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A comparative study of physical fitness variables of handball and throwball players

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Abstract
The purpose of this research was to compare national level performing Handball and Throwball players on the basis of selected Physical Fitness Variables. For this study Arm and Shoulder strength, Abdominal Strength, Agility, Explosive Power, Speed, Endurance was selected as the physical fitness variables. For this comparative study 200 national level players (N = 200) were chosen using a probability sampling technique called simple random sampling (lottery method). Out of 200 players, (n1=100) were Handball players and (n2= 100) were Throwball players. Out of 100 handball players, 50 were male and 50 were female; similarly, there were 50 men and 50 females among the 100 Throwball players. Age ranges of subjects was 19 to 25 years. Multivariate analysis of Variance (MANOVA) was used as the statistical technique in IBM SPSS 20.0 for comparative analysis among Handball and Throwball Players for selected physical fitness variables According to the findings from the above table, the study's chosen physical fitness variables vary at several comparison levels, including gender, game, and gender + game. When compared to throwball, handball is a to-and-fro game where a lot of physical conditioning is needed since the game's dynamism is restricted by net separation. The study's unique findings suggest that handball players significantly outperformed throwball players in terms of agility and abdominal endurance. In terms of agility, handball players outscored football players (a sport with a comparable dynamic to handball). Jumping ability is necessary for both handball and throwball, but no discernible difference was found for standing broad jump, but there was a significant difference for abdominal endurance, with handball players having higher values. This could be due to the different types of jumps performed in handball, or it could be interpreted as throwball players consistently jump in one direction, whereas handball players jump in multiple directions.

Keywords: Physical fitness, handball, throwball and MANOVA

Introduction
Handball and Throwball, two court games, have been considered in the current investigation. Court games are distinct from other types of sports because they are played in a confined space, require players to manipulate a ball or another comparable item, and often entail the use of an implement (Dhull, 2023; S. Kumar *et al*., 2023) [7, 4]. In order to acquire a strong court position and compete with one's opponent on both offensive and defensive movements, a great degree of running, manoeuvrability, and complete body agility is required (Gulia & Rajesh, 2019; D. Kumar, Kumar, *et al*., 2023) [8, 4]. The ability to start quickly, block quickly, halt quickly, dodge quickly, and accelerate quickly are the essential qualities for excellent court play (D. Kumar, Dhull, *et al*., 2023; D. Kumar, Kumar, *et al*., 2023; Kumari & Chaudhary, 2023) [7, 4, 15]. Because court sports sometimes include situations during bursts of play at a strong pace, having a high degree of anaerobic endurance and also having outstanding jumping ability is of utmost significance. (Jenson, Clayne R, 1979) It is generally accepted that consistent training will result in the development of physical fitness, which is necessary for improved sports performance (Deepak *et al*., 2022a; Deepak & Yadav, 2016; D. Kumar, Nara, *et al*., 2023; D. Kumar & Dhull, 2023) [6, 5, 4, 7]. It has been shown via in-depth studies of the anatomical and physiological features of well-known athletes that it is feasible to create predictions of athletic performance that are quite accurate. Scores acquired by different static and dynamic tests display varying degrees of correlation with the scores achieved in competition, and it has been simple to select out the tests that produce the greatest coefficients of correlation due to the fact that the scores gained by these tests exhibit varying degrees of correlation with one another (Sagre *et al*., 2022; Sagre &

Ahlawat, 2023) [6, 14]. Therefore, it has been shown that dynamic tests have a better predictive value than static tests. The kind of physique, strength and power, respiratory efficiency, and cardiovascular components are among the elements that determine performance; however, no two, three, or four factors, even when combined in the most effective way, assess all aspects of fitness. Among the factors that influence performance are the type of physique, strength and power, respiratory efficiency, and cardiovascular components (Deepak Kumar, 2023; Dhull, 2023) [4, 7]. When fitness tests were administered to athletes who had previously won titles, the athletes who were still actively training had the greatest results. Improvements in cardiovascular function may be seen very immediately after beginning an endurance training program. The ability of an endurance athlete to utilize oxygen is tied to their circulatory and respiratory capacity; but, in sprinting, lifting weights, and swimming, there are many other crucial aspects to consider. (Cureton TK., 1956) [3] This study aimed to compare selected male and female national-level handball and throwball players for their selected physical fitness variables.

