10.61186/aassjournal.1545 Video summary on YouTube Infographic summary on LinkedIn

Ann Appl Sport Sci InPress(InPress): e1545.
e-ISSN: 2322-4479; p-ISSN: 2476-4981

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

[1]Maath Abdull Kareem Fadhil, [1]Mustafa Ahmed Obaid*, [2]Mutasim Abdul Karim Fadhil

[1]College of Physical Education and Sports Sciences, University of Baghdad, Baghdad, Iraq.
[2]College of Physical Education and Sports Sciences, University of Kirkuk, Kirkuk, Iraq.
***. Corresponding Author: Mustafa Ahmed Obaid**; **E-mail:** mostafa.a@cope.uobaghdad.edu.iq

Submitted February 24, 2025;
Accepted June 11, 2025.

KEYWORDS
Handball,
Volleyball,
Basketball,
Motor Response Speed.

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 and depends 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 on 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, reaching a value of F=9.79, p=0.01, which indicates significant differences at a significance level of 0.05. Handball players excelled in the motor response test of the hands with an average 55 and a standard variation 2.21, while volleyball players scored the best in the two-man motor response test (Saqer) with an average time 1.25 seconds and a standard deviation 0.12. **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 handball and basketball counterparts 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 highlight 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 to enhance 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). As well as individual differences among players. Different sports demand varying levels of motor response ability based on the types and intensities of stimuli encountered during matches, which are frequently surprising and changeable, necessitating players to be always prepared (9, 10).

Studies on motor reaction time are limited, but it emphasizes 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 through 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 shown in a comprehensive review that high-interference trainings involving constant switching between different tasks contribute to a deeper consolidation of motor skill 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, and not just a product of physical abilities. Magill and Anderson (2024) have shown that interpreting sensory stimuli, making an appropriate decision, and implementing

an effective motor response 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 time of handball and volleyball players during a running one-leg vertical jump. 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 between athletes from different 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 is based on his quest to compare the motor response time of the arms and legs of handball, basketball and volleyball players of the age group 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). And 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 time of the arms and legs, as a 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, so that handball players excel in the speed of response of the arms due to the nature of the game, while volleyball players excel in the response of the legs due to the nature of their performance based on fast mobility and pouncing.

MATERIALS AND METHODS

Study Design. The use of the method in scientific research varies according to the nature of the problem and the method of solving it. Therefore, researchers used the descriptive method because it is appropriate for the nature of the problem and the objectives of the research, as it allows to analyze the differences in the motor response time between different sports groups within a unified training environment. Although the nature of the study did not depend on 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 fully control variables within natural mathematical environments. However, the enhancement of the design strength would have been further achieved by conducting statistical power Analysis to determine the minimum required sample size, which is recommended in the future 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), where with the determination of the magnitude of the expected effect at f=0.40,

the significance level α=0.05, the number of groups = 3. The analysis showed that this sample achieves a statistical power = 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 players, totaling 19, were excluded from the study because they belong to other age groups (11, 12, and 13 years).

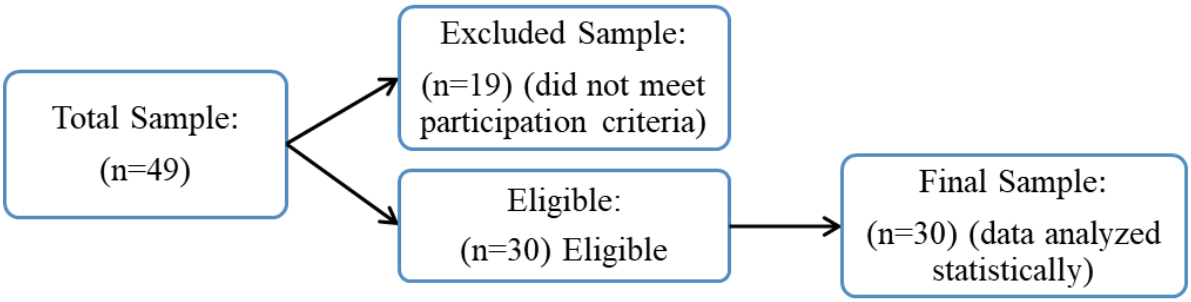

Figure 1. Stages of sample testing and data analysis.

