RELIABILITY OF LEG SOFT TISSUE MARKER MOTION FOLLOWING MANUAL DIGITIZATION

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INTRODUCTION

Soft tissues of the lower extremities move with respect to the underlying bone during impact events such as landing from jumps, or during walking and running. Tracking and quantifying this motion will help to understand how impact shock travels through the lower extremities following impact, which in turn may help reduce injuries resulting from these common activities. Soft tissue motion during impact can be captured by high speed video, and software utilizing automatic feature tracking can quantify soft tissue motion. However, the reliability of this approach has not been assessed to date. Therefore, it was the purpose of this study to determine the between- and within-measurer reliability of shank skin marker position and velocity data obtained from high speed video of heel first impacts.

METHODS

A square grid of dots was applied to each participant’s right shank with a permanent black marker (Figure 1). Impacts were applied to participants’ right heel pad using a human pendulum [1] and via drop landings from a 1.5 cm high box. Heels impacted a force platform in both conditions at speeds ranging between 1-1.15 m/s and peak forces between 1.8-2.8 times body weight, which were repeated three times each (i.e. 6 impacts/participant). A high speed camera (Troubleshooter HR, Fastec Imaging, San Diego, CA; 1000 frames/s; 640x480 pixels) captured the lower extremity from the knee down in the sagittal plane during the impact event.

Three measurers analysed each video, with one measurer analyzing the videos twice using Pro Analyst (Xcitex, Cambridge, MA) following appropriate image conditioning. Measurers were instructed to analyse two columns of markers from five zones: 0%, 25%, 50% and 75% of the distance from the medial malleolus to the knee joint centre, and at the heel pad (Figure 1). Position data were imported into a customized LabVIEW® (LabVIEW® 2010, National Instruments, Austin, TX) program, to calculate marker velocity in the horizontal and vertical directions. Between- and within-measurer reliability was assessed with a two-way, random effects for absolute agreement single measures Intraclass Correlation Coefficient (ICC) (model (2,1)) [2].

RESULTS

Measurers successfully selected the same rows of markers more than 87% of the time while missing by two rows <1% of the time. Differences in marker position and velocity were minimal (<0.8 cm and <3.7 cm/s) between-measurers and within-measurer (<0.5 cm and <2.6 cm/s). Good to excellent reliability was shown for all data analysed, with between-and within-measurer ICCs of 0.82 and 0.89, and 0.96 and 0.96 for position and velocity measurements, respectively.

DISCUSSION AND CONCLUSIONS

Displacement measurements based on point selection during manual digitization showed excellent reliability (ICCs>0.75) for 85% of the conditions analysed. Small errors in the initial marker selection during digitization resulted in an average measurement difference of 1.7% between- and 1.0% within-measurer. These small errors had a minimal effect on marker velocities, as the average measurement difference for velocity was 2.8% and 1.6% between- and within-measurer, respectively. The marker system used in the current investigation does not require external devices (e.g. accelerometers) to come in contact with the body, eliminating any non-physiological responses of the soft tissues following impact.

Manually digitizing markers has become more popular for soft tissue analysis [3], but the reliability of this approach has not previously been assessed. The ability for analysts to reliably quantify soft tissue motion is an important consideration for this type of method. This study was able to quantify the position, velocities and reliability of shank soft tissue motion following constrained lower extremity impacts.

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