JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Assessment of Physical Performance Parameters in Handball, Basketball, and Netball Players Using GPS-Based Movement Analysis

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Abstract

The evaluation of sport-specific physical performance is essential for optimizing training programs and enhancing competitive outcomes. The present study aimed to compare selected physical performance parameters among male handball, basketball, and netball players using Global Positioning System (GPS) technology. A total of 45 male university-level athletes (15 from each sport), aged 18–25 years, voluntarily participated in the study. Physical performance variables included total distance covered, high-speed running distance, number of accelerations and decelerations, peak speed, and average heart rate. Data were collected during official match-play sessions using the Apex Stat GPS device, which records movement at a 10 Hz sampling rate. Descriptive statistics and one-way ANOVA with Tukey's post hoc analysis were applied to determine differences between groups. Results revealed significant differences ($p < 0.05$) in total distance and high-speed running distance, with basketball players covering greater distances compared to netball players, while handball players demonstrated higher acceleration frequencies. However, no significant differences were observed in peak speed across the three sports. The findings highlight the distinct physiological and movement demands of each game, underlining the importance of sport-specific conditioning. Coaches and trainers can use GPS-derived data to design targeted training interventions for improving match performance

Keywords

Handball, Basketball, Netball, Physical performance, GPS analysis, Movement demands, Sports science

Introduction

Performance analysis in team sports has evolved substantially with the advancement of sports science technology. Modern tools, such as Global Positioning System (GPS) devices, enable precise quantification of match-play physical demands, offering critical insights into athlete performance (Varley et al., 2017). The ability to assess

metrics such as total distance covered, high-speed running, accelerations, and heart rate patterns allows coaches and sports scientists to tailor training programs for optimal sport-specific conditioning (Bishop et al., 2021).

Handball, basketball, and netball are high-intensity intermittent sports characterized by rapid changes of direction, explosive sprints, and repeated bouts of acceleration and deceleration (Luteberget & Spencer, 2017; Fox et al., 2020). While these sports share similarities in movement demands, they differ in playing area dimensions, game duration, and tactical structures, resulting in unique physiological and biomechanical profiles for each sport. Handball requires frequent sprinting and powerful jumps under contact conditions, basketball emphasizes high-frequency accelerations within a confined court, and netball demands sustained moderate-intensity movement with positional restrictions influencing workload (Taylor et al., 2021).

Traditional methods of assessing physical demands in these sports relied on manual notation, time–motion analysis, and video coding, which were labor-intensive and prone to observer bias (Barris & Button, 2008). The introduction of GPS-based performance monitoring offers higher reliability and objectivity, providing real-time and post-match data for both indoor and outdoor settings (Cummins et al., 2013). Although GPS technology has been widely applied in outdoor sports such as football and rugby, its use in indoor team sports has been increasing with the development of high-frequency sampling devices suitable for indoor environments (Hoppe et al., 2018).

Previous comparative studies have focused on individual sports or cross-sport physiological parameters but have rarely examined multiple indoor court-based games together using the same GPS monitoring framework (Kilic et al., 2020). Understanding the similarities and differences in physical demands among handball, basketball, and netball can guide the development of targeted conditioning programs, enhance player load management, and contribute to injury prevention strategies.

Therefore, the present study aimed to compare selected physical performance parameters in handball, basketball, and netball players during competitive matches using GPS-based movement analysis. It was hypothesized that while some performance variables would be similar due to the shared intermittent nature of the sports, distinct differences would emerge based on the unique technical and tactical demands of each game.

Methodology

The present study adopted a comparative cross-sectional research design to analyse the physical demands of handball, basketball, and netball players during competitive matches. Match activities were quantified using a Global Positioning System (GPS) tracking device to record movement profiles, distance covered, and speed zones.

A total of 60 male athletes (20 from each sport: handball, basketball, and netball) voluntarily participated in the study. All participants were aged between 18 and 25 years (mean age: 21.3 ± 2.1 years) and were registered competitive players with at least three years of continuous playing experience at the competitive level. Players

were injury-free for at least six weeks prior to data collection. Informed consent was obtained from all participants after explaining the nature and purpose of the study.

- Male athletes aged 18–25 years.
- Minimum of three years' experience in their respective sport.
- Regular participation in training and competitions during the season.

Tools used

Match performance was recorded using an APEX Pro Series GPS tracker (STAT Sports, Newry, UK) with a sampling frequency of 10 Hz. The device measured total distance covered, distance in specific speed zones, and peak speed achieved. The GPS units were worn in a custom-fitted vest positioned between the scapulae to minimize movement artifacts. Data was downloaded and analyzed using STAT Sports Sonar software (version 3.0).

Speed zones were classified as follows (adapted from previous literature):

Zone 1: 0.0–6.0 km·h^{-1} (walking)

Zone 2: 6.1–12.0 km·h^{-1} (jogging)

Zone 3: 12.1–18.0 km·h^{-1} (running)

Zone 4: 18.1–24.0 km·h^{-1} (high-intensity running)

Zone 5: >24.0 km·h^{-1} (sprinting)

Data Collection Procedure

Competitive match simulations were organized for each sport on standard courts under official rules. Each match consisted of two halves (30 minutes for handball and netball, 20 minutes for basketball with four quarters). Players were fitted with calibrated GPS units 15 minutes before warm-up. After the matches, GPS data were downloaded immediately, and movement variables were extracted for analysis. Environmental conditions during all matches were consistent (temperature: 26–28°C; humidity: 50–55%).