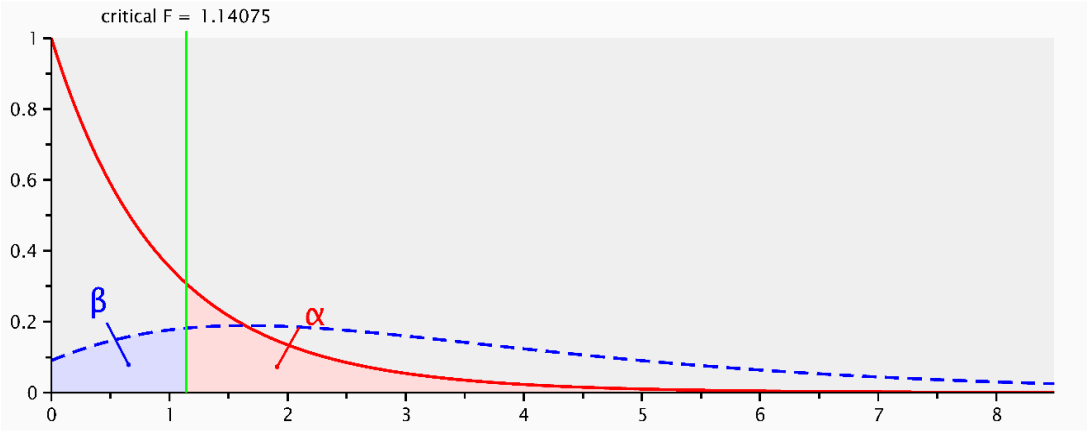

Figure 2. Statistical power analyzer for sample size determination using G*Power.

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 UK-made device, results recording form.

Device Description: The external description of the device is a lightweight electronic board, and it contains 12 circular buttons that can be pressed regularly distributed on the board, and it works 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,

and 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 work, the regularity of the light flashes, and the safety of the operation of the buttons to avoid any malfunctions that may affect the results. In order to standardize the measurement procedures and ensure accuracy in performance, he was pre-trained in practical training on the operation of the device before performing 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 exercises) and then a special warm-up for three minutes focused 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.

Saqer Legs Motor Response Test. Test name: Saqer 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 will indicate one of four colors displayed 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 the 6 touches is calculated for each touch separately and the time of the best attempt is taken.

Data Collection. The study data was gathered through the main experiment, where researchers conducted tests pertinent to the research topic. This included the motor response speed test, which utilized the (Batak micro) device, and the legs motor response (Saqer 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 to minimize errors and optimize 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, where arithmetic averages and standard deviations were used to describe the data, as well as 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 η^2 to determine the strength of the statistical effect of the differences. The significance level $\alpha \leq 0.05$) 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 selection process, enhancing the reliability of the study results and reducing possible biases.

After taking the steps to implement the motor response tests, the researchers were able to obtain the raw scores for these tests and then process them statistically and place them in explanatory tables to display, analyze and discuss them.

The results in Table 1 showed that handball players scored an average of 55 repetitions in the arm motor response test (Batak Micro) with a standard deviation of 2.21, against 52.40 ± 3.23 for basketball players, and 49.30 ± 3.09 for volleyball players.

Regarding the Saqer test for leg motor response, the handball players scored 1.45 ± 0.09 seconds, the basket 1.31 ± 0.09 seconds, and the airplane 1.25 ± 0.12 seconds.

According to Table 2, The test results One-Way ANOVA showed significant differences in the response speed variable F=9.79, p=0.01, with a large effect size η^2=0.43, which indicates a strong influence of the sport type on the response speed. indicating that there are significant differences in this variable among these team sports.

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		olleyball	
			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 leg's 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	α	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 leg's 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); α: Nominal significance level (here, 0.05); p-value: Exact probability value indicating statistical significance.

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

Figures 3 and 4 below show the differences in the average performance of players in the motor response speed of the arms test using the Batak Micro and the Saqer leg's motor response test among handball, basketball, and volleyball players.

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

No.	Variables	Groups	Mean differences	α- 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 leg's 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≥0.05); *: p<0.05; **: p<0.01.