Material and Methods

Selection of subjects

For the purpose of this study, 200 national level players (N = 200) were chosen using a probability sampling technique called simple random sampling (lottery method). Out of 200 players, (n_1=100) were Handball players and (n_2= 100) were Throwball players. Out of 100 handball players, 50 were male and 50 were female; similarly, there were 50 men and 50 females among the 100 Throwball participants. Age ranges of subjects was 19 to 25 years.

Selection of variables

After reviewing the literature, following physical fitness variables have been selected for the present study along with their criterion measure (ref table below).

Table 1: Test and Criterion Measures for the Selected Variables

S. No.	Variables	Tools/ Instruments	Unit of measurements
1.	Arm and Shoulder strength	Pull ups	In Numbers
2.	Abdominal Strength	Sit ups	In Numbers
3.	Agility	Shuttle run	Seconds
4	Explosive Power	standing broad jump	Centimetre
5.	Speed	50 M run	Seconds
6.	Endurance	600-yard run / walk	Minutes

Administration of tests

Speed (50 m Run)

- **Purpose:** The objective of this test was monitoring the development of the athlete's ability, effectively and efficiently to build up acceleration, from a standing start or from starting blocks, to maximum speed.
- **Equipment:** Flat non-slip surface and Stopwatch.
- **Procedure:** This test requires the athlete to sprint as fast as possible over 50meters. The athlete was asked to warm up for 10 minutes. The scholar was asked to mark out a 50 meters straight section with cones. The athlete was asked to start on command and sprints as fast as possible over the 50 meters. The scholar was asked to starts the stopwatch on the athlete's 1st foot strike after starting and stops the stopwatch as the athlete torso crosses the finishing line. The test was conducted 3 times.
- **Scoring:** The fastest recorded time was taken to assess the athlete's performance.

600 Yard Run/Walk

- **Purpose:** The purpose of the test is to measure maximal functional capacity and endurance of the cardio-respiratory system.
- **Procedure:** 600 yard walk and Run can be organized on track subject runs a distance of 600 yard. The subject takes a standing start from the starting line. The subject may walk in between. However, the objective is to cover the distance in the shortest time when he crosses the finish line he is informed of his time.

Abdominal Strength

- **Purpose:** The purpose of the sit-up is to evaluate abdominal muscular strength endurance.
- **Procedure:** To assume the starting position, the subject was asking to lie on his back with knees flexed, feet on floor, with heels between 12 and 18 inches from the buttocks. The feet were held by the partner to keep them in touch with the testing surface. The subject, by tightening his abdominal muscles, curls to the sitting position. Arm contact with the chest must be maintained. The chin should remain tucked on the chest. The sit-up is completed when the elbow touches the thighs. To complete the sit-up the subject returns to the down position until the mid-back makes contact with the testing surface.

The timer was asked to give the signal "ready go" the sit-up performance was asked to start on the word "go". Performance was stop on the word "stop"

Scoring: The number of correctly executed sit-ups in 60 seconds was the score.

Agility (Shuttle run)

- **Purpose:** Shuttle Run was used to measure speed and agility.
- **Equipment:** Wooden blocks, marker cones, measurement tape, stopwatch, non-slip surface was used for this test.
- **Procedure:** The subjects was asked to stand in stationary position (hands cannot touch the ground) behind the starting line marked on the ground, with one foot in front of the other. This test requires the subjects to run back and forth between two parallel lines as fast as possible. The testing area was asked to mark with two lines of cones 30 feet apart and three balls was asked to place behind one of the lines. Starting at the line opposite to the blocks; on the signal, "Ready? Go!" the subject runs to the other line, picks up a ball and

returns to place it behind the starting line, then returns to pick up the second ball, then again run quickly and place it behind the starting line, finally then the subject was returns to pick the third ball and runs with it back across the line.
- **Scoring:** Two trails was given to the subjects, and the quickest time was recorded. Results was recorded to the nearest tenth of a second.

