

Impact of Transmission Cricket in Learning Selected Handball Skills among High School Boys at Hyderabad

JAAFAR GHADEER ABBAS

Master of Physical Education, University College of Physical Education Osmania University, INDIA

ABSTRACT:

The study is the role of cricket skills in performing handball sport. This study is an in-depth analysis to explain the cricket and handball skills. This study conducts analysis to explain the how cricket skills help handball players to perform effectively in handball sport. The analysis of it clearly explains the similarities between cricket and hand ball skills. This study clarifies that the knowledge about the sport and the importance of it has to be explained.

Keywords: Cricket Skills, Handball Skills, Skill performance.

INTRODUCTION:

Handball is a team sport played by two male or female teams. The players are allowed to handle and throw the ball using their hands, but they must not touch the ball with their feet. The objective of the game is to score and avoid getting goals. The team that scores more goals in a given period of time wins the match. The game is played at a very high speed and body contact is permitted. As a result, Fair Play has a central importance. Basic handball is either played in a sports hall or outdoors on a 40x20 meter court. The other variations of the game, such as Mini handball, Beach Handball or Wheelchair Handball, are all based on the fundamental rules of the game, although both facilities and rules shall be adapted to their needs.

Handball is a combination of Basketball, Soccer and Netball. It is played indoors on a court about the size of two basketball courts. At the each end of the court is a net which is 9 feet wide by 6 1/2 feet high. The object of the game is simply to score more goals than the other team. The ball is usually moved around the court by passing. However, the ball can be dribbled, but like in basketball you cannot double-dribble.

You can dribble for as long as you want (though you risk getting the ball taken away). You can only take at most three steps after catching a pass. You cannot hold the ball for more than three seconds without passing it. If a player is fouled he is allowed a free zone 9 feet wide to restart play. Each team has 12 members, two of which are goalkeepers. 7 team members' play and substitutions can be made at any time. There is a halfway line on the court. There is also a safety area that extends about 20 feet around the goal. A player is not allowed to be in this area. Shooters may leap into this area if they shoot before they land.

If there is a penalty a player is warned. The next two penalties are two-minute suspensions. After that players can be disqualified (which means they are removed, but can be replaced after two minutes). They can also be excluded, which means they cannot be replaced and the team will have one less player on the court. Each goal counts as 1 point. Usually 20 goals are scored in a game. The games consist of two 30 minute halves with a 10 minute rest period in between the halves. The handball weighs 16 ounces (13

ounces for women) and is about the size of a cantaloupe.

Cricket Skills:

Cricket requires a variety of skills that are commonly used in a number of sports. Hand-eye coordination, throwing or catching a ball, balance and intense, long-term concentration are just a few. Through consistent practice and by applying these skills to the elements of cricket, such as a batsman watching the ball at all times, you will see a dramatic improvement in your game. Bob Woolmer, former head coach of the South African cricket team, wrote in "The Art and Science of Cricket," that batting has five basic principles: "Watch the ball, keep your head still on release of the ball, judge length accurately, allow your hands to lead your body and feet into the correct position and select the correct shot." Your grip on the bat should feel natural, using the same tension as when you pick the bat up from the ground. Try to relax at the crease since tension will restrict your movement and have a negative impact on your technique. Lift the bat up as the bowler approaches, keep your head still, focus on the ball and commit fully to the shot you select.

Whether you're a fast bowler, medium-paced bowler who swings the ball in the air or spin bowler who gets the ball to move dramatically off the pitch, bowling has a foundation of skills that each player must learn. Woolmer wrote that by focusing on "momentum, balance and timing" within the context of the run-up, the set-up, the unfold, the delivery and the follow through, bowlers will become consistent and accurate and will be able to take wickets. Bowlers should start off slowly and gain speed and momentum as the run-up progresses into the set-up. Point your left arm -- if you're a right-handed bowler -- in the direction you want the ball to land. As your

action begins to unfold, your bowling arm will begin a 360-degree rotation. Fix your eyes on the target and place your left foot on the popping crease to begin the delivery. Your momentum will naturally bring your arm through to release the ball. Always complete your follow by continuing until you naturally come to a stop. Do not stop quickly or you'll increase the risk of injury. Catching requires five basic skills: Excellent reflexes to get the ball, good hand-eye coordination, anticipation and alertness to react to the ball quickly, and a still head to keep the technique together. As the ball comes toward you, try to use two hands, keep still and keep your eye on the ball. Point your fingers away from your body to create a large surface area by spreading your fingers wide. When the ball enters your hands, try to cushion the ball by moving your hands back toward you. This "give," as Woolmer calls it, will reduce the chances of the ball bouncing back out of your hands.