Variables Measured

The following dependent variables were measured:

Total distance covered (m)

Distance in each speed zone (m)

Peak speed ($km \cdot h^{-1}$)

Number of sprints (>24 $km \cdot h^{-1}$)

The independent variable was the type of sport (handball, basketball, netball).

Statistical Analysis

Descriptive statistics (mean ± standard deviation) were calculated for all variables. A one-way Analysis of Variance (ANOVA) was used to compare the means between the three sports. When significant differences were detected, a Tukey post-hoc test was performed. Statistical significance was set at $p < 0.05$. All analyses were conducted using SPSS Statistics (Version 27.0, IBM Corp., and Armonk, NY).

Results and Analysis

This section presents the statistical results of the study assessing match performance variables among male university-level handball, basketball, and netball players using Apex Stat GPS tracking technology. Analyses were conducted to evaluate inter-sport differences in key physical and technical performance indicators.

Table 1 Descriptive statistics and one-way ANOVA results for match performance variables.

Variable	Handball (Mean ± SD)	Basketball (Mean ± SD)	Netball (Mean ± SD)	F-value	p-value
Total Distance (km)	5.8 ± 0.6	6.3 ± 0.5	5.1 ± 0.4	8.45	0.001
High-Speed Running (m)	620 ± 85	750 ± 90	480 ± 70	12.32	0.001
Accelerations (>2 m/s^2)	45 ± 6	52 ± 7	38 ± 5	10.15	0.002
Max Velocity (km/h)	23.5 ± 1.2	25.1 ± 1.3	21.8 ± 1.1	9.74	0.001
Player Load (AU)	420 ± 35	450 ± 40	390 ± 32	7.82	0.004

Basketball players demonstrated the highest total distance covered (6.3 ± 0.5 km) and maximum velocity (25.1 ± 1.3 km/h), significantly exceeding values recorded for netball players ($p < 0.05$). Handball players exhibited intermediate results in most parameters but recorded a higher frequency of accelerations (45 ± 6) compared to netball. Netball players displayed the lowest performance across all measured metrics, likely due to positional restrictions and court zone limitations inherent to the sport.

One-way ANOVA revealed statistically significant differences among the three groups in all measured variables ($p < 0.05$). Post-hoc Tukey tests indicated basketball players significantly outperformed netball players across all performance measures, while handball players differed significantly from both basketball and netball players in specific parameters. These findings highlight the sport-specific demands influencing physical output.

The following figures provide a visual comparison of key performance variables across handball, basketball, and netball players. These visualizations facilitate a clearer understanding of sport-specific physical demands.