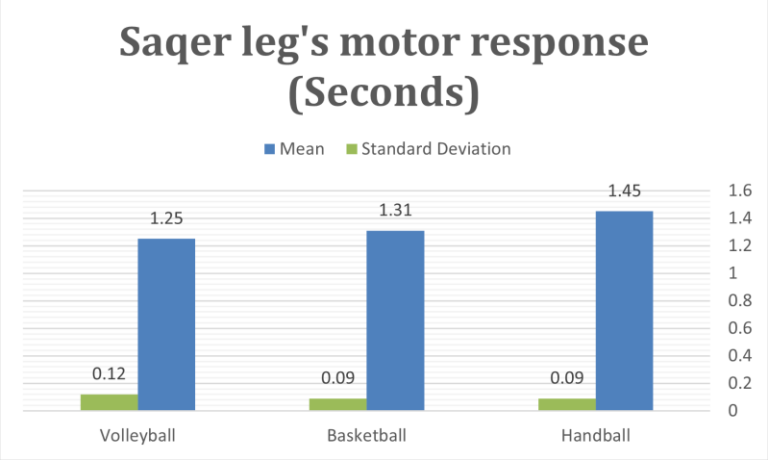

Figure 3. Arithmetic averages and standard deviations of the motor response time test of the legs (Saqr test) among handball, basketball, and volleyball players.

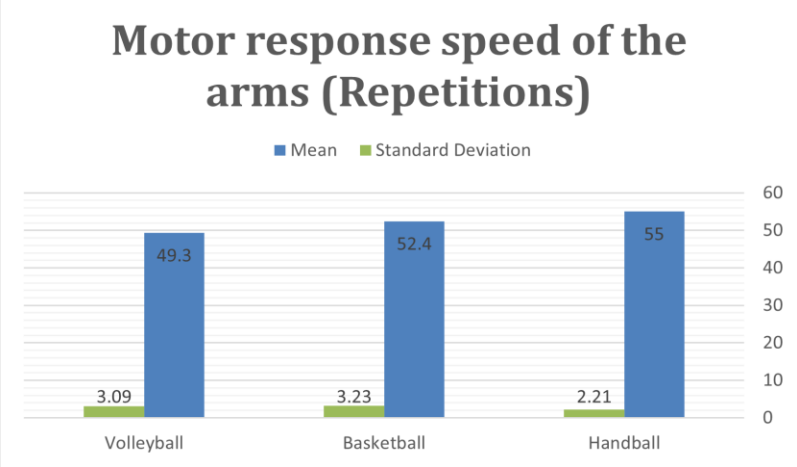

Figure 4. Arithmetic averages and standard deviations for testing the number of motor responses of the arms using the Batak Micro Device among handball, basketball, and volleyball players.

DISCUSSION

The results of the study showed the superiority of volleyball players in the speed of motor response of their legs due to the constant need for a quick transition between defensive and offensive roles, the multidirectional type of

movement on a smaller court. This is in line with the results of recent studies, such as the study of Przednowek et al. (2019), which showed that training using moving lighting significantly improves 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 improves the players' ability to coordinate movement. 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. (2020) stated that athletes in team games require high abilities in responding to rapidly changing stimuli and emphasized that the development of these abilities is directly related to skill performance (30).

Both Hassan and Sebhan 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 jumping. All of these tasks require leg and arm strength characterized by speed, agility, and excellent coordination. This was confirmed by the study badau et al. 2022 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, 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. She 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 such as the study of Behringer et al. (2011) found that strong resistance systems improve the motor performance of the lower extremities in adolescents, it also depends on the history of training. 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. 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 movement to any part of the court, whether stationary or in motion.

The Saqer test showed insignificant 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, while in basketball, players have a designated time of 24 seconds to execute a single offensive play, reflecting a high-speed environment for performing 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 the individual skill level and organizational experience of the players 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, and not just because of the nature of the sport. This is supported by the study of

Vučković et al. (2020), which indicate that the speed of motor response is closely related to basic motor skills in team games, and not just to the type of sport (30). It also indicated that increasing response speed is a crucial component of improving academic performance. The modern literature also recommends the need to include indicators Training Load and control them in the analysis of differences, to avoid bias resulting from the different intensity of training. This is indicated by the study of Fox et al., 2022 which found that the intensity and frequency of exercises play a big 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 (2019) highlight that diverse training with instant feedback is the key to effective transition between these stages and 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 the arms and legs is related to performance in this age group by 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 to conduct prospective studies that 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 basketball and volleyball coaches' interest 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.

ACKNOWLEDGMENTS

We would like to thank and appreciate everyone who contributed to the completion of this study through scientific guidance or scientific support.

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

I do not have any financial investments associated with the tools and equipment utilized in this manuscript.

FINANCIAL DISCLOSURE

I hereby warrant that I have no relevant financial interests or conflicts of interest related to this manuscript. My research has not been funded by any government institutions or other organizations.

FUNDING/SUPPORT

No other organization provided material or financial support for this project.

ETHICAL CONSIDERATION

This study followed the ethical guidelines at 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 while maintaining the confidentiality of the participants' personal data, and this was approved by Ethical Consideration Committee.

