

## ASSESSMENT OF THROWING ARM ANGLES IN VERTICAL JUMP SHOT OF HANDBALL PLAYERS

**Karam Shyamananda Singh**

Research Scholar, Department of Physical Education and Sports Science  
Manipur University, Imphal, Manipur (India)

**Laishram Thambal Singh (PhD)**

Professor, Department of Physical Education and Sports Science  
Manipur University, Imphal, Manipur (India)

Received: 10<sup>th</sup> July, 2025

Revised & Accepted: 15<sup>th</sup> November, 2025

Published: 25<sup>th</sup> December, 2025

DOI: <https://doie.org/10.65985/AS.2026332413>

### Abstract

**Background:** *The kinematic analysis of jump shot with reference to the analysis of the release angle of different joints of the arm helps us to understand how to improve the maximal force muscles produced where the motor actions are performed at the instant frame of release.*

**Objective:** *The main objective was to investigate, assess and compare the angle of release of different joints of the right arm among handball players of under-14 and under-18.*

**Methodology:** *Thirty (30) right handed national-level handball players, fifteen players (15) of each under-14 and 18 years of age were selected. For measuring the angle of release of different joints of the right arm (wrist joint, elbow joint and shoulder joint) at the instant frame of the handball released, a high-speed action camera (GoPro 12) was used to capture the frame in this study. Kinovea, a video annotation tool designed for sports movement analysis was used to record and further investigation analyzing the angle of the joints of the right arm.*

**Result and Conclusion:** *Significant differences were found between the two groups of their means comparison of the shoulder joint and the elbow joint ( $p < 0.05$ ), but there was no significant contrast in the wrist joints of the two groups, which were considered for this study ( $p > 0.05$ ). Following the result of the study could give a few conclusions regarding the speed generated by the groups and injuries that could be identified in future by studying the range of movements.*

**Keywords-** *Kinematic, Angle of Release and handball*

### **I. Introduction**

Handball was introduced early in the Olympics and is a very vigorous team sport enjoyed by millions of people around the globe [1-2]. Handball is a game that originated in Europe and is now played worldwide. It is played by both male and female athletes. It is a dynamic team sport where two teams of seven players each aim to score more goals than their opponents by

throwing the ball into the opposing team's goalpost. A game of handball consists of two periods of 30 minutes each, with a 10-minute halftime break. The team that scores the most goals during the game wins the match. If the score is tied at the end of the game, the match is considered a draw. The game is played on a court that measures 40 meters in length and 20 meters in width. The court is divided into two halves, with a centre line marking the halfway point. Each team has a goalpost at either end of the court, and the aim is to throw the ball into the opposition's goalpost. Handball is a fast-paced and high-scoring game. The game involves a lot of running, jumping, and throwing, making it a physically demanding sport. Body contact is allowed when defending, but fouls are penalized, and players can be sent off the court for repeated fouls.

Handball is a high-intensity contact sport of various actions such as dribbling, running, passing, jumping, blocking, pushing and catching [3-4]. Male players generally tend to produce higher throwing speeds than female players. This could be attributed to differences in physical strength and muscle mass between the two genders [5]. The speed of the ball is definitely a crucial factor when it comes to successfully throwing the ball towards the goal. The faster the ball travels, the more difficult it becomes to save by the goalkeeper. However, accuracy and ball placement are also important factors to consider when attempting to score a goal. The release angles of the arm play a major role in producing the speed of the handball. The maximum endpoint velocities of the hand and wrist segments produced different speeds in males and females. Both male and female players exhibited the same throwing technique in handball [6]. In handball, there are different types of shots employed by players for scoring goals, such as jump shots, diving shots penalty shots etc. The jump shots can be divided into two types: vertical jump shots and forward jump shots. Jump throws are an essential task in handball and are frequently used from different positions when players shoot towards the goal. In handball competition, 73-75% of all throws during the play constitute jump throws, followed by the run-up standing throw of 14-18%, penalty throw with 6-9%, diving throw with 2-4% and direct free throw of 0-1% [7].

