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THE RELIABILITY OF BIOMECHANICAL ANALYSIS IN DYNAMIC SIDE-CUTTING TASKS

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SUMMARY

Side-cutting tasks are commonly used in the dynamic assessment of ACL injury risk, but only limited information is available concerning the reliability of kinematic and kinetic descriptors of side-cutting performance. Our detailed investigation quantified intrinsic and extrinsic reliability and identified the likely sources of errors and variability in side-cutting data.

INTRODUCTION

The weight acceptance phase, around 0-20% ground contact, of side-cutting is when non-contact ACL injury is most likely to occur [1,2,3]. A highly dynamic and multi-planar task like side-cutting could have a large magnitude of variability and error, potentially beyond that reported previously for gait and other dynamic tasks [4,5]. It is important to quantify such variables so that meaningful differences can be reported with confidence.

Natural variation would be represented as inter-trial variation providing measures of intrinsic reliability of the data and then a comparative reference to explore extrinsic variation from other sources [4]. Whilst the intrinsic variation can be monitored, extrinsic variations or error can be reduced with careful consideration of methodological detail. Schwartz et al., [4] reported extrinsic variation from inter-session and inter-therapist analyses and compared findings to intrinsic or inter-trial variation using discrete and waveform analyses. Such analysis in side-cutting would provide new information on the variability associated with the execution of the task to be considered in interpretation of findings.

The aim of this study was to investigate the reliability of side-cutting both within and between researchers and days, so that appropriate interpretations can be made using these methods in the future.

METHODS

Eight participants consented to participate in this study (four males, four females; mean age: 25.8 ± 4.4 yrs; mass: 64.8 ± 7.2 kg; height: 1.7 ± 0.1 m). A repeated-measures design was used. Each subject attended six testing sessions; four on day one and two on day two. Two therapists conducted three sessions each; two each on day one, and one each on day two. This allowed each participant to be tested by each

therapist within and between days (see figure 1). There was a one hour rest period between sessions on the same day.

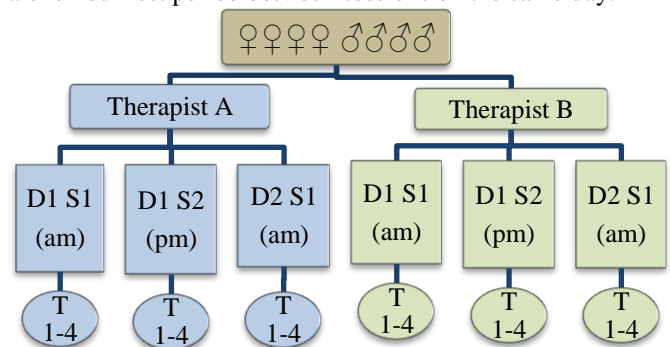


Figure 1: An outline of the study design (D = Day; S = Session; T = Trial).

After warm-up and familiarisation, 45° side-cuts were performed with a $4-5 \text{ m.s}^{-1}$ controlled approach speed. Each participant was had 44 spherical reflective markers attached according to the LJMU-model; a 6-degrees-of-freedom, eight segment model including feet, upper and lower legs, pelvis and trunk [6]. Geometric volumes were used to represent segments based on cadaver segmental data. Functional hip joint centres and functional knee joint axes were calculated to reduce the effect of anatomical location misplacement [7]. All side-cutting was performed on a force platform sampling at 1500 Hz, kinematic data were synchronously recorded using 10 optoelectronic cameras sampling at 250 Hz.

The reliability of peak values and waveforms (every time point during ground contact) was analysed by calculating the inter-trial (σ^{trial}), inter-session (σ^{sess}) and inter-therapist (σ^{ther}) errors [4]. For peak values, therapists versus trial error ratios were also calculated ($\sigma^{\text{ther}}/\sigma^{\text{trial}}$).

RESULTS & DISCUSSION

The mean $\sigma^{\text{ther}}/\sigma^{\text{trial}}$ ratio across all measures for side-cutting provided the highest ratio (2.1) for transverse plane knee angles (internal/ external rotation) and the lowest ratio, 1.3, for knee sagittal plane moments (flexion/ extension, see Table 1).

