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## The test retest reliability of gait outcomes in subjects with anterior knee pain

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### ABSTRACT

**Introduction:** Anterior knee pain (AKP) is a common condition frequently causing young, athletic patients to attend sports rehabilitation centres. Abnormal biomechanics are thought to contribute towards the development and chronicity of the condition. Gait analysis is commonly used to identify abnormal biomechanics in subjects with AKP, however the reliability of these measurements are unknown. Therefore, the aim of this study was to quantify the test retest reliability of hip, knee and ankle kinematics during gait in an AKP population so the true effects of an intervention can be established.

**Methods:** Thirty-one subjects with AKP attended the 3D Motion Analysis Laboratory at Tygerberg Medical Campus of Stellenbosch University in Cape Town, South Africa, for gait analysis. Participants returned seven days later at approximately the same time to repeat the gait analysis assessment from day one. The same assessor tested all subjects on both occasions. The intra-class correlation coefficients (ICC) and standard error of measurement (SEM) were calculated for hip, knee and ankle kinematic outcomes on the affected side and used for analysis.

**Results:** All outcomes obtained were acceptable to excellent test retest reliability scores for both measures of relative reliability (ICC = 0.78–0.9) and measures of absolute reliability (SEM = 0.94–4.2°). Hip frontal plane and ankle sagittal plane outcomes were the most reliable and had the lowest measurement error. Hip transverse plane outcomes were least reliable and demonstrated the highest measurement error.

**Conclusion:** Hip, knee and ankle kinematic factors that are commonly associated with AKP can be measured reliably using gait analysis. Daily and weekly variation in symptoms in an AKP population may influence the reliability of knee sagittal plane outcomes. Therefore, it is important to document factors that could influence the kinematics such as pain, activity levels and the use of pain medication.

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### 1. Introduction

Anterior knee pain (AKP) is a common condition characterised by pain perceived at the anterior aspect of the knee during activities that load a flexed knee joint. The term “anterior knee pain” is often used interchangeably with “patellofemoral pain syndrome” and the diagnosis is most commonly made based on the area; aggravating activities, as well as the exclusion of other pathologies (Nunes et al.,

2013). AKP is thought to be multifactorial in nature and the etiology is not well understood (Aminaka and Gribble, 2008). Many studies have been done on the proposed mechanism of the condition yielding conflicting results and high intra-subject variability (Powers et al., 2014).

Accurate objective measures for anterior knee pain are of paramount importance as without them the accurate diagnosis and monitoring of treatment cannot take place. Reliable measurement of kinematics is also critical for data analysis because it ensures that changes in a specific measurement represent a true change in performance (Nakagawa et al., 2013). This is particularly important in epidemiological analyses where clinical decisions are made (Sinclair et al., 2012).

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Three-dimensional (3D) gait analysis is a recommended and reliable method of examining lower limb function. Clinical gait analysis aims to distinguish between “abnormal” gait associated with injury and normal gait that one would expect to find in an asymptomatic individual (Baker, 2006).

Variability in pre-versus post-intervention measurements may be due to the effects of the intervention, measurement error or both. Therefore, quantifying measurement error allows researchers to establish whether or not a treatment effect is clinically meaningful and this limits the risk of over analysing small differences.

There are various factors that can result in measurement errors between sessions. These include marker placement errors, inconsistent anthropometric measurements, variations in walking speed, data processing errors and measurement equipment errors (Monaghan et al., 2007).

McGinley et al., 2009, did a systematic review investigating the reliability of gait related kinematics and kinetics of normal adults tested using 3D motion analysis systems. They looked at reliability within and between subjects, within and between sessions and within and between assessors. Based on this review, the highest reliability was found in the sagittal hip and knee kinematics, the lowest errors were found in transverse and frontal plane pelvis and hip frontal plane kinematics and the lowest reliability and highest error was found in the transverse plane hip and knee outcomes (McGinley et al., 2009). However, these results were for asymptomatic populations only and therefore the authors recommended that for future reliability studies, the sample recruited should be symptomatic or clinically diagnosed with the condition being investigated (i.e. AKP) as one cannot assume that the reliability of gait outcomes will be the same in healthy and symptomatic populations. An error of 2° or less is considered to have good reliability, errors of 2–5° can be considered acceptable but small changes may require some caution in data interpretation and errors of more than 5° should raise concern as this could mislead clinical interpretation (McGinley et al., 2009).