Standing Broad Jump
- **Purpose:** to measure the explosive power of the legs.
- **Equipment required:** tape measure to measure distance jumped, non-slip floor for takeoff, and soft-landing area preferred. Commercial Long Jump Landing Mats are also available.
- **Procedure:** The athlete stands behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed.
- **Scoring:** The measurement is taken from take-off line to the nearest point of contact on the landing (back of the heels). Record the longest distance jumped, the best of three attempts.

Upper body Strength (Pull Ups)
- **Purpose:** To measure arm and shoulder girdle strength.
- **Equipment's:** Horizontal bar, score sheet and pencil.
- **Procedure:** The bar should be high enough from the floor so that the feet of the boy do not touch the floor while performing the test. The subjects was asked to hangs from the bar by his hands with forward hand grip and pulls himself up until his chin is even with his hands, and then lower the body until his arms are straight.
- **Scoring:** Number of legal pull ups completed was recorded as score.

Statistical procedure

Initially, descriptive statistics were used to analyse the data, which meant that the mean, standard deviation of all the variables were calculated in IBM SPSS 20.0. Multivariate analysis of Variance (MANOVA) was used as the statistical technique for comparative analysis among Handball and Throwball Players for selected physical fitness variables. (Verma J P, 2013) [19].

Results

Table 2: Descriptive Statistics of selected Physical Variables

Physical Variables	Gender	Game	Mean	Std. Deviation
Speed	Male	Handball	6.9800	.63513
		Throwball	6.9452	.60926
	Female	Handball	6.9016	.56924
		Throwball	6.9222	.63046
Abdominal Strength Endurance	Male	Handball	23.6800	8.89265
		Throwball	20.9600	6.65769
	Female	Handball	25.2200	6.66177
		Throwball	19.8400	7.90340
Agility	Male	Handball	10.2110	.68403
		Throwball	9.7526	.82172
	Female	Handball	9.9088	.84941
		Throwball	9.6908	.75533
SBJ	Male	Handball	239.8600	17.48587
		Throwball	239.3600	17.64012
	Female	Handball	239.7400	17.17474
		Throwball	239.7400	17.57527
Pull ups	Male	Handball	20.0000	7.73542
		Throwball	20.6200	7.48029
	Female	Handball	9.8000	7.35125
		Throwball	6.1600	2.55039

Table 2 represents the descriptive statistics i.e., mean, and standard deviation of selected Physical variables for selected males and females of Handball and Throwball. For Handball, male and female speed mean and standard deviation in seconds was ± and ± respectively. For Throwball, male and female speed mean and standard deviation in seconds was ± and ± respectively.

For Handball, male and female sit ups mean and standard deviation in was ± and ± respectively. For Throwball, male and female sit ups mean and standard deviation in was ± and ± respectively. For Handball, male and female agility mean and standard deviation in seconds was ± and ± respectively. For Throwball, male and female agility mean and standard deviation in seconds was ± and ± respectively. For Handball, male and female standing broad jump mean and standard deviation in cm was ± and ± respectively. For Throwball, male and female standing broad jump mean and standard deviation in cm was ± and ± respectively. For Handball, male and female pull ups mean and standard deviation in was ± and ± respectively. For Throwball, male and female pull ups mean and standard deviation in was ± and ± respectively.

Table 3: Levene's Test of Equality of Error Variances

Variable	F	Sig.
Speed.	.081	0.999
Abdominal Strength Endurance	1.393	0.215
Agility.	1.273	0.123
SBJ	1.164	0.146
Pull ups	1.491	0.177
Tests the null hypothesis that the error variance of the dependent variable is equal across groups.		
a. Design: Intercept + Gender + Game + Game * Gender		

Table 3 represents the test of equality variances i.e., Levene's test. In the table F-value for Arm and Shoulder strength, Abdominal Strength, Agility, Explosive Power, Speed, Endurance, were 0.999, 0.215 0.123 0.146, and 0.177 respectively. The obtained p- value is insignificant as the p-value determined is more than 0.05, and it is concluded that the variance of selected games and region groups are equal and the assumption for equality of variances is not violated.