ROLE OF THE SPONSOR

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

ARTIFICIAL INTELLIGENCE (AI) USE

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

REFERENCES

1. Ameen IQ, Fadhil MA. The Effectiveness of an Educational Program Using the Eisenkraft Model in the Accuracy of Serving and Spiking In Volleyball for Students. Revista iberoamericana de psicología del ejercicio y el deporte. 2023;18(1):113-6.
2. Ahmed Obaid M, Hussein Khalifa A, Saad Rabeea M. The Effect of an Electronic Device Designed to Measure the Knee Bending Angle in Developing the Skill of Catch and Clearance the High Ball for Football Goalkeepers. Annals of Applied Sport Science. 2024 Jun 10;12(2):0-. [doi:10.61186/aassjournal.1286]
3. Badau D, Stoica AM, Litoi MF, Badau A, Duta D, Hantau CG, Sabau AM, Oancea BM, Ciocan CV, Fleancu JL, Gozu B. The impact of peripheral vision on manual reaction time using fitlight technology for handball, basketball and volleyball players. Bioengineering. 2023;10(6):697. [doi:10.3390/bioengineering10060697] [PMid:37370628]
4. Salim AT, Kareem MA, Alwan SA. The effect of (HIT) training on immune globulins and white blood cells for amateur weightlifters after the return of activity from the mandatory quarantine for the Covid-19 epidemic. Revista iberoamericana de psicología del ejercicio y el deporte. 2022;17(5):328-31.
5. Spieszny M, Kamys Z, Kasicki K, Wąsacz W, Ambroży T, Jaszczur-Nowicki J, Rydzik Ł. The Impact of Coordination Training on Psychomotor Abilities in Adolescent Handball Players: A Randomized Controlled Trial. Applied Sciences. 2024;14(17):7974. [doi:10.3390/app14177974]
6. Popowczak M, Domaradzki J, Rokita A, Zwierko M, Zwierko T. Predicting visual-motor performance in a reactive agility task from selected demographic, training, anthropometric, and functional variables in adolescents. International Journal of Environmental Research and Public Health. 2020;17(15):5322. [doi:10.3390/ijerph17155322] [PMid:32722036]
7. Ghuntla TP, Mehta HB, Gokhale PA, Shah CJ. A comparison and importance of auditory and visual reaction time in basketball players. Saudi Journal of Sports Medicine. 2014;14(1):35-8. [doi:10.4103/1319-6308.131616]
8. Debnath P. Comparetive study of reaction time among football, handball and basketball players. Int J Physiol Nutr Phys Educ 2020;5(1):125-127.
9. Alia SK, Fadhilb MA, Zulnaidic H. Effectiveness of Coordination and Agility Exercises on the Performance of Basic Fencing Skills amongst University of Baghdad Students. International Journal of Innovation, Creativity and Change. 2019;7(3):117-28.
10. Singh LT, Singh TS. Comparative investigation of hand and foot reaction ability between the basketball and handball players. Sport Sciences for Health. 2024 Sep;20(3):773-8. [doi:10.1007/s11332-023-01154-9]
11. Nohrizal A, Kahri M. The effect of interval run training on increasing vo_2max on futsal player. In1st South Borneo International Conference on Sport Science and Education (SBICSSE 2019) 2020 Feb 27 (pp. 136-137). Atlantis Press. [doi:10.2991/assehr.k.200219.039]