Picking the ball up quickly and efficiently and throwing the ball at the wickets are the other skills required to be a good fielder. A quick pickup requires short steps as you approach the ball. Bend your knees, place your strongest foot alongside the ball and pick it up with one hand. Woolmer explains that "the ideal throw is the one used in baseball," where you draw the ball back over the shoulder "so it faces backward" before unwinding the arm and throwing it straight over the shoulder at the target.

RELATED STUDY:

Myklebust, G., Engebretsen, L., Brækken, I. H., Skjøberg, A., Olsen, O. E., & Bahr, R. (2003) research evaluate the impact of a neuromuscular preparing program on the frequency of anterior cruciate ligament wounds in female group handball players. Players from the three top divisions: control season (1998–1999), 60 groups

(942 players); first intercession season (1999–2000), 58 groups (855 players); second mediation season (2000–2001), 52 groups (850 players).

A five-stage program (span, 15 min) with three diverse offset activities concentrating on neuromuscular control and planting/arriving abilities was created and acquainted with the players in the fall of 1999 and overhauled before the begin of the season in 2000. The groups were told in the system and supplied with an instructional feature, blurb, six parity mats, and six wobble sheets. Moreover, a physical specialist was joined to every group to catch up with the intercession system amid the second mediation period. The quantity of anterior cruciate ligament wounds amid the three seasons and agreeability with the system.

There were 29 front cruciate ligament wounds amid the control season, 23 wounds amid the first mediation season (OR, 0.87; CI, 0.50–1.52; $p = 0.62$), and 17 wounds amid the second intercession season (OR, 0.64; CI, 0.35–1.18; $p = 0.15$). In the world class division, there were 13 wounds amid the control season, six wounds amid the first intercession season (OR, 0.51; CI, 0.19–1.35; $p = 0.17$), and five wounds in the second mediation season (OR, 0.37; CI, 0.13–1.05; $p = 0.06$). For the whole accomplice, there was no distinction in harm rates amid the second mediation season between the individuals who agreed and the individuals who did not consent (OR, 0.52; CI, 0.15–1.82; $p = 0.31$). In the first class division, the danger of damage was lessened among the individuals who finished the front cruciate ligament harm aversion program (OR, 0.06; CI, 0.01–0.54; $p = 0.01$) contrasted and the individuals who did not. His study demonstrates that it is conceivable to counteract front cruciate ligament wounds with particular neuromuscular training.

Olsen, O. E., Myklebust, G., Engebretsen, L., & Bahr, R. (2004) research portray the systems for anterior cruciate ligament wounds in female group handball. Twenty tapes of front cruciate ligament wounds from Norwegian or global rivalry were gathered from 12 seasons (1988–2000). Three therapeutic specialists and 3 national group mentors efficiently broke down these features to depict the harm systems and playing circumstances. Furthermore, 32 front cruciate ligament–injured players in the 3 upper divisions in Norwegian group handball were met amid the 1998–1999 season to analyze the harm attributes between player review and the feature investigation.

Two primary damage instruments for anterior cruciate ligament wounds in group handball were recognized. The most widely recognized (12 of 20 wounds), a plant-and-cut development, happened for every situation with a powerful valgus and outer or inside turn with the knee near to full expansion. The other primary harm instrument (4 of 20 wounds), a 1-legged bounce shot arriving, happened with a commanding valgus and outside turn with the knee near to full augmentation. The outcomes from the feature examination and survey information were comparative. The damage instrument for front cruciate ligament wounds in female group handball gave off an impression of being a compelling valgus breakdown with the knee near to full expansion joined with external or internal rotation of the tibia.

According to Myklebust, G., Holm, I., Mæhlum, S., Engebretsen, L., & Bahr, R. (2003), research Long term result after anterior cruciate ligament damage among top-level rotating competitors is unknown. To assess result among aggressive group handball players after front cruciate ligament harm.

SAMPLE:

Twenty participants were selected as participants. Ethics approval for this study was granted by the researchers' faculty of Osmania University was received prior to all experimental procedures. Participants were divided into two groups of handball teams according to their deliberate practice experience in cricket and hand

ball; and analysis made. The Participants are divided into two groups (Group –I, Experimental Group, Number Players = 10& Group –II, Control Group, Number Players = 10). They Experimental group is already has experience in cricket skills which help them perform more efficient handball skills and control group is a handball team.