Biomechanics of motor movements is the science that studies human movement and discovers the laws that mechanically regulate the results of movement. The study and knowledge of biomechanics are crucial in playing handball due to its impact on performance and injury prevention. The biomechanical analysis provides insights into movements, coordination, technique, and forces exerted on the body during sports-specific actions like throwing, jumping, and sudden changes in direction [8]. In handball, where high forces are generated around the knee joint and arm joints, understanding biomechanics is essential to prevent injuries like ACL ruptures, which are common in the sport [9-10]. Additionally, biomechanical assessments help in identifying neuromuscular deficits, optimizing rehabilitation programs post-injury, and enhancing specific agility, throwing performance, and overall game-based training methods for improved performance [11]. Studying biomechanics in handball aids in optimizing technical skills, enhancing performance, and correcting errors through the analysis of motor actions and movement characteristics using technical tools [12]. It helps in optimizing techniques for maximal performance, such as increasing handball speed by improving shoulder angular velocity, separation angle, and trunk rotation timing [13]. Therefore, a comprehensive understanding of biomechanics is vital for handball players to enhance performance, prevent injuries, and support effective rehabilitation strategies.

One of the most researched parameters in biomechanics is the jump shot since it is frequently used during play. Every movement of the human body, especially in sports, has an optimal execution technique, which is characterized above all by maximum efficiency and minimum energy consumption. Therefore, design changes in one or more biomechanical parameters can affect the final results [14]. Studying the relationships between the biomechanical analysis and the playing capacity of handball players can improve their performance in future [15].

## II. Objective

The main objective was to investigate and assess the angle of release of different joints of the right arm among handball players. Further, it was to examine the significant differences among the angles of release of different joints of the right arm between the age groups of under-14 and under-18.

## III. Methodology

Thirty (30) right handed handball players 15 each from under-14 (U14) and under-18 (U18) who have represented national-level tournament were selected by employing a stratified random sampling technique so that the possibilities of selection of players from each position were uniform [16]. For measuring the angle of release of different joints of the right arm (wrist joint, elbow joint and shoulder joint) at the instant frame of the handball released, the subjects were asked to throw the ball towards the goal beyond the 9m marking with three step running while executing vertical jump shot and a high-speed action camera (GoPro Hero 12) was used for capturing the frame for this study [17]. Kinovea, a video annotation tool designed for sports movement analysis was used for recording and analysis of the angle of the joints of the right arm. The video were fitted in the software and necessary annotations were made to study the different angles of the arm. The following variables had been recorded and shown in table 1.

**Table 1. Variables**

Sl.no.	Variables
1	Angle of Shoulder Joint
2	Angle of Elbow Joint
3	Angle of Wrist Joint

