



## ORIGINAL ARTICLE

# A Comparative Study of the Average Motor Response Time for the Arms and Legs of Handball, Basketball, and Volleyball Players Aged 14-16 Years

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## KEYWORDS

*Handball,  
Volleyball,  
Basketball,  
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## ABSTRACT

**Background.** The motor response is a fundamental ability that is evident during any physical or motor activity. However, the need for this ability varies from one sport to another, depending on the specific skills required in each sport. **Objectives.** This study aims to compare the average motor reaction times of the arm and leg among handball, basketball, and volleyball players aged 14 to 16 years. **Methods.** The sample included 30 players aged 14-16 years from the sports talent care center, evenly distributed among handball, basketball, and volleyball. Standardized tests were used to measure the speed of motor response, including the Batak Micro test for hands, which records the number of responses to light stimuli in 30 seconds, and the Saqer test for legs, which measures the response time to a visual stimulus by running towards a colored cone and recording the best time of six attempts. **Results.** The results showed statistically significant differences in the speed of motor response between handball, basketball, and volleyball players ( $F = 9.79$ ,  $p = 0.01$ ). Handball players excelled in the motor response test ( $55 \pm 2.21$ ), while volleyball players scored the best in the two-man motor response test (Saqer) ( $1.25 \pm 0.12$  seconds). **Conclusion.** The study concluded that the speed of motor response in both arms and legs is crucial for athletic performance in this age group. Volleyball players outperformed their counterparts in handball and basketball in arm response speed, and they also excelled compared to handball players in the motor response test.

## INTRODUCTION

Sports play a significant role in enhancing public health and developing psychomotor, psychological, and social aspects of individuals. They are essential activities for improving both the physical and technical abilities of a person. Among the key factors that affect sports performance, motor reaction time is considered one of the most critical elements, as it reflects the efficiency of the neuromuscular system in responding to external stimuli (1).

The advancements in scientific research are not coincidental; they stem from ongoing development and staying updated with the latest knowledge in various fields, including sports (2, 3). Recently, there has been remarkable progress in team sports at a global level, particularly in the Arab world. Sports such as handball, basketball, and volleyball have notably advanced in their technical and tactical aspects, alongside the excitement, speed, and suspense in performances

(4). These improvements demonstrate that coaches and specialized researchers are utilizing measurement and evaluation methods to assess their players' conditions, identifying strengths and weaknesses to address them by developing effective training programs based on sound scientific principles, thereby enhancing players' physical and skill levels (5, 6).

Motor response is a fundamental ability that becomes evident during any physical or motor activity. However, the necessity for this ability varies from one sport to another, depending on the type and form of skills required in each sport (7, 8). In addition to individual differences among players. Different sports require varying levels of motor response ability, depending on the types and intensities of stimuli encountered during matches, which are often surprising and unpredictable, necessitating that players are always prepared (9, 10).

Studies on motor reaction time are limited, but they emphasize the importance of this ability in improving overall motor performance. A study by Nohrizal and Kahri (2020) aimed to identify the differences in basic physical abilities between futsal and football players. The findings indicated that futsal players outperformed football players in tests measuring transitional speed and strength characterized by speed, as well as the transitional motor response test. Conversely, football players excelled in the strength endurance test and the speed endurance test compared to futsal players (11).

Motor reaction time is a key indicator of an individual's ability to respond to changes in their environment and plays a crucial role in athletic performance, particularly in team sports that depend on quick decision-making and movement execution (12, 13). Response and reaction are fundamental motor qualities shared by these team sports, especially those that involve catching or throwing a ball (14, 15). While the specific movements and skills may vary, sports tend to have similarities, despite differences in ball size, weight, and circumference, as well as variations in field dimensions, sports rules, and scoring methods (16, 17).

The study by Nuri et al. (2013) compared reaction time and anticipatory skills between volleyball players and sprinters. Results showed that sprinters had better auditory reaction times, while volleyball players excelled in anticipatory skills related to the speed of the ball (18).

