth filter (2nd order, LP = 6Hz) and 3D segment lengths were calculated in MATLAB® (MathWorks, 2024). Pearson correlation coefficients (r) examined the relationship between GS and FreeMoCap derived measurements (Table 1). Bland-Altman plots examined bias using mean difference and upper and lower 95% confidence interval limits (IBM SPSS v.29).

Results and Discussion

Bland-Altman plots determined mean bias for right leg length of -3.4 (-0.5;-6.3) cm, left leg length of -2.6 (0.2;-5.5) cm, right thigh length of -8.4 (-6.3;-10.6) cm, left thigh length of -7.2 (-4.8;-9.5) cm, right shank length of -9.2 (-11.0;-12.9) cm, and left shank length of -9.4 (-11.0;-13.0) cm.

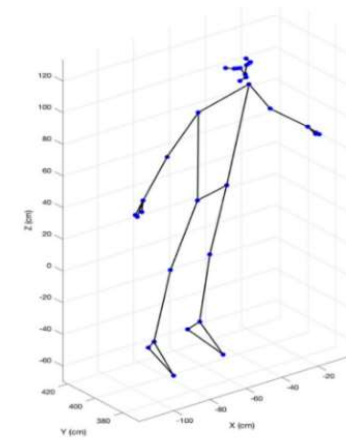

Figure 1: 3D reconstruction of standing pose.

Conclusions

Given the positive linear relationship and good agreement for the leg and shank lengths, pose estimation through FreeMoCap may be more accurate in detecting larger segment lengths than segments with less obvious joint segment locations (hip or knee joint). FreeMoCap may be a suitable alternative to the GS methods of segment length collection with additional offsets to account for errors.

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References

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Table 1: Anatomical landmarks, mean and standard deviation (± SD), and Pearson correlation (r) for right (R) and left (L) limbs.

Segment	GS Landmark	Mean ± SD (cm)	FreeMoCap Landmark	Mean ± SD (cm)	Correlation
Leg	Anterior superior iliac spine to medial malleolus	R: 88.43 ± 7.04 L: 88.45 ± 7.15	Proximal: hip joint Distal: ankle joint	R: 91.82 ± 9.21 L: 91.12 ± 9.65	R: r(19) = .733, p = <.001 L: r(19) = .759, p = <.001
Thigh	Greater trochanter to lateral femoral epicondyle	R: 38.51 ± 2.37 L: 38.97 ± 2.37	Proximal: hip joint Distal: knee joint	R: 46.95 ± 3.91 L: 46.12 ± 4.15	R: r(19) = -.026, p = .768 L: r(19) = -.205, p = .374
Shank	Fibular head to lateral malleolus	R: 33.94 ± 2.41 L: 33.88 ± 2.56	Proximal: knee joint Distal: ankle joint	R: 44.96 ± 5.45 L: 45.08 ± 5.65	R: r(19) =.726, p = <.001 L: r(19) =.761, p = <.001