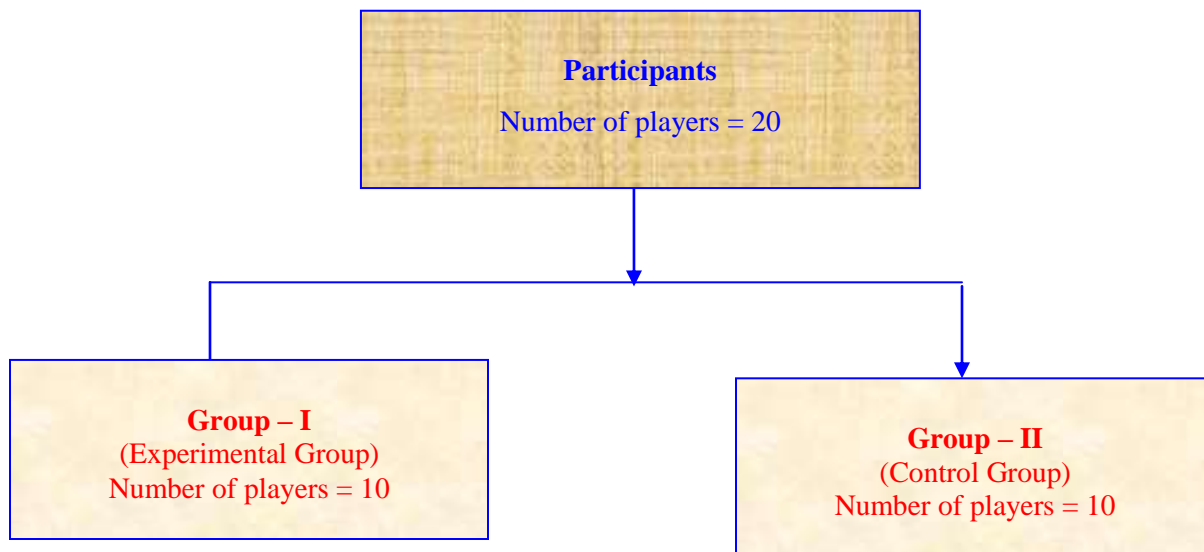


Figure 1: Flow chart of Participants

Subjects	Age (years)	Weight (kg)	Height (cm)	BMI (kg·m ⁻²)
Experimental group (n = 10)	23.78 ± 1.13	60.21 ± 10.98	168.34 ± 8.33	16.04 ± 8.54
Control group (n = 10)	24.41 ± 0.96	65.48 ± 10.17	172.40 ± 9.83	21.10 ± 3.76

Table 1: Participants physical details

COLLECTION OF SAMPLE:

The samples were collected from Osmania University of Telangana a state of India. The analysis is carried out from players who play in these selected hand ball.

DESIGN OF THE STUDY:

After a general and a handball specific warm up of 20 min, the participants were asked to perform 10 valid (for each throwing technique) standing throws without run-up, standing throws with run-up, vertical jump throws, and pivot throws (jump throw take off with both legs after

turning). The ranking order of the four throwing techniques was randomized for each participant. After five valid throws the participants changed the throwing technique and repeated this procedure a second time to ensure that fatigue did not influence the results.

To measure throwing performance we used a square of 1×1 m at about eye level (1.75 m high) and instructed the participants to throw the ball with a maximal ball velocity to the center of the target. Horizontal distance between the ball and the target at ball release was about 8 m, except for the standing and pivot throw (about 7 m). In team-handball competition the standing (penalty throw) and pivot throw were used at distances near the goal (6-7m), whereas the standing throw with run-up and jump throw were used from backcourt players when throwing from a greater distance (8-12m). In the testing situation we decided to choose different distances to the goal (7 vs. 8m) which enabled conditions similar to those in competition, although this implicates different throwing angles to the target.

A throw was valid if the ball did not deviate from the center of the target in the horizontal and vertical directions by more than 0.5 m, and if all data were recorded without failure. This was done until 10 valid throws were recorded for each of the four throwing techniques for each participant (to measure the percentage of missed throws all throws of each throwing technique were counted). To ascertain that only the best throws of the four throwing technique of every participant were calculated, the six throws with the greatest ball velocity for every participant were used for statistical analysis.