## IV. Result and Interpretation:

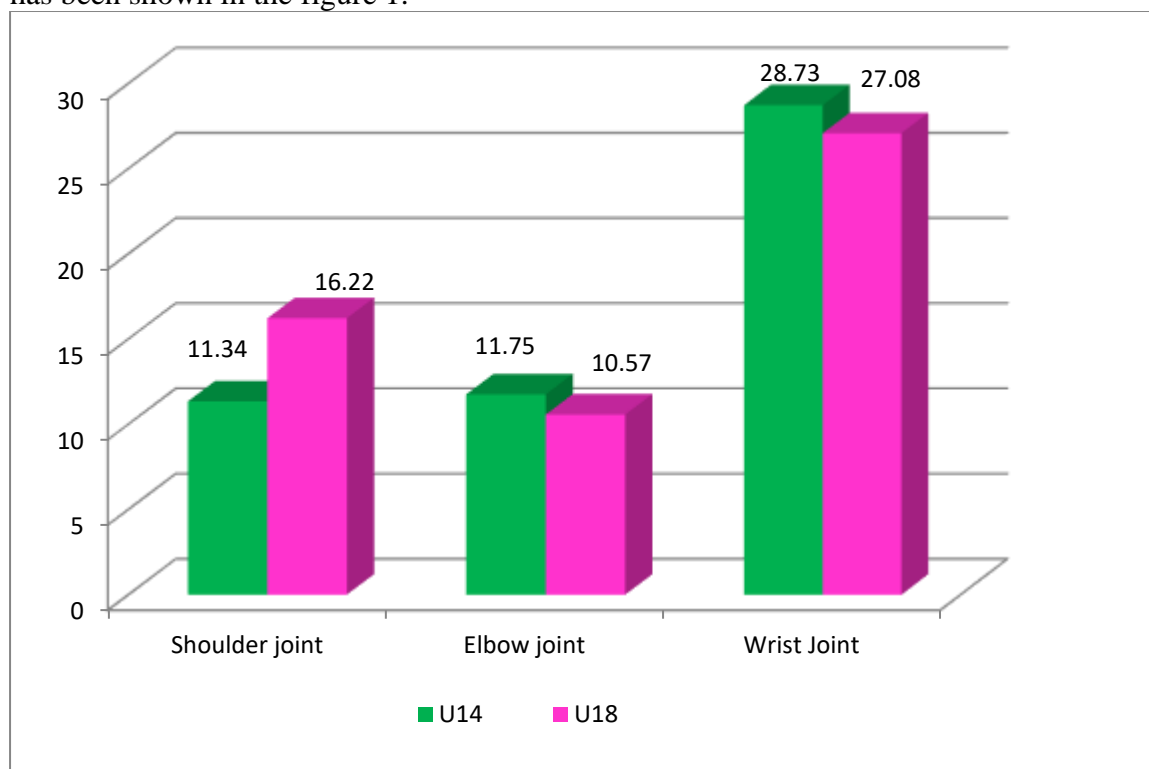
The pertaining data were analyzed descriptively and presented as mean  $\pm$  standard deviation. Normality of distribution and test for equality of variances was assessed using the Shapiro–Wilk test ( $p > 0.05$ ) and Levene’s test for equality of variances ( $p > 0.05$ ) respectively. The level of significance was set at  $\alpha = 0.05$ .

The collected data were analyzed to observe the main attributes and nature of the data and independent t-test to find out differences between the groups. The descriptive investigation of the obtained data for the different angles of the right arm for both U14 and U18 are presented in table 2.

