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Medial and Lateral Knee Deviation Angular Measurements to Assess Knee Instability Using Smart Phone Video technology

Open Access **Research Article**

Michael J Callaghan*[1], James Richards[2], Lee T Atkins[3] and James Selfe[1]

[1]Department of Health Professions Manchester Metropolitan University Manchester, United Kingdom
[2]School of Sport and health Sciences University of Central Lancashire Preston, United Kingdom
[3]Physical Therapy Department Angelo State University Texas, United States

***Address for Correspondence**

Michael J Callaghan, Department of Health Professions, Manchester Metropolitan University, Manchester, M15 6GX, United Kingdom,

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Abstract

Background: A step down task (SDT) is often used by clinicians to assess abnormal knee movement. A frontal plane assessment of dynamic knee stability in the medial and lateral directions might be more appropriate than FPPA.

Purpose: To assessing dynamic knee alignment medial and lateral knee deviation during a SDT and establish the reliability of smart phone video technology software.

Methods: The cohort was a convenience sample of 30 healthy individuals. Each participant performed the SDT with two separate methods i) heel touching the floor and ii) toe touching the floor. Five trials of each method for each subject were captured. The Technique Application (App) software (Hudl inc USA) was used to measure the medial and lateral deviation of the knee relative to the midline.

Data Analysis: The intra-rater, inter-rater and inter-session reliability were calculated with the $ICC_{2,1}$, standard error of measure (SEM) and the minimal detectable change (MDC).

Results: For medial and lateral deviation intra-rater reliability for both heel touch and toe touch methods was poor to moderate. Inter-rater reliability for heel and toe touch was good.

Conclusion: The medial and lateral knee deviation measures during a SDT can be assessed with moderate reliability using smart phone video technology software. This method may be used to assess frontal plane knee mediolateral stability during SDT in a clinical setting.

Introduction

The frontal plane projection angle (FPPA) is commonly used to perform a 2D assessment of the amount of knee valgus for a functional task such as the step down test (SDT)*[1,2]*. However, it is possible that there is little difference between the initial FPPA at the beginning of the task and the final FPPA measurement, but considerable knee medial and lateral deviation during the descent. The deviations may be considered indicators of dynamic knee stability due to a lack of muscle control during a functional task *[3]*. Altered movement control patterns during a SDT are risk factors for painful knee conditions such as anterior cruciate ligament injury and patello femoral pain, and lead to femoroacetabular impingement *[4]*.Currently, there is no indication if this measurement has sufficient reliability to detect if an individual has active limb instability during a SDT.

Aims

The aim of this study was to assess dynamic knee alignment in the frontal plane by medial and lateral knee deviation during a SDT by smart phone video technology. The hypothesis was that smart phone motion capture would have good intra-rater, inter-rater and inter- session reliability for these measures.

Methodology

Population: The cohort was a convenience sample of 30 students and staff from Manchester Metropolitan University. Participants were eligible if they had no previous injury or self-reported musculoskeletal problem preventing them from performing a single limb SDT, were willing to have their test filmed and recorded, and could understand spoken and written English. Participants were not eligible if they had undergone major lower extremity joint surgery at any time such as, cruciate ligament reconstruction, meniscal repair/resection, joint surface surgery such as chondroplasty or microfracture, hip labral repair/resection, or spinal surgery. To ensure that abnormal foot posture was not contributing to the knee malalignment, each participant was assessed for static foot posture using the Foot Posture Index *[5]*. Potential participants were excluded if they had a value of +7 for pronation. For intra rater, inter-rater, and inter session reliability there were two independent raters who were qualified physiotherapists. This profession was pertinent as they regularly assess the SDT as part of clinical practice. All participants gave informed written consent before entering the study. Ethical approval was obtained from the Faculty of Health, Psychology and Social Care Ethics committee, Manchester Metropolitan University

(Ref No 0335).

Procedure

The SDT was captured by a smart phone (iPhone 6, Apple Corporation, California, USA), secured on a tripod at a height level with the participants' knees and at a 3m distance from a 20cm height step *(Figure 1)*. Zinc oxide tape (8mm width) was used to identify landmarks on the anterior ankle joint and midpoint of the ankle malleoli. Similar markers were placed on the medial and lateral femoral condyles on the central part of the patella, and the mid-thigh of the leading leg *[3]*. Knee and ankle joint midpoints were determined using a cloth tape measure. The angle of the smart phone was adjusted so that both femoral condyle markers were visible during the whole task. Before SDT trials were recorded, participants completed three practice attempts on the test leg. For the standardized starting position, the participant stood with their arms on their hips without contact between the two legs. They were instructed to keep the trunk as upright as possible and perform the SDT by lowering their preferred kicking leg down to the floor using two randomly ordered methods; until either their heel or their great toe touched the floor. Each trial was conducted over 5 seconds using a timer, verbalised to the participant by the examiner. Data were captured for 5 trials. Only data collected from trials 3, 4 and 5 were included in the analysis. If a trial was discounted due to inappropriate technique such as loss of balance or a technical problem, either trial 1 or 2 was included as an alternative *[6]*.