Recent studies show that directing the learner's focus towards the results of external movement

(external focus) instead of focusing on the body parts themselves (internal focus) contributes to enhancing the speed of response and accuracy of motor performance. Wulf (2013), in a systematic review of fifteen years of experimental studies, reviewed the supporting evidence for the benefit of external goal-oriented instruction, which in turn activates motor nervous systems more efficiently, speeding up the learner's transition from the cognitive stage to the subjective stage according to the Fitts and Posner model of the three stages in learning motor skills, and promotes long-term consolidation of the skill (19).

Some studies have also shown that increasing the speed of motor response requires careful coordination between cognitive and motor processes, facilitated by attention and immediate feedback. McMorris (2014) confirmed that the diversification of practice contexts and the use of instructions focused on the results of external movement supports the construction of flexible motor representations, accelerating the transition of the trainee from dependence on intensive conscious processing to rapid and accurate automatic performance in competitive situations (20).

Contextual interference is one of the important factors affecting the development of motor response speed, as a variety of exercises and training situations stimulate cognitive processing and enhance neuromotor adaptation. Magill and Hall (1990) have demonstrated in a comprehensive review that high-interference training, involving constant switching between different tasks, contributes to a deeper consolidation of motor skills and improved response speed in complex performance situations, compared to repeated low-interference training (21).

Modern concepts in motor learning suggest that the speed of motor response is influenced by cognitive and sensorimotor factors, rather than being solely a product of physical abilities. Magill and Anderson (2024) have demonstrated that interpreting sensory stimuli, making informed decisions, and executing effective motor responses are interrelated processes that are refined through regular practice and immediate feedback. This contributes to enhancing the effectiveness of the central nervous system and shortening response time, especially in team games that require cognitive shifts and rapid responses in dynamic and changing environments (22).

The study by Laffaye et al. (2007) compared the motor response times of handball and volleyball

players during a one-leg vertical jump from a running start. The results showed that volleyball players had a temporal-prevailing profile, while handball players had a force-dominant profile. The study highlighted the differences in jumping strategies among athletes from various sports, based on the inherent demands of their chosen sport (23). Additionally, the study by Raiola (2011) focused on the relationship between reaction time and tactical choices of central blockers in volleyball. The results showed that different tactical choices, such as read block and option block, were associated with the timing of the setter's touches on the ball. These findings suggest that motor response time and tactical choices in volleyball are influenced by the specific demands of the sport (24).

This study aimed to compare the average motor reaction times of the arm and leg among handball, basketball, and volleyball players aged 14 to 16 years. The research was conducted to enhance the athletic performance of this age group by identifying differences in motor reaction times across various sports activities. By doing so, it contributes to the design of targeted training programs tailored to the specific needs of each sport.

The importance of this study lies in its quest to compare the motor response times of the arms and legs of handball, basketball, and volleyball players aged 14-16 years, within the Centers of Sports Talent Care in Baghdad governorate. This approach is based on the modern theory of motor learning, which suggests that the development of motor responses depends on the interaction between the central nervous system and environmental stimuli (25). Adolescence is a critical period in the development of these responses, due to the accompanying neuromuscular changes (26). Although there have been previous studies that have addressed these motor aspects in athletes, the comparison between these three group games in the same age groups is still limited, which highlights the cognitive gap that this study seeks to address, unlike some studies such as Badau et al. (2022) which focused on comparisons between different games or in older age groups (27).

This study is specifically aimed at comparing the motor response times of the arms and legs in response to visual stimuli, using metered electronic instruments (Batak Micro and Saqer). The researcher assumes that there are statistically significant differences between the sample members, such that handball players excel in the speed of arm response due to the nature of the game,

while volleyball players excel in the response of their legs due to the nature of their performance, which requires fast mobility and pouncing.