Kinematic analysis and angle calculations

The study also observes the joint angle calculation, we used the same method as described in detail. Joint angles were calculated

by the relative orientation of the proximal and distal segments. The joint flexion angles (knee, hip, shoulder and elbow flexion) were used to determine the longitudinal axes of the proximal and distal segments. The shoulder internal-external rotation angle was defined as the rotation of the humerus along the longitudinal axis of the humerus. A positive value corresponds to internal shoulder rotation. Pelvis/trunk rotation angles were calculated between the sagittal axis of the pelvis/trunk and those of the sagittal axis of the measuring field and the trunk flexion between the projected sagittal trunk axis and the sagittal axis of the measuring field.

Variable calculations and phase classification

Linear and angular velocities were calculated using the 5-point central differential method. Ball release point and ball velocity were determined as described in detail. For a detailed discussion of the results, we separated the throwing movements into three different phases, two phases before ball release (cocking and acceleration phase) and one after ball release (post ball release). Cocking phase was defined from the beginning (400ms before ball release) to the beginning of acceleration phase. We termed the acceleration phase as the time lag between the moment when the angular acceleration of the trunk rotation became maximal to ball release, and post ball release from ball release to the end (100ms after ball release). The total time frame was chosen from 400ms before to 100ms post ball release, because that was sufficient to calculate all relevant variables. Throwing accuracy was determined by the percentage of the throws that missed the target relative to all throws for each participant and the mean radial error.

PROCEDURES

Day 1

test Level 1 (Yo-Yo IR1)

According to the procedures suggested. Test reliability was established in a previous study. A short-range telemetric heart rate monitor was placed on the player approximately 20 min before testing. The heart rate was monitored throughout the test, using a 5 s interval recording time. Post-hoc HR analyses were performed using Polar Precision System SW software. The peak recorded HR was assumed to be the individual's maximal HR.

Day 2

Force-velocity test

A force-velocity test was performed on a standard Monark cycle ergometer as detailed elsewhere. In brief, the maximal pedaling velocity attained during a 7 s all-out sprint was used to calculate the maximal anaerobic power for each braking force, and the highest peak leg power (W_{peak}) was reached if a further increase of loading induced a decrease in power output.

Day 3

Squat Jump (SJ) and Countermovement Jump (CMJ)

Characteristics of the SJ and the CMJ were determined using a force platform. Jump height was determined as the centre of mass displacement, calculated from the recorded force and body mass. Subjects were instructed to keep their legs straight throughout the flight phase. The SJ began at 90° knee flexion; a vertical jump was performed by pushing upward with the legs,

avoiding any downward movement. The CMJ began from an upright position; subjects made a downward movement to 90° knee flexion and simultaneously began the push-off phase. The best of 3 jumps was recorded for each test.

Sprint Performance

After a familiarization session with the sprint test, subjects performed a maximal 5 m sprint on an outdoor tartan surface. Body displacement was filmed. Two trials were separated by an interval of at least 5 min, with the fastest time being recorded. The software converted measurements of hip displacement to velocities reached during the first step (V_S) and over the first 5 m (V_{5m}). The reliability of the camera and data processing software has been described previously. We chose a standing start to give greater consistency to our measurements, although recognizing that in actual play a sprint usually begins from a standing or jogging start.

Day 4

Handball skill test

Speed, agility, and handball skills were tested by a slalom dribbling test. Subjects ran a distance of 15 m, back and forth, dribbling a handball around 5 cones. The distance between the starting line and the first cone, as well as between the other cones, was 3 m. Subjects ran individually. The better of 2 trials was recorded for statistical analysis. All tests were performed on an indoor synthetic pitch, and electronic timing gates were used to record times.

RESULTS:

Table 2: all velocity, maximal velocity of the center of mass in goal-directed movement and throwing accuracy variables for all throwing techniques. *P*-value for determination of statistical differences for four variables, adjusted using the Bonferroni correction $P < 0.01$. Data are means (\pm SD).