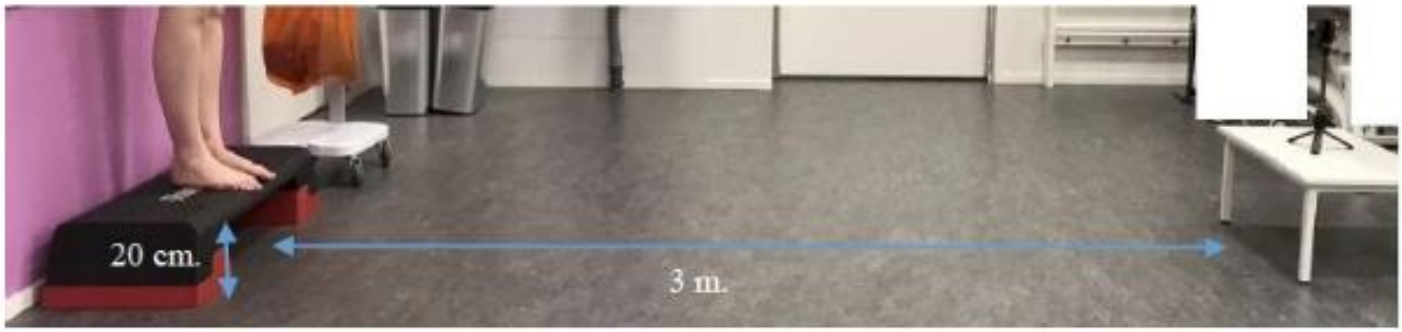

Figure 1: the set up and position of the smart phone and tripod and the step for the SDT.

Outcome Measures

The video clips of each task from each participant were analysed offline on the smart phone using the Hudl Technique App software. Each clip could be played and replayed as often as necessary by the raters who were independent of each other. The use of slow-motion, frame-by-frame scrolling, and pause facilities on the Hudl Technique App were permitted. There were two points of measurement: the start of the SDT at the top of the step, and the finish when either the participant's heel or toe had made contact with the floor; this corresponded to maximum knee flexion angle *[7]*. We calculated medial and lateral knee deviation measures as an indication of lower limb instability throughout the task. Medial and lateral knee deviation during the task was calculated by the rater drawing medial and lateral lines parallel to the knee to measure the medial and lateral movement of the central patellar marker during any part of the SDT *(Figure 2)*.

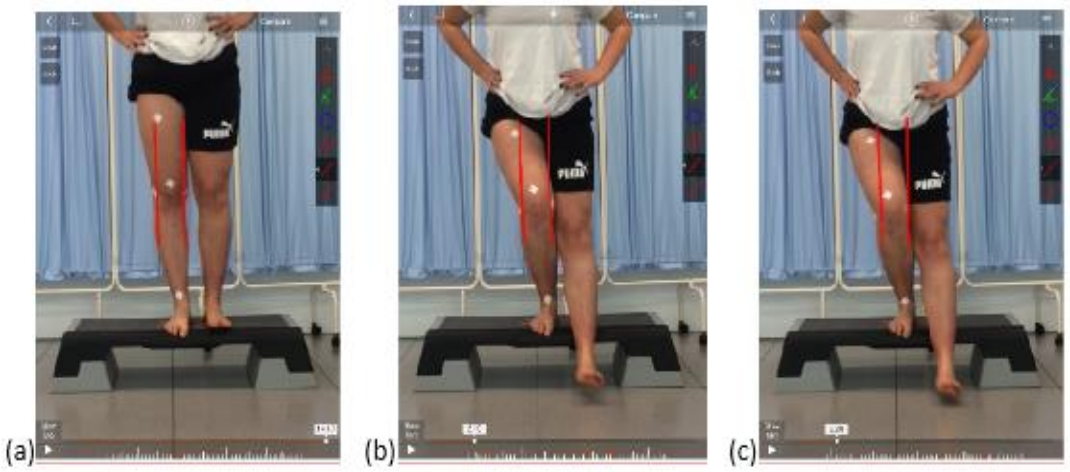

Figure 2: Start (a) and finish positions for assessing maximum medial (b) and lateral (c) deviation of the patellar marker for the heel touch SDT. Red lines were used to judge medial and lateral deviation of the central patella marker.