## MATERIALS AND METHODS

**Study Design.** The application of the method in scientific research varies according to the nature of the problem and the approach used to solve it. Therefore, researchers used the descriptive method because it is appropriate for the nature of the problem and the research objectives, as it allows for the analysis of differences in motor response time between different sports groups within a unified training environment. Although the nature of the study did not require an experimental or semi-experimental design, the choice of this approach is based on the principles of quantitative research in kinematic studies, especially when it is difficult to control variables within natural mathematical environments fully. However, the enhancement of the design strength could have been further achieved by conducting a statistical power Analysis to determine the minimum required sample size, which is recommended for future studies to ensure the reliability and generalizability of the results.

**Participants.** The sample was deliberately selected (positive sampling) from the 49 Sports Talent care center players, where the research sample amounted to 30 players representing 61.22% of the original community, evenly distributed among handball, basketball, and volleyball games, within the age group 14-16 years for the 2023-2024 sports season (Figure 1). The sample was limited to males only to ensure the homogeneity of physical and psychological characteristics and to minimize the influence of gender as a confounder variable. The sample size ( $n = 30$ ) was determined based on statistical power analysis using the G\*Power Program (version 3.1). This analysis was conducted to determine the magnitude of the expected effect at  $f = 0.40$ , with a significance level of  $\alpha = 0.05$  and three groups. The analysis showed that this sample achieves a statistical power of 0.80, which is sufficient to detect significant differences between the groups, as shown in Figure 2. The history of sports training was taken into account to ensure homogeneity among the sample under study; all participants were selected from the players of sports talent care centers in Baghdad governorate, who are undergoing a unified

training program in terms of the number of weekly units (4 to 5 units), under the supervision of certified trainers and within the training curricula codified by the Ministry of youth and sports. The training history of the participants ranges from 3 to 5 continuous years, reflecting a convergent level of organized sports experience.

This sample is divided as follows: there are 10 handball players out of 21, which represents 47.62%; 10 basketball players out of 17, representing 58.82%; and 10 volleyball players out of 11, representing 90.90%. The remaining 19 players, who belonged to other age groups (11, 12, and 13 years), were excluded from the study.

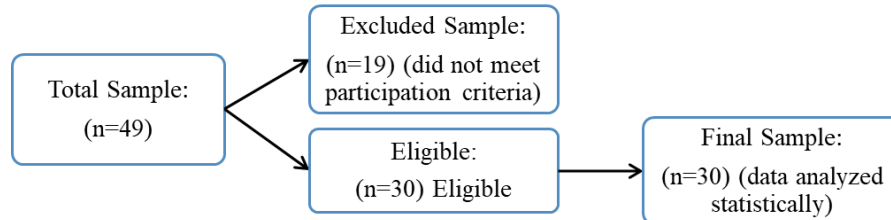


Figure 1. Stages of sample testing and data analysis.

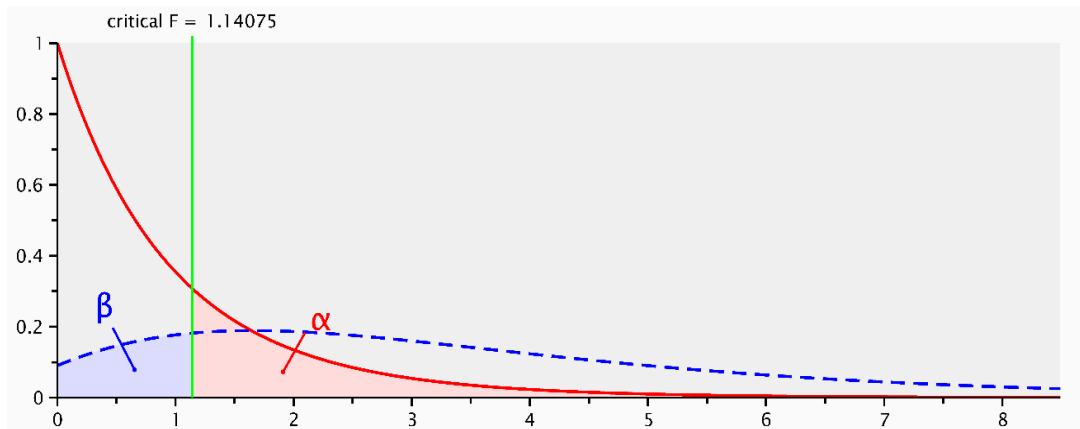


Figure 2. Statistical power analyzer for sample size determination using G\*Power.