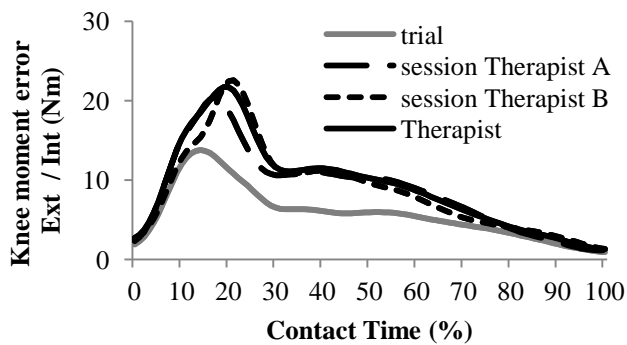


Figure 2: Waveform variability for knee external/ internal rotation moments.

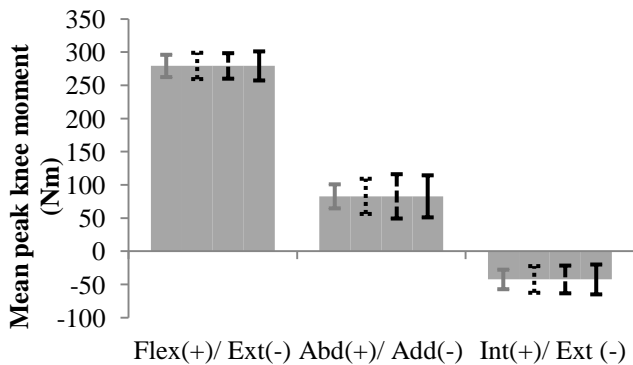


Figure 3: Absolute peak knee moment data with instantaneous error during the weight acceptance phase in side-cutting.

Moment data presented a larger magnitude of variation in the deceleration phase of side-cutting, around 0-20% ground contact (see Figure 2). However, the $\sigma^{ther} / \sigma^{trial}$ ratio remained low across the waveform, indicating σ^{trial} error, or intrinsic variation, was similar to the σ^{sess} error and σ^{ther} error, or sources of extrinsic variation. Schwartz et al., [4] suggested that the $\sigma^{ther} / \sigma^{trial}$ ratio represents the true reliability within the data but this ratio may miss the σ^{sess} error. The similarity of σ^{sess} (or intra-therapist error) and σ^{ther} for angle and moment data, suggests that the therapists in this study were equally proficient in their control of the protocol and not affected by session schedule. Typically research has presented σ^{trial} , σ^{sess} and σ^{ther} variability to be incremental [4,8] due to possible differences in joint palpation experience and marker placement, this was not the case in the present study. The findings suggest that extrinsic

error, above the intrinsic error, may be from the same experimental source. The similarity between the σ^{sess} and σ^{ther} error may be indicative of experimental error that has been removed with the use of functional methods of calculating joint axes [2,7]. This suggests that dynamic side-cutting data will be equally reliable, independent of therapist and session, when such functional methods are adopted in the protocol.

Peak knee moment data suggests that larger proportional variations were found for abduction variance (27.4 Nm) and internal rotation variance (19.6 Nm) than for knee mean peak flexion moment variance (19.4 Nm) (see Figure 3). The calculated normalised peaks represent 1.3, 0.7 and 4.3 Nm.kg, respectively, which are comparable to previous research [3]. It was noted that no discernible peaks could be established for peak hip angles in the frontal and transverse plane indicating that peak data for such angles should be interpreted cautiously. Peak data is valuable for establishing how such data interacts with reported instantaneous variability but is limited to that point of measurement.

CONCLUSIONS

The present findings indicate that the investigation of reliability using discrete peak and waveform analyses of side-cutting assessment is valuable for exposing sources of potential error. Seemingly high absolute magnitudes of variability can be caused by the intrinsic natural variability that remains in the task execution. Experimental sources of extrinsic error previously found in reliability studies may be removed using functional methods of establishing joint axes. Further research should explore the reliability of other dynamic tasks to fully understand the variability that may exist within such data.

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Table 1, Mean inter-therapist/ inter-trial ratio ($\sigma^{ther} / \sigma^{trial}$) ratio taken from waveform data to represent the reliability hip and knee angle and moment data for side-cutting.

	Hip Joint mean $\sigma^{ther} / \sigma^{trial}$ ratio			Knee Joint mean $\sigma^{ther} / \sigma^{trial}$ ratio		
	Flexion/ Extension	Abduction/ Adduction	External/ Internal Rot.	Flexion/ Extension	Abduction/ Adduction	External/ Internal Rot.
Angles	1.8	1.4	1.9	1.3	1.9	2.1
Moments	1.7	1.7	1.7	1.3	1.6	1.5