**Table 2: Descriptive Analysis for different angles of the right arm for both U14 and U18**

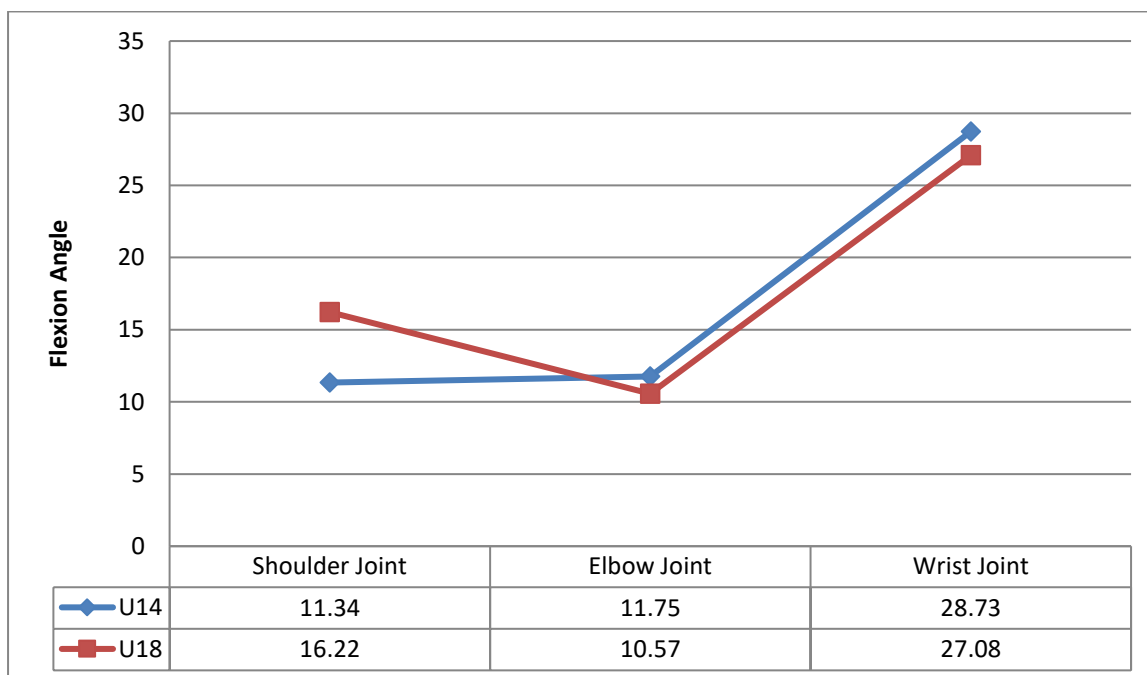
Variable	Group	N	Min	Max	Mean	SD
Angle of Shoulder Joint	U14	15	6.00	15.80	11.34	2.61
	U18	15	9.70	23.00	16.22	3.32
Angle of Elbow joint	U14	15	9.70	13.00	11.75	1.01
	U18	15	9.00	13.00	10.57	1.04
Angle of Wrist Joint	U14	15	22.70	36.80	28.73	4.12
	U18	15	22.50	32.50	27.08	2.54

Table 2 shows the means and standard deviations of the angle of the joints of the right arm of different age group. Means and standard deviations of U14 for shoulder, elbow and wrist joint were  $11.34 \pm 2.61$ ,  $11.75 \pm 3.32$  and  $28.73 \pm 4.12$ . For U18, means and standard deviations of shoulder, elbow and wrist joint were  $16.22 \pm 3.32$ ,  $10.57 \pm 1.04$  and  $27.08 \pm 2.54$  respectively. The graphical representation of means for U14 and U18 for different angles of joints of arm has been shown in the figure 1.



**Fig. 1:** Means for U14 and U18 for different angles of joints of right arm.

The mean comparison of U14 and U18 handball players to assess the contrasts between the groups on different angles of joints of the throwing and thrusting arm in handball players have been interpreted by finding out independent t-test between U14 and U18 handball players. Further their differences were also shown in the form of line diagram as below.



**Fig. 2:** Means of U14 and U18 for different angles of joints of right arm.

The mean comparisons of shoulder, elbow and wrist joint between U14 and U18 have been shown in the table 3.

**Table 3: The means comparison of angles for shoulder, elbow and wrist joints between U14 and U18**

Variable	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
Shoulder Joint	4.48*	28	<0.01	4.88	1.09
Elbow Joint	3.17*	28	<0.01	1.19	0.37
Wrist Joint	1.31	28	0.20	1.25	1.25

\*Significant Value of  $t (0.05, df-28) = 2.05$

The independent t-test was employed to compare the means between U14 and U18. A significant difference was found between the two groups in the shoulder joint and the elbow joint as the obtained value of  $t(0.05, df-28) = 4.48$  and  $t(0.05, df-28) = 3.17$  respectively, were greater than the table value of  $t(0.05, df-28) = 2.05$  ( $p < 0.05$ ). Further, the mean differences indicate that the angle of the shoulder joint in U18 players was significantly greater than that of U14 players, whereas the angle of the elbow joint in U14 players was considerably greater than that of U18 players. No significant difference was found in the case of the wrist joints as the obtained t value = 1.13 was smaller than the table value of  $t(0.05, df-28) = 2.05$  ( $p > 0.05$ ).

