Validation and Reliability of a Video-based, AI-Powered Motion Capture Application for Assessing Motor Performance: A Study Protocol

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Introduction

The assessment of motor performance skills (MPS) provides important information about an individual's current motor performance level as well as the development of the motor performance over time. Such information is essential for the targeted promotion of the motor performance and for leveraging the positive effects of well-developed motor performance skills [1], and it is therefore frequently collected in physical education, motor development research and health-related studies [2,3]. The assessment is typically conducted using motor test batteries [4,5]. However, such assessments are limited by their subjective nature and the restricted information they provide.

Objective assessment of MPS can be achieved through the analysis of kinematic variables obtained via motion capture [6]. Most commonly, this is carried out using marker-based systems with multiple cameras in laboratory settings. However, such systems are time-consuming, costly, and confined to the laboratory [7]. With the rise of artificial intelligence (AI), pose estimation software represents a promising alternative to marker-based motion capture. It is capable of detecting anatomical landmarks and can be integrated into everyday devices such as smartphones or laptops [6].

The integration of AI-based motion capture tools creates new opportunities to assess motor performance in large and diverse populations outside the laboratory setting, thereby enabling scalable, data-driven insights into MPS in everyday environments. At the same time, the study highlights key challenges regarding the handling of sensitive movement data, aligning with DiTraRe's focus on the responsible and transparent use of digital technologies in research.

Objective

The objective of this study is to validate a video-based, AI-powered motion capture application for the assessment of various motor performance skills and to evaluate its reliability.

Methods

This study is designed as a cross-sectional study. The study will include at least 20 participants recruited of the Institute of Sports and Sports Science at the Karlsruhe Institute of Technology. Eligibility criteria include being at least 18 years old and having no musculoskeletal injuries at present or within the previous six months. Ethical approval and data protection clearance will be obtained from the ethics committee of the Karlsruhe Institute of Technology before the start of data collection. All procedures will be conducted in accordance with the Declaration of Helsinki.

During the performance of various motor tasks, kinematic variables (e.g., joint angles) are simultaneously recorded using a marker-based 3D motion capture system (Vicon Motion Systems; Oxford Metrics Group, Oxford, UK) and the AI application via a laptop camera (ThinkPad). The application uses BlazePose (Google ML Kit) as its underlying pose estimation model to detect the anatomical landmarks and calculate the joint angles [8].

The statistical analyses will be performed in R [9]. To verify the validity between the two measurement instruments, the Pearson correlation coefficient (r) will be calculated separately for each recorded exercise. Reliability will be assessed using a two-way mixed-effects intraclass correlation coefficient (ICC3,1) for absolute agreement based on single measurements. The significance level for all statistical analyses will be set at $p < 0.05$.

Discussion

The study will provide new insights into whether a video-based, AI-powered application can serve as a valid and reliable tool for assessing motor performance skills. Beyond the methodological validation, the study also contributes to the broader discourse on the digital transformation of research, as addressed by the Leibniz ScienceCampus "Digital Transformation of Research" (DiTraRe). Within this framework, the project illustrates how digital and AI-based technologies can transform data collection, analysis, and interpretation in sport science, while ensuring the responsible handling of sensitive data and contributing to the use case "Sensitive Data in Sport Science."

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