RELIABILITY OF LOWER EXTREMITY ANTHROPOMETRIC MEASUREMENTS AND THEIR EFFECT ON WOBBLING MASS TISSUE PREDICTION

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INTRODUCTION

Many biomechanical models of the lower extremities do not take into consideration soft tissue motion effects relative to bone. The motion of segmental soft tissues or wobbling masses (WM) has been shown to significantly influence the magnitude of impact kinetics (Gruber et al., 1998). Since there is a lack of information regarding WM tissues for living people that can be put into such models, Holmes et al. (2005) developed and validated regression equations to predict the WM of the lower extremity (thigh, leg, and leg and foot segments) of young healthy adults. These equations require inputs such as segment length, circumference, breadth and skin-fold thickness, and subject data such as height, weight and sex. However, the reliability of these measurements and the effect on predicted WM estimates from the equations has yet to be determined. Therefore, the purposes of this study were to measure the inter- and intra-measurer reliability of the anthropometric dimensions necessary as inputs into the prediction equations (Holmes et al., 2005), and to quantify the effects on the predicted WM magnitudes.

METHODS

Fifty participants (25 males and 25 females with a mean (S.D.) age of 22.5 (2.79) years, height 1.72 (0.09) m and mass of 72.3 (13.3) kg), were recruited from the University of Windsor population. Two measurers were each responsible for collecting two sets of unilateral measurements from the right upper and lower limb (the upper limb data were recorded for a subsequent study). 9 upper limb and 10 lower limb anatomical landmarks were marked with 0.64 cm diameter stickers that were used to quickly identify the start and end points of the segment dimensions. Following landmark identification, segment measurements were taken using standard measuring equipment (soft measuring tape, anthropometer, and callipers). 6 lengths, 6 circumferences, 8 breadths, and 4 skin-fold thicknesses for the upper and lower limbs were acquired. Measurements were made in different planes (e.g. frontal, sagittal) and at different points on each segment (e.g. proximal, midway, distal), where possible. Landmark stickers were removed and a new set attached before the second set of measurements took place. Once the second set of measurements were collected by the first measurer, the second measurer followed with the identical protocol. Mean differences in measurements between and within measurers were statistically evaluated using ANOVA, and correlational analyses (Intra-class correlation coefficients or ICCs) were conducted using a 2-way random effects model for absolute agreement (Weir, 2005) to quantify reliability. The four sets of measurements were input into the prediction equations of Holmes et al. (2005) to produce WM tissue estimates for both attempts by each measurer. Differences in tissue estimates were quantified in terms of percent error and RMSerror.

RESULTS AND DISCUSSION

Significant differences were found between measurers and between sexes ($p<0.05$) in half of the measurement sites. However, the mean measurement differences were relatively small in general (e.g. 90% of between-measurer differences were < 1 cm).

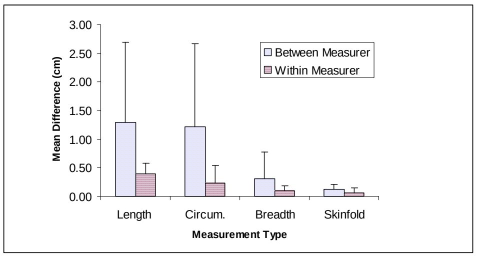

Figure 1: Mean (S.D.) measurement type differences by segment.

Differences between attempts were found not to be statistically significant for almost all the measurements. Mean measurement type differences were also small ranging from only 0.13 to1.29 cm for skinfold and lengths, respectively (Figure 1). Circumference differences were higher on average because of the compressibility of the soft tissues. These types of measurements were less affected where they occurred around bony processes with little underlying soft tissue. Discrepancies in landmark positions between measurers led to higher length differences overall.

The average measurement type ICCs were 0.79, 0.86, 0.85 and 0.86 for lengths, circumferences, breadth and skinfolds, respectively, which indicates good to excellent reliability. Measurement site ICCs also showed good to excellent reliability (mean ICC = 0.84). The higher reliability within-measurer vs. between-measurer was expected as small differences in marker placement between measurers were noted. Difference in placement of a single marker could contribute to errors in multiple measures (e.g. the location of the mid-calf marker has an effect on one circumference, one length, and two breadth measurements).

WM magnitude predictions were moderately affected by the measurement differences with maximum errors of 13.3% and 4.7% for between- and within-measurers, respectively (Table 1).

Table 1: Mean RMSerror and % error in WM predictions.

Segment	Mean (S.D.)	RMSe	% Error	
			Btwn	Within
Thigh	8443.82 (1369.13)	218.92	13.3	0.9
Leg	2817.24 (393.71)	147.43	9.2	4.7
Leg and Foot	3469.97 (509.71)	172.35	10.7	3.6

SUMMARY/CONCLUSIONS

Overall, the measurement differences between- and within-measurers were found to be small, with within-measurer estimates more consistent than between. Almost all measurements had high to excellent reliability. The WM predictions from the equations were moderately affected by the measurement differences, but within-measurer effects were considerably lower in general. This highlights the importance of measurer training and limiting the number of measurers in large scale studies when the WM prediction equations will be used.

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ACKNOWLEDGEMENT

This study was funded by NSERC.