## V. Discussion of the Finding

In this study to analyse and compare the angles of the throwing arm while performing the vertical jump shot in handball, there were the significant differences in the shoulder joint and the elbow joint but there was no significant difference in the wrist joints between the groups. This study was supported by another study that there were no critical contrasts within the kinematic parameters of handball jump shots when comparing the average ball release angle [18]. In another study, the kinematics of the jump shot technique and found to have many similarities while executing the skill and the angle between the shoulder axis and the horizontal axis in the sagittal plane at the terminal phase of the take-off was found to have a significant difference [19]. Further, the arm's shoulder flexion, abduction, internal rotation and elbow flexion angle were similar in both throwing techniques in handball as players used the same movement and techniques while executing the shot, which resulted in no significant between groups [20]. The kinematic parameters of the jump shot, such as release height, release angle, and ball release velocity, differ between national and inter-varsity level players, with national players exhibiting higher values [21]. In handball, the number of jump shots is the highest that is used during a match as compared to other types of shots. The significant contrast in the angle of the shoulder joint might be due to personal throwing style, differences in flexibility among the players of different age groups, and their released angle, so the chances of scoring are high.

## VI. Conclusion

There were significant differences between the two groups in their means comparison for the shoulder joint and the elbow joint ( $p < 0.05$ ), but there was no significant difference and contrast mean in the wrist joints of the two groups, which were considered for the study ( $p > 0.05$ ). It has concluded that the kinematics of the throwing arm did not have a significant difference in the angles of the joint of the arm except the joint of the shoulder and elbow while executing the vertical jump shot in handball as during the execution, almost all the players used the same technique of this particular shot. Following the result of the study could give conclusions regarding the speed generated by the groups as kinematics parameters of other movements might influence the output and injuries could be identified in the future by studying the range of movements.

### **Informed consent statement:**

The participants were fully aware of the nature of the study and have given their voluntary agreement to participate in this study.

### **Acknowledgments:**

The authors would like to acknowledge the participants involved in this study.

### **Disclosure statement:**

No potential conflict of interest was reported.

### **Funding**

There was no funding associated with the work for this article.

