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Research Article

The Impact of Anaerobic Strength on Shooting Accuracy in Professional Wheelchair Basketball Players

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Abstract

Background: Functional skills and performance of the upper extremities are crucial for enhancing athletic success. This study aimed to investigate the relationship between anaerobic power and shooting accuracy, which is a key determinant of athletic success, in professional wheelchair basketball players. **Methods:** A total of 23 male professional wheelchair basketball players, aged 18–40, participated in the study. Anaerobic power was assessed using the Medicine Ball Throw Test (MBTT); while shooting accuracy was evaluated using the 4-meter (4m) and 8-meter (8m) Pass for Accuracy Test. **Results:** A moderate positive correlation was identified between anaerobic power and 4m shooting accuracy ($r=0.488$, $p<0.05$), and a strong positive correlation was observed between anaerobic power and 8m shooting accuracy ($r=0.792$, $p<0.05$). **Conclusions:** The results indicate that anaerobic power significantly influences shooting accuracy in wheelchair basketball players. Clinicians and trainers can utilize simple, reliable tests, such as the MBTT, to monitor progress and design individualized training plans.

Keywords: Anaerobic power; Athletic performance; Shooting accuracy; Upper Extremity; Wheelchair basketball

Introduction

Wheelchair basketball is a sport adapted for individuals with physical disabilities, first introduced in 1949 in the USA. Initially, it was used as a form of rehabilitation, socialization, and integration for individuals with disabilities following World War II. By 1960, it had gained worldwide popularity and is now recognized as a form of adapted physical activity and sport for individuals with physical disabilities, improving their physical condition and socialization process [1]. The degree of disability in individuals with physical impairments affects their motor, cognitive, social, and emotional functions. These functional limitations may negatively affect their ability to perform age-related activities and participate in social interactions [2].

Wheelchair basketball is the most popular sport among disability sports disciplines. According to data from the International Wheelchair Basketball Federation (IWBF), approximately 30,000 individuals with disabilities participate in this sport globally [3]. In wheelchair basketball, players are classified using a functional classification system developed by the IWBF to ensure fair competition. This system evaluates various aspects of body movement, including trunk stability, sitting balance, and the ability to perform actions such as manoeuvring the wheelchair, dribbling, passing, shooting, and handling the ball [4].

Regular sports play a significant role in supporting the social, psychological, and physiological well-being of individuals, contributing to their self-esteem, self-confidence, socialization, and sense of achievement [5]. Building on the foundational role of wheelchair basketball in promoting physical and social well-being, it is essential to explore the specific physical attributes, such as anaerobic power, that directly influence athletic performance in this sport [6].

Basketball is a demanding sport that requires participants to demonstrate high levels of physical fitness and specialized athletic skills [7]. In wheelchair basketball, muscle strength, power and coordination of the upper extremity are the main determinants of activity performances such as pushing, passing and shooting. Studies have shown that upper extremity power and coordination directly influence shooting accuracy and overall athletic success [8,9]. During activities such as manual wheelchair propulsion, passing, and shooting, numerous kinetic [10], electromyographic [11,12], and musculoskeletal modelling studies have demonstrated the critical importance of shoulder muscles [13]. It is reported that the greatest contribution to upper extremity performance is provided by the elbow flexor and extensor muscles and the shoulder flexors that generate the propulsive force [10-13]. Anaerobic strength and endurance of important scapulothoracic muscles such as serratus anterior, trapezius and rhomboid, which play a critical role in providing scapular stabilisation, are closely related to the capacity of the shoulder muscles to produce functionality.

In addition to upper extremity muscle strength, trunk muscle strength also plays an important role in ensuring postural stability in sitting position and achieve effective performance [14]. Although wheelchair basketball players use the same court and hoop dimensions as running basketball players, their on-court mobility is achieved through the upper extremities. Therefore, the functional skills and performance of the upper extremities are crucial for enhancing athletic success [15]. In wheelchair basketball players, high anaerobic power and trunk stability can enhance manual wheelchair propulsion performance and contribute to athletic success [16]. While studies have shown that higher anaerobic power in wheelchair basketball players is associated with greater speed and strength during games [17,18], no relationship has been identified between anaerobic power and shooting accuracy, which is one of the key indicators of athletic success. While previous studies have explored the role of anaerobic power in athletic performance, its specific relationship with shooting accuracy in wheelchair basketball remains underexplored. The aim of our study is to examine the relationship between anaerobic power and shooting accuracy as an indicator of athletic success in professional wheelchair basketball players. Our hypothesis was that anaerobic power positively correlates with shooting accuracy. The findings of this study have broader implications for developing evidence-based training programs to improve athletic performance and competitive outcomes.

Materials and Methods

This study was conducted between April and May 2022 at the Department of Physiotherapy and Rehabilitation, Research Laboratory, Cyprus International University. Ethical approval for the study was obtained from the Cyprus International University Scientific Research and Publication Ethics Committee (dated 18.04.2022, numbered EKK21-22/013/006). Before the study commenced, participants were informed about the study, and written informed consent was obtained. The study included 23 professional wheelchair basketball players, aged 18-40, who were competing in the Turkish first league. Athletes with any musculoskeletal problems or pain in the upper extremities within the last six months, a history of surgery in this region, or chronic systemic diseases were excluded. All assessments in the study were performed by the same physiotherapist.