12. Zwierko M, Jedziniak W, Popowczak M, Rokita A. Effects of six-week stroboscopic training program on visuomotor reaction speed in goal-directed movements in young volleyball players: a study focusing on agility performance. BMC Sports Science, Medicine and Rehabilitation. 2024;16(1):59. [doi:10.1186/s13102-024-00848-y] [PMid:38424539]
13. Khalifa AH, Obaid MA. A Comparative Analytical Study of Some Biomechanical Variables and Their Relationship to The Accuracy of The Performance of The Shooting Skill of Jumping High in The Weak and Strong Foot the Players for Youth Handball. Wasit Journal of Sports Sciences, 2024;18(1):313-26. [doi:10.31185/wjoss.443]
14. Çakıt İ, Çamlıgüney F, Erdil G. The Impact of Differential Learning Model on Motor Skills and Handball-Specific Coordination Performance in 11-13-Year-Old Beginners in Handball. International Journal of Sport Exercise and Training Sciences-IJSETS. 2022;8(4):152-60. [doi:10.18826/useeabd.1152610]
15. Sadiq AJ, Obaid MA. The effect of rehabilitative exercises according to some kinematic variables in relieving lower back pain for women aged 25-35 old. Wisdom Journal for Studies & Research. 2024;4(04):1327-43. [doi:10.55165/wjfsar.v4i04.324]
16. Jasem ZK, Mohammed KS, Dawood MS, Liayth Abd Alkreem K. The Psychological Well-being and Its Relationship with the Functional Creativity of Female Gymnastics' Trainers. Annals of Applied Sport Science. 2024;12(2):0-. [doi:10.61186/aassjournal.1369]
17. Rabeea MS, Khalifa AH, Obaid MA. The Effect of Suggested Exercises on Developing Some Mental Abilities for Children Aged 4-6 Years. JSRSE. 2024;34(4):473-8. [doi:10.55998/jsrse.v34i4.681]
18. Nuri, Leila, et al. Reaction time and anticipatory skill of athletes in open and closed skill-dominated sport. European journal of sport science. 2013;13(5):431-436. [doi:10.1080/17461391.2012.738712] [PMid:24050458]
19. Wulf G. Attentional focus and motor learning: a review of 15 years. International Review of sport and Exercise psychology. 2013;6(1):77-104. [doi:10.1080/1750984X.2012.723728]
20. McMorris T. Acquisition and performance of sports skills. John Wiley & Sons; 2014 May 27.
21. Magill RA, Hall KG. A review of the contextual interference effect in motor skill acquisition. Human movement science. 1990;9(3-5):241-89. [doi:10.1016/0167-9457(90)90005-X]
22. Magill RA, Anderson D. Motor learning and control: Concepts and applications. McGraw Hill; 2024.
23. Laffaye G, Bardy BG, Durey A. Principal component structure and sport-specific differences in the running one-leg vertical jump. International journal of sports medicine. 2007;28(05):420-5. [doi:10.1055/s-2006-924507] [PMid:17111321]
24. Raiola G. Block in volleyball with the help of Bodily Communication. Journal of Social Sciences. 2011;7(4):666. [doi:10.3844/jssp.2011.666.670]
25. Schmidt RA, Lee TD. Motor learning and performance 6th edition with web study guide-loose-leaf edition: From principles to application. Human Kinetics Publishers; 2019 Sep 18.
26. Patel P, Lee S, Myers ND, Lee MH. Missing data reporting and analysis in motor learning and development: A systematic review of past and present practices. Journal of Motor Learning and Development. 2020;9(1):109-28. [doi:10.1123/jmld.2020-0018]
27. Badau D, Badau A, Ene-Voiculescu C, Larion A, Ene-Voiculescu V, Mihaila I, Fleancu JL, Tudor V, Tifrea C, Cotovanu AS, Abramiuc A. The impact of implementing an exergame program on the level of reaction time optimization in handball, volleyball, and basketball players. International Journal of Environmental Research and Public Health. 2022;19(9):5598. [doi:10.3390/ijerph19095598] [PMid:35564993]
28. Przednowek K, Śliż M, Lenik J, Dziadek B, Cieszkowski S, Lenik P, Kopeć D, Wardak K, Przednowek KH. Psychomotor abilities of professional handball players. International journal of environmental research and public health. 2019;16(11):1909. [doi:10.3390/ijerph16111909] [PMid:31151149]
29. Dabbour Y. modern handball. 1st ed. Alexandria: Maarif publishing and distribution company; 1996.
30. Vučković I, Gadžić A, Marković S, Sekulić Ž. The validity and reliability of The reaction time and basketball defensive slide speed test. Facta Universitatis, Series: Physical Education and Sport. 2022;1:061-72. [doi:10.22190/FUPES220218006V]
31. Hassan T, Sebhan S. kills of offensive and defensive plans. the good word; 2011.

32. Behringer M, Vom Heede A, Matthews M, Mester J. Effects of strength training on motor performance skills in children and adolescents: a meta-analysis. Pediatric exercise science. 2011;23(2):186-206. [doi:10.1123/pes.23.2.186] [PMid:21633132]
33. Fox JL, Stanton R, Sargent C, Wintour SA, Scanlan AT. The association between training load and performance in team sports: a systematic review. Sports Medicine. 2018;48:2743-74. [doi:10.1007/s40279-018-0982-5] [PMid:30225537]
34. Fitts PM, Posner MI. Human performance. Belmont (CA): Brooks/Cole Pub. Co.; 1967.