## References

1. Serrien, B., Clijsen, R., & Blondeel, J. (2015). Differences in ball speed and three-dimensional kinematics between male and female handball players during a standing throw with run-up. *BMC Sports Sci Med Rehabil*, 7, 27. <https://doi.org/10.1186/s13102-015-x>
2. Plummer, H. A., & Oliver, G. D. (2017). The effects of localised fatigue on upper extremity jump shot kinematics and kinetics in team handball. *Journal of sports sciences*, 35(2), 182–188. <https://doi.org/10.1080/02640414.2016.1160143>
3. Gorostiaga, E. M., Granados, C., Ibáñez, J., & Izq. (2005). Differences in physical fitness and throwing velocity among elite and amateur male handball players. *International journal of sports medicine*, 26(3), 225–232. <https://doi.org/10.1055/s-2004-820974>
4. Milanese, C., Piscitelli, F., Lampis, C., & Zancan. (2011). Anthropometry and body composition of female handball players according to competitive level or the playing position. *Journal of sports sciences*, 29(12), 1301–1309. <https://doi.org/10.1080/02640414.2011.591419>
5. Jöris, H. J., van Muyen, A. J., & van Ingen Schenau. (1985). Force, velocity and energy flow during the overarm throw in female handball players. *Journal of biomechanics*, 18(6), 409–414. [https://doi.org/10.1016/0021-9290\(85\)90275-1](https://doi.org/10.1016/0021-9290(85)90275-1)
6. Van Den Tillaar, R., & Cabri, J. M. (2012). Gender differences in the kinematics and ball velocity of overarm throwing in elite team handball players. *Journal of sports sciences*, 30(8), 807–813. <https://doi.org/10.1080/02640414.2012.671529>
7. Wagner, H., Pfusterschmied, J., & von Duvillard, S. (2011). Performance and kinematics of various throwing techniques in team-handball. *Journal of sports science & medicine*, 10(1), 73–80.
8. Zebis, M. K., & Bencke, J. (2018). Biomechanical Aspects in Handball: Lower Limb. *Handball Sports Medicine: Basic Science, Injury Management and Return to Sport*, 61-68. [https://doi:10.1007/978-3-662-55892-8\\_5](https://doi:10.1007/978-3-662-55892-8_5)
9. Setuain, I., Bikandi, E., Amú Ruiz, F., Urtasun, F., & Izquierdo, M. (2019). Horizontal jumping biomechanics among elite female handball players with and without anterior cruciate ligament reconstruction: an ISU based study. *BMC Sports Sci Med Rehabil* 11, 30, <https://doi.org/10.1186/s13102-019-0142-8>
10. Setuain, I., Bencke, J., Alfaro-Adrián, J., & Izquierdo, M. (2018). A Biomechanical Perspective on Rehabilitation of ACL Injuries in Handball. In L. Laver, P. Landreau, R. Seil, & N. Popovic, *Handball Sports Medicine* (pp. 493-504). Berlin: Springer, Berlin, Heidelberg. [https://doi.org/10.1007/978-3-662-55892-8\\_34](https://doi.org/10.1007/978-3-662-55892-8_34)
11. Wagner, H., Fuchs, P. X., & von Duvillard, S. P. (2018). Specific physiological and biomechanical performance in elite, sub-elite and in non-elite male team handball players. *The Journal of sports medicine and physical fitness*, 58(1-2), 73-81. <https://doi.org/10.23736/S0022-4707.16.06758-X>
12. Hussein, S. A., Ivanov, V. A., & Vyaltsev, A. S. (2016). Control of the biomechanical characteristics in handball with the use of technical means. *Bulletin of the Moscow State Regional University*, (3), 98-113. doi: 10.18384/2310-7189-2016-3-98-113
13. Lucy, P., Kevin, B., & Clare, M. (2014). Biomechanical characteristics of handballing maximally in Australian football. *Sports Biomechanics*, 13(4), 307-319. doi: 10.1080/14763141.2014.981201

14. Markovic, S. (2016). Biomechanics of handball, Retrieved from <https://www.researchgate.net/publication/317759484> Biomechanics of handball on 4/11/2023
15. Singh, L., & Gill, G. S. (2018). Relationship of biomechanical analysis and performance of handball players. *International Journal of Yogic, Human Movement and Sports Sciences*, 3(1), 37-38.
16. Elfil, M., & Negida, A. (2017). Sampling methods in Clinical Research; an Educational Review. *Emergency (Tehran, Iran)*, 5(1), e52.
17. Park, M. S., Brock, A., Mortimer, V., Taussky, P., Couldwell, W. T., & Quigley, E. (2017). GoPro Hero Cameras for Creation of a Three-Dimensional, Educational, Neurointerventional Video. *J Digit Imaging* 30, 561–565 <https://doi.org/10.1007/s10278-017-9948-7>
18. Ghosh, P., & Mondal, P. (2017). Effect on kinematics parameters of jump shot in handball. *International Journal of Physical Education, Sports and Health*, 4(4), 453-456.
19. Šibila, M., Pori, P., & Bon, M. (2002). Basic Kinematic Differences Between Two Types Of Jump Shot Techniques In Handball.
20. Wagner, H., Buchecker, M., von Duvillard, S. P., & Müller, E. (2010). Kinematic Comparison of Team Handball Throwing With Two Different Arm Positions. *International journal of sports physiology and performance*. 5, 469-83. 10.1123/ijsp.5.4.469
21. Akl, A.-R., Hassan, I., Hassan, A., & Bishop, P. (2019). Relationship between Kinematic Variables of Jump Throwing and Ball Velocity in Elite Handball Players. *Applied Sciences*. 9(16), 3423. <https://doi.org/10.3390/app9163423>.