	standing throw without run-up	standing throw with run-up	jump throw	pivot throw	<i>P</i> -value	Effect size
Velocity (m·s⁻¹)						
Ball velocity	22.3 (1.2)	23.9 (1.2)	21.9 (1.6)	20.4 (1.2)	< .001 _a	.97
Maximal velocity center of mass in goal-directed movement	1.5 (.3)	3.0 (.3)	2.6 (.4)	1.6 (.3)	< .001	.95
Throwing precision						
Missed throws (%)	16 (12)	20 (7)	19 (10)	15 (11)	.44	.21
Mean radial error (m)	.30 (.11)	.30 (.10)	.32 (.07)	.38 (.08)	.21	.51

a: significant difference ($p < 0.05$) between standing throw with and without run-up; b: significant difference ($p < 0.05$) between standing throw and jump throw; c: significant difference ($p < 0.05$) between standing throw and pivot throw; d: significant difference ($p < 0.05$) between standing throw with run-up and jump throw; e: significant difference ($p < 0.05$) between standing throw with run-up and pivot throw; f: significant difference ($p < 0.05$) between jump throw and pivot throw.

Table 3: Pearson Product-Moment correlation coefficients and *P*-values between kinematic parameters and ball velocity. *P*-value for determination of statistical differences for 52 variables adjusted using the Bonferroni correction $P < 0.001$.

	Maximal angular vel.	Timing of max. angular vel.	Maximal angle	Timing of max. angle
Hip flexion (lead leg)			$r = .49, P < .001$	
Hip extension (lead leg)			$r = .48, P < .001$	
Knee flexion (follow leg)		$r = .52, P < .001$		
Pelvis external rotation			$r = .64, P < .001$	
Pelvis internal rotation	$r = .72, P < .001$			
Trunk external rotation			$r = .65, P < .001$	$r = -.49, P < .001$

Trunk internal rotation	$r = .78, P < .001$			$r = .51, P < .001$
Shoulder internal rotation	$r = .47, P < .001$			
Elbow extension	$r = .47, P < .001$			

Significant differences ($p < 0.001$) in performance were found between the four throwing techniques for the ball velocity but not for the percentage of missed throws and the mean radial error.

High and significant ($r > 0.70, p < 0.001$) correlations to the ball velocity were found for the maximal pelvis and trunk rotation angular velocity, moderate ($r > 0.50, p < 0.001$) correlations were found for the velocity of the center of mass in goal-directed movement ($r = 0.54, p < 0.001$), the maximal external pelvis and trunk rotation angle and the timing of the maximal internal trunk rotation angle as well as knee flexion (follow leg) angular velocity and small ($r < 0.50, p < 0.001$) correlations were found for the maximal shoulder internal rotation and elbow extension angular velocity, maximal hip flexion and extension angle (lead leg) and timing of the maximal trunk external rotation angle.

Based on the results of the Pearson Product-Moment correlations we calculated differences between the four throwing techniques in selected maximal angular velocities and between angles and their timing. Significant differences ($p < 0.002$) between the four different throwing techniques were found in the maximal pelvis ($p < 0.001, \eta^2 = 0.91$), trunk ($p < 0.001, \eta^2 = 0.90$) and shoulder ($p < 0.003, \eta^2 = 0.74$) internal rotation angular velocity and the timing ($p < 0.003, \eta^2 = 0.75$) of the maximal trunk internal rotation angular velocity. Significant differences between the four throwing techniques were also found for the maximal pelvis ($p < 0.001, \eta^2 = 0.96$) and trunk ($p < 0.001, \eta^2 = 0.89$) external/internal rotation angle as well as the timing of the maximal pelvis external ($p < 0.001, \eta^2 = 0.94$) and trunk external/internal ($p < 0.001, \eta^2 = 0.90$) rotation angle. In the lower body we found significant differences in the maximal hip hyperextension ($p < 0.001, \eta^2 = 0.93$) angular velocity of the follow leg as well as the maximal hip flexion ($p < 0.001, \eta^2 = 0.96$) angular velocity of the leading leg and their timing ($p < 0.001, \eta^2 = 0.84$) and in the maximal hip flexion ($p < 0.001, \eta^2 = 0.84$) and hyperextension ($p < 0.001, \eta^2 = 0.96$) angle as well as the timing of the maximal hip flexion ($p < 0.002, \eta^2 = 0.75$) and hyperextension ($p < 0.002, \eta^2 = 0.79$) angle of the leading leg.

