Evaluating the Accuracy of the Judging Support System (JSS) in Artistic Gymnastics Compared to the 3D Motion Analysis System

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Summary

The Judging Support System (JSS) has been introduced in international artistic gymnastics competitions to support the human judges. This system uses markerless motion capture technology to calculate the three-dimensional posture of skeletal segments throughout the whole body. This study evaluated the feasibility of JSS as a motion analysis tool by comparing split angles derived from its coordinate data with those from the VICON motion capture system. Nine female gymnasts performed three split leaps on a low balance beam.

Split angles were evaluated for their maximum values and time-series changes. Results demonstrated overall agreement between the systems, with minor discrepancies observed. The accuracy of the split angle measurements, particularly during split leaps, was high. These findings suggest that JSS holds promise as a practical and reliable tool for movement analysis in artistic gymnastics.

Introduction

In recent years, the Judging Support System (JSS, Fujitsu Ltd., Japan), an AI-based scoring support system, has been introduced in international artistic gymnastics competitions to assist human judges in skill recognition and scoring. Based on markerless motion capture technology, JSS can obtain the three-dimensional posture of skeletal segments throughout the body. This obtained data can be utilized for objective skill recognition for judges and quantitative kinematic evaluation for researchers [1]. However, the accuracy of the positional data obtained by JSS remains unclear. The purpose of this study was to evaluate the accuracy of kinematics variables derived from JSS by comparing them with those obtained from gold-standard 3D motion capture system (VICON, Vicon Motion Systems Ltd., Oxford, UK) and to explore its potential as a novel tool for motion analysis in artistic gymnastics.

Methods

The participants were nine female gymnasts (age: 19.1±1.0 years, height: 1.52±0.4 m, weight: 52.7±3.48 kg). Each participant performed three split leaps on a low balance beam.

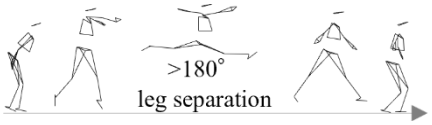

Figure 1: Experimental trials of the split leap

The split leaps tasks were recorded using four video cameras with 30 Hz for JSS, and 14 Vicon cameras with 240 Hz. The split angle, formed by lines connecting the hip to the front and back ankles during the leap, was calculated. Time-series waveform similarity was assessed using Dynamic Time Warping (DTW) and Derivative DTW (DDTW) to evaluate measurement accuracy between the systems.

Results and Discussion

Figure 2 shows the time-series waveform similarity of split angles between JSS and Vicon, with the color area highlighting the aerial phase, critical for skill recognition. In Figure 2a, data from both systems align closely along the reference dashed line ($y=x$), demonstrating high agreement. Figure 2b shows discrepancies in the initial and final phases but maintains high agreement during the aerial phase.

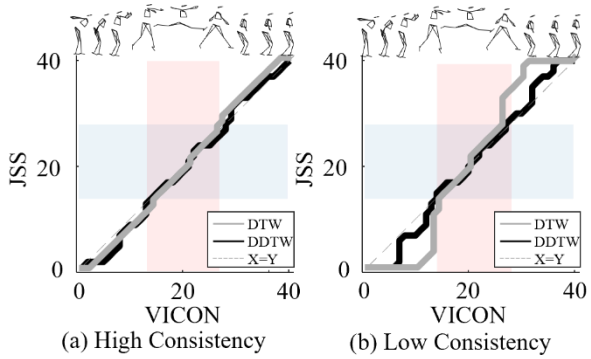

Figure 2: Time-Series Consistency via DTW and DDTW

These findings suggest that the discrepancies are primarily due to the characteristics of the model-specific difference. However, the aerial phase, essential for skill recognition, exhibited high consistency across both systems. Therefore, the JSS would evaluate the simple split movement in artistic gymnastics with high accuracy. These results highlight the potential of the JSS as a robust and supporting tool for skill evaluation and performance analysis in artistic gymnastics.

Conclusions

JSS demonstrated high agreement with the Vicon system, confirming its reliability. Future studies should evaluate its accuracy for complex movements to expand its applicability.

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References

[1] Kanazawa Yuzi et al. (2019). J. Japanese Society for Artificial Intelligence, 34(4): 531-538.