The 3D gait analysis measurements are frequently used in clinical research on subjects with AKP for the objective measure of lower limb function. To date no studies have been done to establish the intra-session reliability of gait related kinematics for anterior knee pain. This means that the true result of gait analysis findings as well as treatment effects are unclear.

Therefore, the aim of this study is to use a repeated measures design to establish the test retest reliability of 3D hip, knee and ankle kinematics that have been shown to be associated with AKP during gait.

## 2. Methods

Ethics approval was obtained from the Health Research Council of the Stellenbosch University under ethics number **N13/05/078**. Informed consent was obtained from all participants over the age of 18 years and from parents/guardians for subjects under the age of 18 years.

### 2.1. Population and sample

Thirty-one subjects (meeting the eligibility criteria) with AKP were used to assess and the retest reliability of the measurement procedures. Our sample size was determined from a priori power analysis. We estimated the effect size using pilot data from a previous case series on a sub-sample of 8 participants. A two-tailed Wilcoxon-signed rank test was used as we assumed that the data was abnormally distributed. Therefore, assuming that  $\alpha = 0.05$ , power = 0.95 and effect size = 0.75, we needed a sample size of  $n = 27$ . We recruited 31 participants to allow for drop out.

### 2.2. Diagnostic criteria

Subjects were recruited by advertisements placed in community, university and school-based newspapers in order to attract a range of participants from a wide spectrum of activities, backgrounds, sports and ages. Advertisements/letters of invitation were also sent to the clinics of all collaborators/sports groups. All potential participants were screened using an evidence-based diagnostic checklist specifically developed for this study (Leibbrandt & Louw, 2017a) to ensure standardised diagnosis and exclusion of other pathologies. This checklist is based on an up-to-date evidence synthesis on systematic reviews and can be found attached as [Appendix A](#).

At the first testing session, a clinical assessment was done by the physiotherapist (DL) to confirm that the participant had AKP. This assessment comprised specific functional tests, a palpation, and special tests to exclude other pathologies (seen in [Appendix A](#)). Once the subjects had met the criteria of the physical examination, they could proceed to the 3D motion analysis part of the assessment.

### 2.3. Setting

The study was conducted at the FNB 3D Motion Analysis Laboratory at Tygerberg Medical Campus of Stellenbosch University in Cape Town South Africa. The same assessor tested all subjects on both occasions.

### 2.4. Measurement procedure

#### 2.4.1. Instrumentation

A VICON Motion Analysis (Ltd) (Oxford, UK) 3D system was used to obtain the 3D movement analysis data. The VICON has demonstrated high accuracy and reliability (Ehara et al., 1997). The T10 is a motion-capturing system with a unique combination of high-speed accuracy and resolution. The system has a resolution of 1-mega pixels and captures 10-bit grey scale images using  $1120 \times 896$  pixels, with the ability to capture speeds of up to 250 frames per second. Retro-reflective markers with a diameter of 9.5 mm were used. The standard plug-in gait model was used, as the model provided the angle output sought in the current study. VICON-specific anthropometric measurements that were obtained included: height; weight; leg length, knee and ankle diameter. All marker placements were done by the researcher, who has received training in marker placement and has 2 years' experience in marker placement. This serves to reduce marker bias.

#### 2.4.2. Trial capture procedure

Participants were required to perform six barefoot walking trials at a self-selected speed, in a straight line, across a flat walk way in the motion analysis laboratory. Participants returned seven days later at approximately the same time, to repeat the full testing procedure from day one. This interval was chosen because it is long enough to avoid memory bias from the first occasion (Meldrum et al., 2014) and short enough to avoid a change in gait due to variation in symptoms (Whatman et al., 2013).

Self-reported usual pain was also measured at both testing sessions using the numeric pain rating scale (NPRS).

#### 2.4.3. Outcomes

The mean peak angles for hip transverse and frontal plane, Knee sagittal plane at foot contact, Peak knee sagittal plane, overall ankle sagittal plane ROM, ankle sagittal plane at foot contact and peak foot progression frontal plane obtained for the six trials were used for analysis. These outcomes were chosen as they are the factors

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