Integrating Wearable Sensors to Quantify Training Loads in Badminton Singles and Doubles

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Summary

This study examined wearable sensors' use for assessing badminton training loads, focusing on the relationship between heart rate and IMU-derived features (accelerations along each axis and PL). Fifteen collegiate male players were equipped with IMU sensors on their lower backs and racket-hand wrists during simulated singles and doubles games. Feature importance analysis using a Random Forest model revealed that in singles, the vertical acceleration of the lower back and racket-hand PL were the most significant for heart rate prediction, while in doubles, the anterior-posterior acceleration of the racket-hand and lower back PL were the most influential factors. These findings highlight the significance of sensor placement for capturing biomechanical and physiological metrics, providing valuable insights for optimizing training load monitoring and performance.

Introduction

Wrist-mounted sensors excel at capturing swing dynamics but may not fully represent the overall load. In contrast, waist-mounted sensors better reflect total load but cannot capture finer movements [2]. Previous studies have identified the lower back and racket hand as optimal sensor placements for estimating player load (PL) during specific badminton movements [3].

This study aims to evaluate the effectiveness of wearable sensors, including heart rate monitors and IMUs, in assessing training loads in badminton, providing insights to optimize performance, manage workload, and prevent injuries.

Methods

Fifteen collegiate male badminton players (age: 21.2 ± 1.6 years; height: 175.3 ± 6.4 cm; weight: 68.2 ± 8.5 kg; BMI: 22.1 ± 2.2; training experience: 7.5 ± 3.7 years) participated, including 9 expert players and 6 intermediate players. Two simulated badminton games (singles and doubles) were conducted under the 21-point rally scoring system. Participants wore IMU sensors (Capture.U, ±16 g; Vicon Motion Systems, UK) on the lower back and racket hand wrist (1600 Hz), and a Polar H10 heart rate sensor on the chest (1 Hz). IMU axes were defined as X (vertical), Y (medial-lateral), and Z (anterior-posterior).

Player load (PL) was computed as the instantaneous change in acceleration across all axes, expressed in arbitrary units (a.u.) [1]. Data fusion combined heart rate and acceleration data, and feature importance was analyzed using a Random Forest model to identify critical IMU-derived metrics in predicting heart rate responses.

Results and Discussion

The Random Forest model identified significant IMU features contributing to heart rate predictions during singles and doubles badminton games. In singles, vertical acceleration of the lower back (ax_LB) and racket hand PL (PL_RH) were most influential, emphasizing the role of vertical trunk motion and racket hand workload. In doubles, anterior-posterior acceleration of the racket hand (az_RH) and lower back player load (PL_LB) were the most significant, reflecting the importance of directional movements and trunk load due to teamwork and dynamic positioning. These findings underscore the importance of sensor placement, with the lower back and racket hand providing complementary insights into the differing physical demands of singles and doubles.

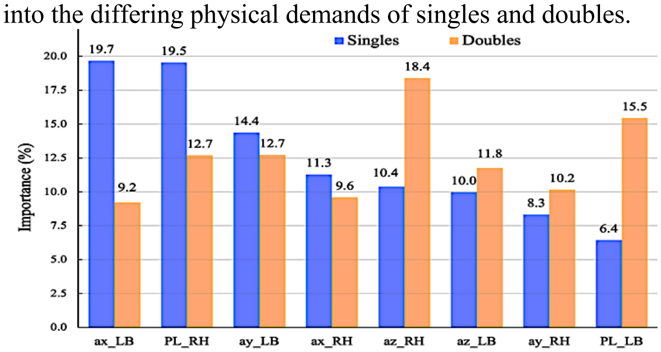

Figure 1: Feature importance rankings derived from the Random Forest model for singles and doubles simulated badminton games.

Conclusions

This study highlights that vertical acceleration of the lower back and player load from the racket hand was critical in singles, while the anterior-posterior acceleration of the racket hand and player load from the lower back were most significant in doubles. These findings offer valuable insights into optimizing training strategies, managing workloads, and preventing injuries among badminton athletes.

References

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