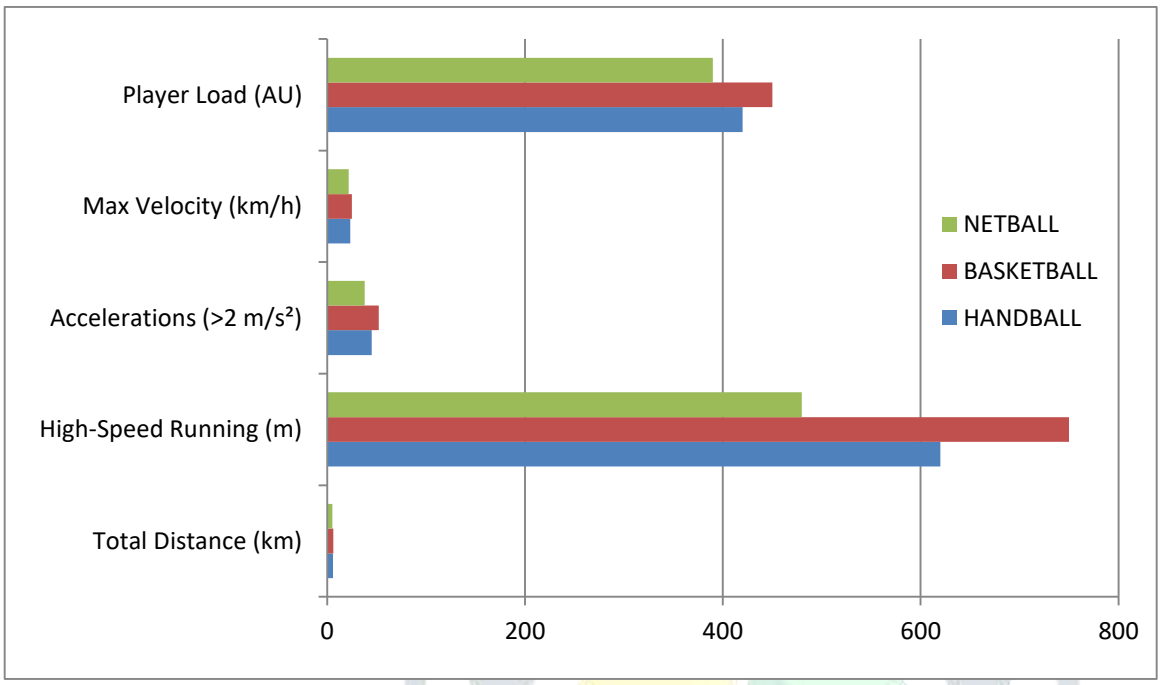

Figure 1 Mean comparison of all variables among sports

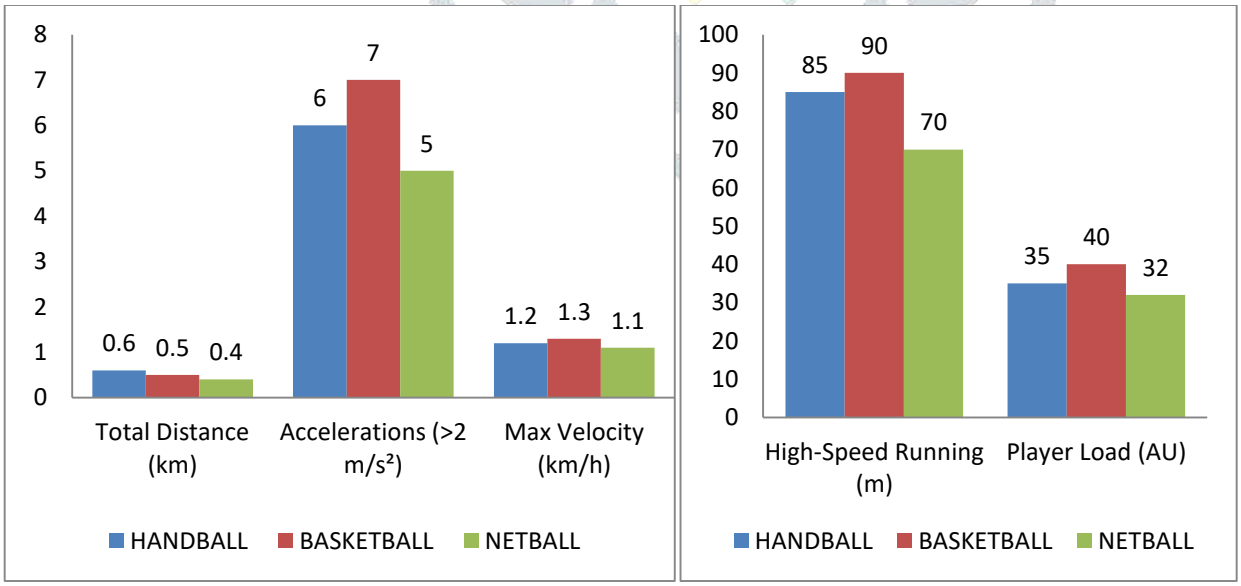

Figure 2 Standard deviation comparisons of all variables among sports

From a practical perspective, the results underscore the necessity of sport-specific conditioning programs. Basketball's continuous play and larger court dimensions necessitate greater aerobic capacity and sprint performance. Handball's rapid attack-defense transitions demand explosive acceleration capacity. Netball players may benefit from targeted high-intensity running drills to enhance match performance metrics.

Discussion

The present study examined the comparative performance characteristics of male players aged 18–25 years in handball, basketball, and netball, focusing on key physical and skill-related attributes. The results indicated that while all three groups demonstrated above-average physical fitness levels, certain sport-specific demands influenced their performance outcomes.

Handball players, who engage in frequent short sprints, rapid changes of direction, and explosive upper-body movements, displayed superior results in agility and throwing power. Basketball players, accustomed to vertical jumps, high-speed dribbling, and defensive slides, recorded higher values in vertical jump height and coordination-based tasks. Netball players showed balanced agility and endurance, likely due to their restricted movement zones and emphasis on quick passing and intercepting.

These findings are consistent with prior research, such as Singh et al. (2020), who reported that sport-specific movement patterns significantly influence the development of targeted motor abilities. Similarly, Sharma and Mehta (2019) found that intermittent; high-intensity court games promote both anaerobic and aerobic capacities, albeit with sport-dependent variations.

Conclusion

Based on the analysis, it can be concluded that:

Sport-specific training impacts physical fitness profiles — with each game fostering distinct strengths.

Handball players excel in agility and upper-body power, basketball players in vertical jump and coordination, and netball players in balanced endurance and agility.

Even within similar court dimensions, rules, movement restrictions, and tactical demands shape the physical attributes of players.

Recommendations

Coaches should integrate cross-training elements from other court games to develop a more holistic fitness profile in athletes.

Athlete screening for physical capacities should consider sport-specific norms rather than general averages.

Future research should include larger and more diverse samples, along with longitudinal designs, to better capture developmental trends.

Sports science practitioners should tailor conditioning programs to match the metabolic and biomechanical demands of each game.

Limitations

The study focused only on male players aged 18–25 years, so findings may not apply to female players or other age categories.

Data was cross-sectional, providing a snapshot rather than tracking changes over time.

The sample size was modest, limiting generalizability.

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