**Arm Motor Response Speed Test (BATAK MICRO).** Purpose of the test: To measure the speed of motor response of the arms.

Tools used: Batak Micro, a UK-made device, and a results recording form.

Device Description: The external description of the device is a lightweight electronic board containing 12 circular buttons regularly distributed on the board. It operates by charging or connecting directly to electricity.

As for the internal part, the device contains a central processing unit and a charging battery that works for several hours without an electric current, and it contains fast glowing lights (LED) mounted on the buttons from the inside, and the device has a huge number of on and off maps, so that a specific map is not recognized during tests. The device can prepare 17 cases, depending on the type of test.

Device Setup: The Batak Micro was set up to test the speed of the motor response of the arms by fixing it tightly to a flat wall using custom metal mounts and adjusting its height to match the lengths of the participants so that the illuminated buttons fall within the visual field and the circumference of the movement of the arms during normal standing. The distance between the player and the device is set at about 60 cm to ensure comfort during performance and achieve optimal response. The device has undergone a prior technical inspection to ensure the efficiency of its operation, the regularity of the light flashes, and the safety of the button operation, thereby avoiding any malfunctions that may affect the results. To standardize measurement procedures and ensure accuracy in performance, he was pre-trained in practical exercises on the device's

operation before conducting the test and recording the data. The training included conducting experimental tests under the supervision of the research team. The same person was approved to conduct all tests on all sample members in order to reduce deviations in the procedures and ensure measurement consistency. Before the start of the test process, all participants committed to performing a standard warm-up program that included general exercises for five minutes (such as light running and dynamic movements) and then a special warm-up for three minutes, focusing on stimulating the arms and shoulders through circular movements and light push-ups. This warm-up was conducted to ensure the physical and neuro-motor readiness of the participants and to enhance the reliability of the results obtained.

**Method of performance:** The device is hung on the wall and fixed well or placed on a table at a suitable height above the ground and in proportion to the height of the tested player (the height of the device above the ground is determined by the tallest and shortest player in the sample), then the player stands facing the device, and when preparing it to start, a flash and a readiness sound will appear, and when starting, the buttons begin to glow and the player turns off the lights with his preferred hand, and so on until the set time is completed, and the number of responses appears on the main screen within 30 seconds, and the recorder records the score obtained by the player and re-prepares the device to test another player.

**Recording method:** The test result appears on the device screen, represented by the number of responses within 30 seconds, and the recorder records the result in the form designated for this test.

**Saqr Legs Motor Response Test.** Test name: Saqr legs motor response test.

**Purpose of the test:** To measure the motor response time to a visual stimulus.

**Method of performance:** The device should be positioned on a table at a suitable height relative to the center of gravity of the player being tested. The tester stands in front of the device, approximately 30 cm to the side. Upon receiving the start command from the test administrator, the player passes by the device and activates the optical sensor, which displays one of four colors on a wooden board.

The player then sprints at full speed towards the cone that corresponds to the color shown and

touches the pressure sensor located at the top of the cone. After making contact, the player returns to the front of the device to repeat the process. This sequence is performed six times, with the time for each repetition being recorded separately. An electronic timer within the device starts counting as soon as the command is given and stops when the pressure sensor at the top of the cone is touched. Performance conditions:

- The tester stands in front of the device, focusing on the person conducting the test, who will signal the start.

- The distance between the tester and the cones is 2 meters, and the distance between each cone is also 2 meters.

- The person conducting the test records the time taken for each touch, collecting data over six touches.

- The tester may only be retried in the event of an injury or fall, with a sufficient rest period provided before attempting again.

