Three-Dimensional Body Scanning is Accurate for Limb Segment Measures But Not Body Composition

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Summary

Body dimensions are used in biomechanics research for scaling, normalizing, and fitting personalized models. Traditional anthropometric methods with tape measures are time-consuming and prone to error. While traditional motion analysis systems can provide some measures, they have considerable overheads. This study evaluated the reliability and validity of a 3D body scanning system for measuring limb lengths, girths, and body composition. The system provided valid and reliable measures of segment girths and reliable measures of segment lengths, though different landmarks may affect validity. Body composition measures varied based on the sample's body mass index.

Introduction

Anthropometry measures can inform performance, health, and disease risk, and evaluate training outcomes and injury risk. Traditional methods like Dual X-ray absorptiometry (DEXA) and manual measurements are costly, time-consuming, and often restricted to clinical environments. Three-dimensional scanners, showing up to 93% accuracy (Lee et al., 2015), show promise to save time and increase data accessibility for research. This study aimed to determine the reliability and validity of the Styku 3D scanner (Model S100X, Styku, Los Angeles, USA).

Methods

Fifty men and women volunteered from the local community for this project (male, n = 25, age: 31.8 ± 8.1 years, mass: 80.5 ± 11.2, height: 1.78 ± 0.07, BMI: 25.4 ± 3.3 kg/m^2; female, n = 25, age: 31.7 ± 7.7 years, mass: 64.6 ± 8.4 kg, height: 1.67 ± 0.06 m, BMI: 23.1 ± 3.0 kg/m^2). All participants provided written, informed consent approved by Macquarie University Human Research Ethics Committee (HREC: 520221085239582).

Participants' body mass and height were measured upon arrival, followed by a 3D body scan and manual anthropometric assessments. Each measurement was performed three times by the same researcher for reliability. After the final measurements, participants underwent a whole-body DEXA scan within two hours, except for two participants who had their DEXA scan two days later.

Intra-rater reliability of the manual anthropometry measurements was assessed using intraclass correlations (ICC), with values interpreted as moderate, good, or excellent, and the three measurements averaged to produce a single score for each segment's circumference and length. Absolute reliability of the Styku was evaluated using standard error of measurement (SEM). Validity of the Styku measures compared to manual anthropometry and DEXA scan results were assessed using Pearson's correlation.

Results and Discussion

Manual anthropometry measures showed excellent intra-rater reliability (ICC > 0.98), while the 3D body scanner had excellent reliability for segment circumferences, body composition, and volume (ICC > 0.95), and good to excellent reliability for segment length and width estimates (ICC = 0.80-0.97).

Upper and lower limb circumference correlations to assess validity ranged from very-large to nearly perfect regardless of sex, age, and BMI (Table 1). Body composition measures, compared to DEXA, were generally large to very large, although there was considerable variation when stratified by age, sex, and BMI measures.

Table 1: ICC for segment circumferences compared to Styku 3D Body Scanner and manual anthropometry.

	Sex		Age (years)		BMI (kg/m^2)	
	Female	Male	≤ 31	≥ 32	≤ 24.9	≥ 25.0
Biceps (L)	0.94	0.91	0.93	0.96	0.95	0.82
Biceps (R)	0.91	0.95	0.96	0.96	0.95	0.89
Forearm (L)	0.94	0.96	0.98	0.98	0.94	0.98
Forearm (R)	0.94	0.97	0.98	0.98	0.96	0.96
Upper Thigh (L)	0.97	0.89	0.93	0.92	0.81	0.85
Upper Thigh (R)	0.97	0.87	0.91	0.92	0.80	0.80
Calf (L)	0.98	0.99	0.99	0.98	0.97	0.97
Calf (R)	0.98	0.98	0.98	0.98	0.98	0.94

Conclusions

The Styku 3D scanner show promise for easy and fast measurement of segment girths and lengths in biomechanical research. However, caution is required when evaluating body composition measures.

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References

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