The power analysis for the study was conducted using G*Power 3.1.9.2. Based on the analysis, with a Type I error (alpha) of 0.05, a Type II error (1-β) of 0.8, and an effect size (Cohen's d) of 0.5, the total number of participants required for the study was calculated to be 23.

Data Collection Tools

The demographic information of the participants-including age, gender, height, body weight, body mass index (BMI), and dominant upper extremity-along with details regarding their disability, classification score, weekly training duration, playing position, and basketball experience, were recorded. The dominant upper extremity was determined by observing which hand the participants used for writing.

Upper Extremity Open Kinetic Chain Function and Anaerobic Power Assessment

The assessment of upper extremity open kinetic chain function and anaerobic power was conducted using the Medicine Ball Throw Test (MBTT). This test is a valid and reliable method for evaluating the open kinetic chain function of the upper extremities and measuring explosive power [19]. At the start of the test, the athlete's wheelchair was positioned so that the front bar did not cross the starting line. Participants were instructed to throw a 3 kg medicine ball using a chest pass motion. The distance between the point where the ball first made contact with the ground and the front bar of the wheelchair was measured and recorded in centimetres (cm). The test was repeated three times, and the average value was recorded [20].

Assessment of Athletic Performance

Athletic performance was assessed using the 4-meter (4m) and 8-meter (8m) Pass for Accuracy Test. This test was designed to evaluate the athletes' ability to make accurate passes from different distances and their overall athletic performance. A square measuring 30 cm on each side was drawn on a wall, with its center positioned 120 cm above the ground. Athletes were instructed to pass the ball into the square from distances of 8m and 4m alternately for a duration of 2 minutes. At the end of the test, accurate passes from the 8m distance were awarded 2 points, while accurate passes from the 4m distance were awarded 1 point. The scores for accurate passes from each distance were recorded. During the test, athletes were allowed to use chest passes, overhead passes, or one-handed throws; however, bounce passes were not permitted [21].

Statistical Analysis

The statistical analysis of the data was performed using IBM Statistical Package for Social Sciences (SPSS) version 26.0. Continuous variables were presented as mean ± standard deviation ($\bar{X}$±SD), while categorical variables were expressed as frequency (n) and percentage (%). The normality of the distribution of variables was assessed using "Histogram" and "Detrended Normal Q-Q" plots, skewness and kurtosis coefficients, the coefficient of variation, and the "Shapiro-Wilk Test." It was determined that the variables followed a normal distribution. Consequently, the direction and strength of the relationships between variables were analysed using Pearson Correlation Analysis.

Results

A total of 23 male professional wheelchair basketball players participated in this study, with a mean age of 31.5 ± 5.8 years and a mean BMI of 24.2 ± 1.2 kg/m². Among the participants, 87% reported their dominant upper extremity as the right side. Additionally, 78.3% stated that they had been playing basketball for more than 9 years. Regarding weekly training frequency, 43.5% trained 3-4 days per week, while 56.5% trained 5 or more days per week. Of the participants, 65.2% reported having played for the national team. When examining their positions within the team, 39.1% were guards, 21.7% were centres, and 39.1% were forwards. All participants reported having been disabled for 9 or more years. Furthermore, 78.3% indicated that they did not require assistance in daily living activities, while 21.7% reported needing assistance.

The basketball classification scores of the professional wheelchair basketball players, the MBTT results for anaerobic power, and the accurate pass test results from 4m and 8m distances for the evaluation of athletic performance are presented in table 1.

	n	Mean ± SD	Min – Max
Basketball Classification Points	23	2.6 ± 1.2	1.0 – 4.5
Anaerobic Power (cm)	23	493.6 ± 103.6	288.3 – 677.6
Accurate Pass 4m (points)	23	44.0 ± 9.2	24 – 56
Accurate Pass 8m (points)	23	8.6 ± 6.1	0 – 19
SD: Standard deviation			

Table 1: Basketball Classification Scores and Measurement Results of Participants

The correlations between anaerobic power and athletic performance tests for the athletes included in the study are presented in **table 2**. A moderate positive linear relationship was observed between anaerobic power and the 4m accurate pass test scores (rho=0.488; $p<0.05$). Additionally, a strong positive linear relationship was found between anaerobic power and the 8m accurate pass test scores (rho=0.792; $p<0.05$).

