CRITERION VALIDITY OF 2D KINEMATICS FOR THE ASSESSMENT OF ANGLES IN THE FRONTAL PLANE DURING THE SINGLE LEG SQUAT

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The three-dimensional (3D) analysis system is considered the gold standard for kinematic assessments of functional tasks. However, the high cost and specific software necessity makes its use unviable to perform assessments in a clinical setting. As an option, the two-dimensional (2D) measurement may be an accessible way for kinematic evaluations. The validity of this technic, for some tasks, is not well-described. The single leg squat is a frequently used task on kinematic analysis, because it allows to identify the occurrence of undesirable motion patterns, especially on the frontal plane, such as the knee medial collapse, contralateral pelvic drop and ipsilateral trunk lean. Therefore, the purpose of this study was to validate the 2D system analysis for measuring knee, hip and trunk angles on the frontal plane, during the single leg squat. Twenty-four physically active participants (13 men and 11 women, 26±4.6 years, 69±11.8 kg, 1.70±0.10 m) were enrolled in this study. Lower extremity injury or pain were considered as exclusion criteria. The 3D data was collected using a 10-camera Vicon Motion Analysis System (Vicon® Motion Systems, USA) recording at 100 Hz. For the 2D data collection, a digital video camera recording at 30 Hz (Canon D10, Japan) was positioned perpendicular to the frontal plane of the participant, at a 2.5-m distance. Thirty-two reflective markers were placed on anatomical landmarks for each subject for 3D analysis. Six of them were considered for the 2D manual digitalization (medial malleoli, tibial tuberosity, anterior superior iliac spines and acromions). The data was collected simultaneously and synchronized by a light signal. After a warm-up and familiarization period, participants were asked to squat until the exhaustion with their dominant lower limb, respecting a range of motion of approximately 60°of knee flexion and a pace of 3s per repetition. The first repetition of each subject was excluded; the three subsequent, as well as the last three repetitions, were used for analyses. For the 2D data, the knee, hip and trunk angles were measured through the software Kinovea v. 0.8.26 (Kinovea Project, France). The 3D data was analysed using the Visual 3D v 6.00.16 software (C-Motion Inc, USA). The means of the range of motion (ROM) were calculated for each group of three repetitions, for both 2D and 3D analyses, and compared using the student t-test for paired samples. The reliability between methods was tested using the Intraclass Correlation Coefficient (ICC) and the Standard Error of Measurement (SEM). All procedures were carried out in IBM SPSS Statistics 20.0 for Windows

(IBM Inc, USA), and the significance level was set at $p<0.05$. The results are shown on table 1. For the three investigated joint ROMs, the p-value indicates that there is no difference between 2D and 3D measurements. However, as indicated by ICC values, reliability between systems was good (>0.80) only for hip ROM (SEM around 2 degrees both for initial and final repetitions). The ICC values for knee and trunk measures were considered poor. These results suggest that the 2D analysis seems to be similar with the gold standard only for hip ROM in frontal plane during the single leg task. A possible cause for the poor results of knee and trunk measures could be the high influence of the rotational component in the transverse plane, which cannot be analysed using our 2D approach. More researches are needed to investigate this influence.

Table 1. Mean±standard deviation for knee, hip and trunk range of movement (ROM) measured for initial and final repetitions (reps) using 2D and 3D systems, p-values obtained in the t-test and values of the Intraclass Correlation Coefficient (ICC) and the Standard Error of Measurement (SEM).

Repetitions	Joint	2D	3D	p-value	ICC	SEM
Initial	Knee ROM (deg)	4.72±6.12	6.71±4.37	0.109	0.373	4.23
	Hip ROM (deg)	10.14±5.47	10.08±5.78	0.911	0.888	1.86
	Trunk ROM (deg)	1.04±3.22	2.21±3.33	0.321	-0.494	4.02
Final	Knee ROM (deg)	5.40±6.27	8.07±4.26	0.086	0.066	5.29
	Hip ROM (deg)	8.83±5.70	8.44±5.06	0.595	0.805	2.35
	Trunk ROM (deg)	0.89±4.05	2.36±4.67	0.286	-0.141	4.68