**Recording method:** The time of each touch is calculated separately, and the time of the best attempt is recorded.

**Data Collection.** The study data were gathered through the main experiment, during which researchers conducted tests relevant to the research topic. This included the motor response speed test, which utilized the (Batak micro) device, and the leg motor response (Saqr test). The testing took place on Saturday, February 18, 2023, at 10:00 AM, after the participants completed a brief warm-up session.

Each group received a clear explanation of the two tests, followed by a practical demonstration by the personnel responsible for minimizing errors and optimizing time efficiency. The results for each test and each group were recorded on a discharge form prepared in advance by the researchers for statistical analysis and result extraction.

**Data Analysis.** In analyzing the data, the researchers relied on the statistical program SPSS version 23.0 to extract the results, using arithmetic averages and standard deviations to describe the data, as well as to perform the test. One-way ANOVA was used to measure statistical differences between handball, basketball, and volleyball players in Tests of the speed of motor response of arms and legs. To determine the source of the differences, LSD dimensional testing was used. The Effect Size was also calculated by  $\eta^2$  to determine the strength of the statistical effect of the differences. The

significance level  $\alpha < 0.05$ ) was adopted to judge the statistical significance.

## RESULTS

According to the STROBE criteria for observational studies, a flowchart was included showing the stages of sample selection, starting from the total sample community consisting of 49 players, where 19 players were excluded for not meeting the conditions of participation, where a number of them suffer from muscle injuries and some of them were used in the experimental test, and ending with the final sample whose data was statistically analyzed (30 players). This scheme aims to clarify the steps of sample selection and achieve transparency in the process, thereby enhancing the reliability of the study results and reducing potential biases.

After implementing the motor response tests, the researchers obtained the raw scores, processed them statistically, and placed them in explanatory tables to display, analyze, and discuss.

The results in [Table 1](#) show that handball players scored an average of 55 repetitions in the arm motor response test (Batak Micro), with a standard deviation of 2.21, compared to  $52.40 \pm 3.23$  for basketball players and  $49.30 \pm 3.09$  for volleyball players.

Regarding the Saqer test for leg motor response, the handball players scored  $1.45 \pm 0.09$  seconds, the basketball players scored  $1.31 \pm 0.09$  seconds, and the airplane players scored  $1.25 \pm 0.12$  seconds.

According to [Table 2](#), the test results of the One-Way ANOVA showed significant differences in the response speed variable ( $F = 9.79$ ,  $p = 0.01$ ), with a large effect size ( $\eta^2 = 0.43$ ), indicating a strong influence of the sport type on response speed, indicating that there are significant differences in this variable among these team sports.

The least significant difference (LSD) test was conducted to compare the arithmetic means and determine which team sports performed better than the others, as shown in [Table 3](#).

**Table 1. Arithmetic means and standard deviation of the motor response speed test of arms and legs by type of sport.**

No.	Variables	Unit of measure	Handball		Basketball		volleyball	
			M	SD	M	SD	M	SD
1	Motor response speed of the arms Batak micro within (30) seconds	repetition	55	2.21	52.40	3.23	49.30	3.09
2	Saqer's leg motor response test	second	1.45	0.09	1.31	0.09	1.25	0.12

M: Means; SD: Standard deviation.

**Table 2. The results of the One-Way ANOVA analysis of the motor response speed of the arms and legs.**

No.	Variables	Source of variance	SS	df	MS	F value	$\alpha$	p-value
1	Motor response speed of the arms Batak micro within (30) seconds	between	162.86	2	81.43	9.79	0.05	0.01
		internal	224.5	27	8.31			
2	Saqer's leg motor response test	between	0.19	2	0.09	8.30	0.05	0.001
		internal	0.31	27	0.01			

df: Degrees of freedom; SS: Sum of squares; MS: Mean square; F value: F-statistic (ratio of variance between groups to variance within groups);  $\alpha$ : Nominal significance level (here, 0.05); p-value: Exact probability value indicating statistical significance.