Group Statistics

Groups	N	Mean Scores	Std. Deviation	Std. Error Mean
No. of goals	experimental group	10	19.42	1.49649
	control group	10	10.220	2.16673

Table 4: Group Statistics

Discussion

It was not surprising that there were no significant differences in the throwing accuracy since the participants of our study were elite team-handball players with experience in training (10.8 ± 3.8 yrs) and competition. Players were familiar with all utilized throwing techniques and they were able to hit the target frequently and accurately. In agreement with recent studies in team-handball throwing the participants in our study achieved the greatest ball velocity in the standing throw with run-up (defined as 100% ball velocity), followed by the standing throw without run-up (93%), jump throw (92%) and pivot throw (85%). Found that in javelin throwing the run-up velocity is an important contributor to javelin velocity and that javelin throwers of different performance level differ in run-up as well as javelin velocity. In javelin throwing, release velocity can be considered as the sum of run-up velocity and velocity generated by the thrower movements. In the present study we found a correlation between the velocity of the center of mass in goal-directed movement and ball velocity, as well as significant differences in the ball velocity and velocity of the center of mass in goal-directed movement. Therefore, in team-handball, throwing run-up velocity is an important contributor to the ball velocity.

Differences in the knee flexion/extension and hip flexion/extension angles could be explained by the influence of jump in the jump and pivot throw compared to the standing throws. Knee and hip of the follow leg were more flexed and hip of the lead leg were more hyperextended when jumping whereas this flexion and extension angles were higher in the jumps were take-off happened on one leg (jump throw)

compared to two legs (pivot throw). But how those these influence the ball velocity?

In javelin throwing, suggested that the lead leg braces the body, which allows the pelvis, trunk and throwing arm to accelerate over the braced leg and aid in a transfer of momentum through the pelvis and trunk to the throwing arm. Similar results to javelin throwing were also found in the baseball throw. As the team-handball standing throw with run-up that is similar to baseball and javelin throwing maximal angular velocity increased in a proximal-to-distal order beginning with the pelvis rotation through the trunk rotation and elbow extension to the shoulder internal rotation. In javelin throwing, better throwers exhibit a clear double flexion-extension pattern in the knee angle of the leading leg that was also found in our study. In combination with a maximal pelvis and trunk external rotation angle of about 80-90° participants in our study were able to transfer more energy from the trunk to the throwing arm (Stodden et al., 2001). The importance of the maximal pelvis and trunk rotation angular velocity and the maximal pelvis and trunk external angle in the team-handball throwing movement could be shown by the high correlations to ball velocity. The energy transfer from lower body to the throwing arm could explain the higher maximal pelvis rotation, trunk rotation and shoulder internal rotation angular velocity as well as ball velocity in the standing throw with run-up compared to the jump and pivot throw. As shown by the throwing sequence, the standing throw without run-up is similar to the standing throw with run-up. We suggest that the missing run-up in the standing throw without run-up leads to a decrease in the ball velocity (we found a significant correlation between run-up and ball

velocity) although the maximal pelvis, trunk and shoulder internal rotation as well as elbow extension angular velocity was not significant different. In the jump and pivot throw, the missing floor contact of the lead leg demands a different strategy to rotate the pelvis and enable a transfer of momentum through the trunk to the throwing arm. We observed that in the jump and pivot throw the pelvis internal rotation was assisted by the follow leg hip hyper- and knee extension and lead leg hip flexion. To explain this in detail we calculated the differences in the maximal hip hyperextension (follow leg) and flexion (lead leg) angular velocity and their timing. We measured significant differences in the maximal angular velocity of the hip hyperextension (follow leg) and hip flexion (lead leg) between the jump/pivot and standing throw. We postulate that the dynamic movements of both legs in different directions (lead leg flexion vs. follow leg extension) induced an additional torque in the pelvis. Therefore, the significant differences in the maximal pelvis internal rotation angular velocity between the jump ($438 \pm 105^\circ/\text{s}$) and pivot throw ($367 \pm 77^\circ/\text{s}$) may be explained by the significant differences in the maximal follow leg hip hyperextension angular velocity. In team-handball standing and jump throw differences in the ball velocity were due to significant differences in the maximal trunk flexion, rotation and shoulder internal rotation angular velocity. The energy transfer from the pelvis to the shoulder suggests that the differences between the four throwing techniques in the maximal pelvis, trunk and shoulder internal rotation angular velocity were due to the differences in the lower extremity movements and the decreased maximal pelvis and trunk external rotation angle. The

importance of a energy transfer from the pelvis to the shoulder was also shown in baseball and javelin throwing.

