Bounding ahead: A single-camera markerless approach for assessing triple jump technique and performance

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Summary

Single camera markerless motion capture systems hold potential to democratize sports biomechanics research by capturing athletes in their natural environments. This study demonstrates that homography techniques coupled with open-source markerless motion capture software can enable biomechanical analyses of the triple jump "in the wild," though current reliance on manual processes limit scalability.

Introduction

Triple jump is a complex track and field event that demands exceptional acceleration, velocity preservation, and precise timing to execute the hop, step, and jump phases [1,2] to achieve the farthest possible horizontal jump distance [1]. Identifying the movement patterns required to improve triple jump performance can be challenging, warranting the need for quantitative feedback mechanisms. Existing analyses and simulations employed to evaluate triple jump technique have focused on elite athletes and relied on costly hardware and proprietary software. This study demonstrates that combining smartphone video with open-source pose estimation software can enable triple jump analyses in real-world settings.

Methods

Thirty participants (15 female, average age 19.0 ± 4.0 years) performed six triple jumps at track and field facilities. Jumps were captured from the sagittal plane using an iPhone 12 camera (Apple, USA; 4K, 30 Hz), panning to follow the athlete's jump. After testing several pose estimation solutions, Google MediaPipe (GMP; Google, USA) object detection and pose landmark identification tasks were selected to identify the participant and obtain 33 body part landmarks in each video frame, respectively [3]. Gaps in landmark detection were smoothed using cubic spline interpolation. GMP landmark coordinates were converted to real-world 3D space using a novel homography optimization approach [4].

To validate the approach, a series of triple jump performance metrics were computed using the real-world 3D coordinates and compared to elite athlete performances recorded in the 2017 and 2018 World Athletics triple jump reports [5,6]. The selected performance metrics included phase ratios – distances of each phase represented as percentages of the total distance [7], and the horizontal and vertical centre of mass (COM) velocities at take-off for the hop, step, and jump phases. It was anticipated that participants would demonstrate similar phase ratios, given this is a relative metric, and slower horizontal and vertical COM velocities when compared to elite triple jumpers. Moreover, a custom Python tool was built to visually validate the real-world 3D coordinates.

Results and Discussion

Phase ratios across participants were consistent with those observed in elite athletes (Table 1). Other computed metrics aligned with expected outcomes such as slower horizontal and vertical velocities exhibited by studied athletes compared to their elite counterparts. The alignment of these metrics with established benchmarks supports the methodology's validity.

Table 1: Mean and standard deviation (SD) phase ratio percentages for participants and elite athletes, grouped by sex.

Subject	Hop	Step	Jump
Study Female	38.0 (4.78)	27.8 (6.53)	34.4 (5.38)
Elite Female	36.1 (1.30)	29.0 (1.89)	34.9 (1.76)
Study Male	37.9 (3.73)	28.7 (3.49)	33.4 (3.72)
Elite Male	35.8 (1.40)	29.9 (1.90)	34.2 (2.10)

The custom Python tool confirmed the homography approach yielded reasonably accurate real-world 3D coordinates based on visual assessments (Figure 1).

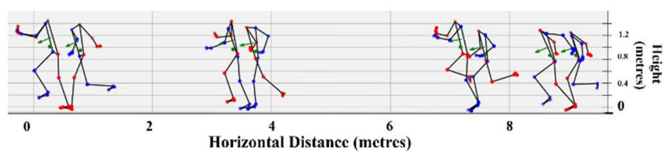

Figure 1: Ground contact positions in real-world 3D coordinates throughout a participant's triple jump.

Conclusions

This study shows that a single-camera markerless motion capture system can analyze triple jumps "in the wild," though the manual labeling currently required for homography makes it impractical for coaches and athletes. Future research should aim to automatically compute real-world coordinates in uncontrolled settings. Despite current limitations, the proposed system holds potential for cost-effective and versatile biomechanical studies for triple jump and beyond.

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References

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