**Table 3. Post-tests of differences in motor response speed of arms and legs between sports.**

No.	Variables	Groups	Mean differences	$\alpha$ - level	Significance
1	Motor response speed of the arms Batak micro within (30) seconds	Handball - Basketball	-2.6	0.05	ns
		Handball - Volleyball	-5.70	0.001	**
		Basketball - Volleyball	3.10	0.02	*
2	Saqer's leg motor response test	Handball - Basketball	0.19	0.01	**
		Handball - Volleyball	0.19	0.001	**
		Basketball - Volleyball	0.05	0.24	ns

ns: Non-significant ( $p \geq 0.05$ ); \*:  $p < 0.05$ ; \*\*:  $p < 0.01$ .

## DISCUSSION

The study's results demonstrated the superiority of volleyball players in terms of motor response speed in their legs, due to the constant need for quick transitions between defensive and offensive roles, as well as the multidirectional nature of movement on a smaller court. This finding aligns with the results of recent studies, such as the study by Przednowek et al. (2019), which demonstrated that training with moving lighting significantly enhances the speed of visual response and motor skills in volleyball players (28).

The sample consists of players who regularly train at the National Center for Sports Talent Care, where the training sessions involve interconnected and varied movements designed to enhance the speed of motor responses. This training enhances players' ability to coordinate their movements. As Dabour (1996) stated, Complex or integrated skills are characterized by a structure comprising several interconnected movement performances, each reciprocally impacting the others to achieve a specific movement action (29).

Players must frequently switch between offensive and defensive roles, making agility and quick decision-making critical during gameplay (28). In contrast, the results did not show significant differences between basketball and volleyball players in the motor response time of their legs, perhaps due to the compatibility of motor performance requirements and playground requirements in both sports. In support of this, a study by Vučković et al. showed that athletes in team games require high abilities in responding to rapidly changing stimuli, emphasizing that the development of these abilities is directly related to skill performance (30).

Both Hassan and Sebnan highlight that "the necessity for players to switch rapidly from defensive to offensive duties, and vice versa (31). demands the development of motor skills, transitional speed, quick reactions, and the ability to perform both vertical and horizontal jumps." For instance, executing offensive hits involves jumping from both the front and back areas of the court, as well as skills such as setting, spiking, and serving while airborne. All of these tasks require leg and arm strength characterized by speed, agility, and excellent coordination. This was confirmed by the study by Badau et al. on The Impact of Implementing

an Exergame Program on the Level of Reaction Time Optimization in Handball, Volleyball, and Basketball Players, where the results of the motor response showed significant progress if volleyball was first, then basketball, and then followed by handball (27).

The literature indicates that the level of skill or experience significantly contributes to the speed of response; for example, the study of Przednowek et al., which showed that motor training (coordination & reaction) led to a tangible improvement in the speed of response in hand players (28). Recent studies have also shown that, as Behringer et al. found, strong resistance systems enhance motor performance in the lower extremities of adolescents, and this improvement also depends on the training history. Therefore, it is likely that the variation of players' skills and their training history had a partial impact on the results, which calls for documenting variables such as years of experience and training intensity in future studies (32).

Additionally, volleyball differs from sports like handball and basketball because the ball remains in the air and cannot touch the ground during play. A team loses a point if the ball hits its side of the court. In contrast, players in handball and basketball can continuously dribble the ball, allowing them to move to any part of the court, whether stationary or in motion.

The Saqer test revealed no significant differences in the motor response of the legs between basketball and volleyball athletes. This can be attributed to the similar speed of performance required in both sports. In volleyball, players must execute three touches quickly, whereas in basketball, players have a designated 24-second time frame to execute a single offensive play, reflecting a high-speed environment that requires them to perform various skills.