	Pearson	Accurate Pass 4m	Accurate Pass 8m
Anaerobic Power	rho	0.488	0.792
(MBTT)	p	0.018*	0.001*
MBTT: Medicine ball throw test; rho: correlation coefficient, *: $p<0.05$			

Table 2: Correlations Between Anaerobic Power and Athletic Performance Tests

Discussion

In the present study, we found a significant positive relationship between anaerobic power and accurate passing, which is one of the most critical determinants of athletic success in wheelchair basketball players. Higher upper extremity function and anaerobic performance in wheelchair basketball players enable athletes to perform faster and stronger during games. Throughout a match, the upper extremities are frequently utilized for wheelchair propulsion, defence, rebounding, and shooting. Therefore, improving upper extremity open kinetic chain function and anaerobic power is essential for enhancing shooting accuracy and overall athletic performance in wheelchair basketball players. Unlike previous studies that focused on general athletic performance, our study specifically highlights the role of anaerobic power in shooting accuracy, a critical skill in wheelchair basketball.

Wheelchair basketball is a high-intensity sport that requires both anaerobic and aerobic performance. Anaerobic power is

particularly critical for explosive actions such as rapid transitions, long-distance passes, and shooting under pressure. These actions are essential for competitive success in wheelchair basketball [22,23]. Anaerobic power also plays a critical role in evaluating training programs and monitoring player development throughout the season [24]. In addition, anaerobic power has been reported to be an important parameter affecting performance and athletic success in wheelchair basketball games [25]. A systematic review conducted by Silva et al. noted that speed, agility, anaerobic power, and accurate passing tests are among the most commonly used field-based skill tests in wheelchair basketball [26]. Establishing reference standards, conducting comprehensive, goal-oriented assessments are crucial in planning individualised training programmes, determining player positions and meeting the specific demands of the team.

Wheelchair basketball requires not only the skills demanded by running basketball but also the ability to maneuver the wheelchair effectively. Basketball is a high-intensity, contact sport where speed and agility are prioritised [27]. In wheelchair basketball, the assessment of anaerobic power and performance is particularly important for actions such as long-distance passing or shooting, propelling the ball to the hoop, rapid changes in position, quick jumps to reach the ball, rebounding, and transitioning quickly from defence to offense after gaining possession [28,29]. A study evaluating the relationship between relative and absolute anaerobic power and athletic performance found that athletes with higher anaerobic power parameters covered distances in shorter times, used their wheelchairs more efficiently, and demonstrated better wheelchair handling and shooting performance [29]. Another study conducted with 23 wheelchair basketball players found that wheelchair propulsion speed, wheelchair handling skills, and shooting performance were associated with maximum anaerobic capacity and power [30]. The measurement methods used in our study are frequently employed in clinical practice, do not require complex equipment, and are both valid and reliable. The results of our study align with findings from other studies in the literature that utilized similar measurement methods.

Shooting accuracy is one of the most critical indicators of athletic success in wheelchair basketball. Moreover, shooting accuracy is influenced by physical factors such as anaerobic power and upper limb muscle strength as well as technical factors such as shooting mechanics and ball kinematics [8,31]. Berberidou et al. was found no significant differences in shooting accuracy between wheelchair basketball players and their able-bodied counterparts; however, it highlighted the critical role of upper extremity power and agility in determining shooting performance [32]. Another study assessed anaerobic performance using the Wingate Anaerobic Test and compared it with field-based tests, including shooting accuracy tests. A strong correlation was found between anaerobic power and shooting accuracy and emphasized that higher anaerobic power improves shooting performance and overall game efficiency [33]. Moreover, a comprehensive study analyzed factors influencing shooting accuracy, including anaerobic power, upper extremity strength, and shooting mechanics. It concluded that anaerobic power significantly contributes to shooting accuracy, especially under game-like conditions [34]. These results align with our findings, which show that anaerobic power is positively correlated with shooting accuracy.

Study Limitations

The current study has a few limitations. First, the study focused exclusively on male participants. Including female athletes could provide a more comprehensive understanding of the relationship between anaerobic power and shooting accuracy across genders. Second, the study primarily focused on physical attributes (anaerobic power and upper extremity strength) and did not account for technical (e.g., shooting mechanics) or psychological factors (e.g., concentration, stress) that may influence shooting accuracy.

Conclusion

This study demonstrates a significant positive relationship between anaerobic power and shooting accuracy in professional wheelchair basketball players, highlighting the importance of upper extremity strength and explosive power for athletic success. The clinical implications of these findings suggest that improving anaerobic power and upper extremity strength should be a primary focus in the training and rehabilitation of wheelchair basketball players. Targeted interventions, including explosive power exercises and trunk stability training, can significantly enhance athletic performance, particularly in areas such as shooting accuracy and passing skills. Additionally, the utilization of straightforward and dependable assessments, such as the Medicine Ball Throw Test, facilitates the monitoring of progress and the development of customized training programs for clinicians and trainers.

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Authors' contributions

MM, BID and HO participated in the conception and design of the study. MM was responsible for data acquisition. BID and HO analyzed and interpreted the data. MM drafted the manuscript and MM, BID and HO critically revised the manuscript for important intellectual content. All authors approved the final version of the manuscript.

Ethics approval and consent to participate

The study was approved by the Scientific Research and Publication Ethics Committee of Cyprus International University (Number: EKK21-22/013/006; Date: 18.04.2022) and written informed consent was obtained from all participants.

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