Data Analysis

Intra-rater reliability data were analysed using the intraclass correlation coefficient ($ICC_{2,1}$ absolute agreement, single measures) and the standard error of measure (SEM) to quantify the precision of the individual measurements and indicate absolute reliability. From the SEM the minimal detectable change (MDC - or the sensitivity to change) was calculated *[8]*. Inter-rater reliability was assessed using $ICC_{2,1}$(absolute agreement, average measures) SEM and MDC using the mean of trials 3,4,5 day 1 for toe touch and heel touch SDT and day 2. We also analysed inter-session reliability with $ICC_{2,1}$(absolute agreement, average measures) SEM and MDC using the mean of trials for day1 with toe and with heel touch; these were compared with the same variables for day2. ICC values were interpreted as follows: poor, less than 0.5, moderate between 0.5 - 0.75, good, between 0.75 - 0.90 and excellent, greater than 0.90 *[9]*. All analyses were performed using SPSS Version 22 (IBM Corporation, Armonk, NY, USA).

Results

Thirty healthy subjects were recruited within a four weeks period. Data were incomplete for 3 subjects due to clothing obscuring the markers. Therefore, there were complete data from 27 subjects (17 female, total mean age 25.9 SD 5 years; mean height 171.1 SD 9cm; mean weight 71 SD 11.7kg). The mean Foot Posture Index was 3.69 SD 2.4 and no participants were excluded due to abnormal Foot Posture Index values. For medial and lateral deviation during the SDT, intra-rater reliability for both heel touch and toe touch methods were moderate for medial deviation and poor for lateral deviation. Inter-rater reliability for medial deviation with heel touch was good and for lateral deviation was moderate. Inter-rater reliability for toe touch was good for medial deviation and lateral deviation *(Table 1)*. The inter-session reliability (day1 v day2) was excellent for medial deviation and for lateral deviation using heel touch and toe touch methods *(Table 1)*. The FPPA during the SDT the intra-rater reliability for toe touch was $ICC_{2,1}$0.74, SEM 3.50 , MDC 9.5 and for heel touch was $ICC_{2,1}$ 0.83, SEM 3.30,MDC 9.1. Inter-rater reliability for toe touch was $ICC_{2,1}$ 0.89, SEM 2.10, MDC 5.8 and for heel touch was $ICC_{2,1}$0.87, SEM 3.30, MDC 9.1.

	Heel Touch SDT				Toe Touch SDT			
Intra-rater	$ICC_{2,1}$95%CI	SEM(°)	MDC	MDC (%)	$ICC_{2,1}$	SEM(°)	MDC	MDC (%)
Medialdeviation	0.54	2.9	8.2	4.7	0.59	3.1	8.5	4.8
Lateraldeviation	0.41	3.3	9.1	5	0.45	2.8	7.7	4.4
Inter-rater	$ICC_{2,1}$	SEM(°)	MDC	MDC(%)	$ICC_{2,1}$	SEM(°)	MDC	MDC(%)
MedialDeviation	0.78	2.1	5.8	2.7	0.88	1.9	5.5	3.2
LateralDeviation	0.53	2.8	7.7	4.4	0.86	1.7	4.7	2.7
Inter-session	$ICC_{2,1}$	SEM(°)	MDC	MDC(%)	$ICC_{2,1}$	SEM(°)	MDC	MDC(%)
MedialDeviation	0.93	2.8	7.8	4.5	0.96	1.2	3.4	1.9
LateralDeviation	0.95	2.6	2.6	1.5	0.96	1.0	2.8	1.6

Table 1: Results Intra-rater and inter-rater and inter-session reliability for medial/lateral knee deviation during the SDT.

Discussion

We chose to measure dynamic knee medial and lateral deviation during the SDT to see if it could be measured as a potential sign of knee instability *[3]*. The possible relevance of this measure was apparent from several individuals in our dataset when there was no indication of knee varus or valgus as measured by the more commonly used FPPA at the end of the SDT, but considerable knee medial and lateral deviation during the descent. We have shown that 2D assessments using a smart phone and appropriate software are a reliable combination to help a clinician identify and quantify these movements. There could be several causes of medial or lateral deviation measured in this study from a healthy cohort. These include weakness of the muscles controlling knee joint flexion and extension, and hip joint adduction and internal rotation. These have been described as a sub-optimal movement pattern, in which muscles are used to perform movements for which they are not primarily designed, potentially resulting in injury *[4,10]*. The SDT in which subjects were instructed to touch the floor with their toe was a more reliable task than using the heel touch method, as seen by the higher ICCs and lower SEMs and MDCs. We would recommend this method in future assessments.

Limitations

This study was conducted on participants with neither knee pain nor lower limb dysfunction, so there should be no inferences made about the measurements recorded in this study and knee conditions.

Conclusion

The medial and lateral knee deviation 2D measures during a SDT can be assessed with moderate reliability using smart phone video technology software. This method may have potential in the clinical setting to assess altered movement control patterns during a SDT.

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