However, the mean angle time series of all participants illustrates not only the differences but also the similarities of the four throwing techniques. Because of standing vs. jumping (one vs. two legged take-off) we found differences in the lower body movements (hip and knee flexion/extension) as well as pelvis and trunk external rotation. In combination with versus without run-up this leads to differences in the maximal upper body angular velocities and the ball velocity. However, a proximal-to-distal sequencing as shown in recent studies in team-handball throwing was used in all four throwing techniques and the angles in the throwing arm, especially in the acceleration phase were quite similar. The participants of our study were able to adapt to different lower body and trunk movement in the four throwing techniques that enabled similar movement of the throwing arm. We found that team-handball players are generally able to adapt to different lower body and trunk movements and similarly also adjust movement of the throwing arm.

CONCLUSION:

The study concludes, in team-handball throwing the participants in our study achieved the greatest ball velocity in the standing throw with run-up (defined as 100% ball velocity), followed by the standing throw without run-up (93%), jump throw (92%) and pivot throw (85%). Found that in javelin throwing the run-up velocity is an important contributor to javelin velocity and that javelin throwers of different performance level differ in run-up as well as javelin velocity. In javelin throwing, release velocity can be considered as the sum of run-up velocity and velocity generated by the thrower

movements. In the present study we found a correlation between the velocity of the center of mass in goal-directed movement and ball velocity, as well as significant differences in the ball velocity and velocity of the center of mass in goal-directed movement. Therefore, in team-handball, throwing run-up velocity is an important contributor to the ball velocity.

RECOMMENDATIONS:

- In team-handball standing and jump throw differences in the ball velocity were due to significant differences in the maximal trunk flexion, rotation and shoulder internal rotation angular velocity.
- The energy transfer from the pelvis to the shoulder suggests that the differences between the four throwing techniques in the maximal pelvis, trunk and shoulder internal rotation angular velocity were due to the differences in the lower extremity movements and the decreased maximal pelvis and trunk external rotation angle
- The importance of a energy transfer from the pelvis to the shoulder was also shown in baseball and javelin throwing.

REFERENCE:

- [1] Bartlett R.M., Best R.J. (1988) The biomechanics of javelin throwing: a review. *Journal of Sports Sciences* 6, 1-38
- [2] Bartlett R.M., Müller E., Lindinger S., Brunner F., Morris C. (1996) Three-dimensional evaluation of the release parameters for javelin throwers of different skill levels. *Journal of Applied Biomechanics* 12, 58-71

[3] Davis R.B., Öunpuu S., Tyburski D., Gage J.R. (1991) A gait analysis data collection and reduction technique. *Human Movement Science* 10, 575-587

[4] Morris C., Bartlett R., Navarro E. (2001) the function of blocking in elite javelin throws: A re-evaluation. *Journal of Human Movement Studies* 5, 175-190

[5] Matsuo T., Escamilla R.F., Fleisig G.S., Barrentine S.W., Andrews J.R. (2001) Comparison of kinematic and temporal parameters between different pitch velocity groups. *Journal of Applied Biomechanics* 17, 1-13

[6] Van den Tillar R., Ettema G. (2003) Instructions emphasizing velocity, accuracy, or both in performance and kinematics of overarm throwing by experienced team-handball players. *Perceptual and Motor Skills* 97, 731-742

[7] Stodden D.F., Fleisig G.S., McLean S.P., Lyman S.L., Andrews J.R. (2005) Relationship of pelvis and upper torso kinematics to pitched baseball velocity. *Journal of Applied Biomechanics*, 17, 164-172

[8] Wagner H., Buchecker M., von Duvillard S., Müller E. (2010a) Kinematic description of elite vs. low level players in team-handball jump throw. *Journal of Sports Science and Medicine* 30, 760-765

[9] Theodore Frankel (2004). *The geometry of physics: an introduction* (2nd ed.). ISBN 0-521-53927-7.

[10] Carmo, Manfredo (1976). Differential Geometry of Curves and Surfaces. ISBN 0-13-212589-7. Classical geometric approach to differential geometry without tensor analysis.

[11] Do Carmo, M. P., & Do Carmo, M. P. (1976). Differential geometry of curves and surfaces (Vol. 2). Englewood Cliffs: Prentice-hall.

[12] Struik, D. J. (2012). Lectures on classical differential geometry. Courier Corporation.

[13] Kobayashi, S. (2014). Differential geometry of complex vector bundles. Princeton University Press.

[14] Elferink-Gemser MT, Visscher C, Richart H, Lemmink K (2004) Development of the Tactical Skills Inventory for Sports 1. Perceptual and Motor Skills 99: 883–895