Basketball players rely on motor speed for essential skills such as shooting, dribbling, and transitioning quickly between the front and back zones. They must also be able to react swiftly to changing situations posed by the opposing team. The ability to respond quickly is crucial, as basketball involves unpredictable and constantly changing scenarios throughout the game. However, the role of individual skill level and organizational experience in influencing the speed of motor response cannot be overlooked. Variables that were not directly measured in this

study constitute one of the important limitations. The similarity in results may be due to the similarity in the skill level of the players or the homogeneity of their training experience, rather than solely to the nature of the sport. This is supported by the study of Vučković et al., which indicates that the speed of motor response is closely related to basic motor skills in team games, rather than just the type of sport (30). It also indicated that increasing response speed is a crucial component of improving academic performance. Modern literature also recommends including Training Load indicators and controlling them in the analysis of differences to avoid bias resulting from the varying intensity of training. This is supported by the study of Fox et al., which found that the intensity and frequency of exercises play a significant role in improving response time, regardless of the type of sport (33).

At the level of motor theories, the Fitts and Posner (Fitts & Posner, 1967) three-stage model explains the development of response speed, starting from the cognitive stage in which the player learns the rules, passing through the associative stage in which the stimulus is connected to the action via repetition and feedback, up to the autonomous stage in which fast and accurate performance is achieved without much conscious effort (34). Schmidt & Lee highlight that diverse training with instant feedback is key to the effective transition between these stages and the acceleration of motor response (25).

Similarly, handball is a fast-paced team sport where response speed is vital for executing motor skills and executing both offensive and defensive movements. The speed of motor response is a fundamental requirement for various sports in general, and specifically for handball. This sport is characterized by continuous and variable nervousness and muscular effort, which changes according to match conditions. Players must be constantly prepared to react to different external stimuli, whether they have the ball or not. This demands quick and accurate responses from the moment the stimulus occurs until the motor response is completed.

Consequently, a high level of physical, skill-based, and tactical abilities is essential for players, reflecting the development of the central nervous system and other bodily systems.

## CONCLUSION

This study concluded that the speed of motor response in both arms and legs is related to performance in this age group, highlighting differences across various sports activities. The results indicated that volleyball players had superior arm response speed compared to handball and basketball players. Furthermore, in the Saqer test for leg motor response, volleyball players outperformed handball players. However, there was no noticeable difference in leg motor response between volleyball and basketball players. To deepen the practical understanding of this relationship, it is recommended that prospective studies be conducted to directly measure athletic performance and test the effect of motor response speed on motor and functional performance variables in a planned training context.

## APPLICABLE REMARKS

- There is potential to enhance the interest of basketball and volleyball coaches in developing their players' motor response speed during training sessions.
- Coaches should conduct ongoing assessments to identify the progress of their players' reaction speed through the exercises and drills they practice.
- Additionally, it would be beneficial to carry out studies that examine how improving motor response speed affects various motor skills in team sports.

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## ETHICAL CONSIDERATION

This study adhered to the ethical guidelines of the University of Baghdad/ Faculty of Physical Education and Sports Sciences. The participants were informed of the potential risks that may occur during the tests, and all participants agreed to these conditions, maintaining the confidentiality of their personal data, which the Ethical Consideration Committee approved.

## AUTHORS' CONTRIBUTIONS

Study concept and design: Maath Abdull Kareem Fadhil. Acquisition of data: Mustafa Ahmed Obaid. Analysis and interpretation of data: Mutasim Abdul Karim Fadhil. Drafting the manuscript: Maath Abdull Kareem Fadhil. Critical revision of the

manuscript for important intellectual content: Mustafa Ahmed Obaid. Statistical analysis: Mustafa Ahmed Obaid. Administrative, technical, and material support: Mutasim Abdul Karim Fadhil. Study supervision: Maath Abdull Kareem Fadhil.

### CONFLICT OF INTEREST

The authors declared any financial investments associated with the tools and equipment utilized in this manuscript.

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### FINANCIAL DISCLOSURE

Hereby warrant that no relevant financial interests or conflicts of interest exist related to this manuscript. No government institutions or other organizations have funded this study.

### ROLE OF THE SPONSOR

There was no funding for the study; therefore, it relied on the efforts of researchers in terms of material, technical, and logistical support.

### ARTIFICIAL INTELLIGENCE (AI) USE

None of the artificial intelligence tools was used to write and conduct this study.

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