Table 4: Multivariate tests for Physical fitness variables

Effect		Value	F	HYPOTHESIS DF	ERROR DF	Sig.
Intercept	Pillai's Trace	.999	24086.138[b]	7.000	190.000	.000
	Wilks' Lambda	.001	24086.138[b]	7.000	190.000	.000
	Hotelling's Trace	887.384	24086.138[b]	7.000	190.000	.000
	Roy's Largest Root	887.384	24086.138[b]	7.000	190.000	.000
Gender	Pillai's Trace	.485	25.589[b]	7.000	190.000	.000
	Wilks' Lambda	.515	25.589[b]	7.000	190.000	.000
	Hotelling's Trace	.943	25.589[b]	7.000	190.000	.000
	Roy's Largest Root	.943	25.589[b]	7.000	190.000	.000
Game	Pillai's Trace	.118	3.639[b]	7.000	190.000	.001
	Wilks' Lambda	.882	3.639[b]	7.000	190.000	.001
	Hotelling's Trace	.134	3.639[b]	7.000	190.000	.001
	Roy's Largest Root	.134	3.639[b]	7.000	190.000	.001
Gender * Game	Pillai's Trace	.042	1.202[b]	7.000	190.000	.303
	Wilks' Lambda	.958	1.202[b]	7.000	190.000	.303
	Hotelling's Trace	.044	1.202[b]	7.000	190.000	.303
	Roy's Largest Root	.044	1.202[b]	7.000	190.000	.303

a. Design: Intercept + Gender + Game + Gender * Game
b. Exact statistic

Table No.4 represents the results of multivariate test for all main effect and interaction effect. In this analysis researcher focused on Hotelling's Trace multivariate test because of normality and homogeneity of variance tests assumptions is not violated. From the table above it can see that, there is significant difference for game and gender for selected dependent variables as its value is less than 0.05 (p<0.05). From the table above it can also be seen that, there is insignificant difference for Game * Gender for selected dependent physical fitness variables as its value is more than 0.05 (p>0.05).

Table 5: MANOVA table (Tests of Between-Subjects Effects)

Source	Dependent Variable	Type III Sum of Squares	DF	Mean Square	F	Sig.
Gender	Speed.	.129	1	.129	.344	.558
	Abdominal Strength Endurance	2.205	1	2.205	.038	.845
	Agility.	1.656	1	1.656	2.721	.101
	SBJ	.845	1	.845	.003	.958
	Pull ups	7601.445	1	7601.445	172.430	.000
Game	Speed.	.003	1	.003	.007	.935
	Abdominal Strength Endurance	820.125	1	820.125	14.248	.000
	Agility.	5.719	1	5.719	9.394	.002
	SBJ	3.125	1	3.125	.010	.920
	Pull ups	114.005	1	114.005	2.586	.109
Gender * Game	Speed.	.038	1	.038	.103	.749
	Abdominal Strength Endurance	88.445	1	88.445	1.537	.217
	Agility.	.722	1	.722	1.187	.277
	SBJ	3.125	1	3.125	.010	.920
	Pull ups	226.845	1	226.845	5.146	.024
Corrected Total	Speed.	73.479	199			
	Abdominal Strength Endurance	12192.875	199			
	Agility.	127.419	199			
	SBJ	59825.875	199			
	Pull ups	16582.795	199			

Table 5 represents the multivariate analysis for main and interaction effect. From the table for gender, it can be seen that significant difference is obtained for Pull ups as p-value is less than 0.05 (p<0.05) it can also be seen that insignificant difference is obtained for Speed, Abdominal Strength Endurance, Agility and SBJ as p-value is more than 0.05 (p>0.05).

From the table for selected game i.e., Handball and Throwball, it can be seen that significant difference is obtained for Abdominal Strength Endurance and Agility as p-value is less than 0.05 (p<0.05) it can also be seen that insignificant difference is obtained for Speed, Pull ups and SBJ as p-value is more than 0.05 (p>0.05).

For interaction effect Game * Gender having insignificant difference is obtained for Speed, Abdominal Strength Endurance, Agility, SBJ and Pull ups as p-value is more than 0.05 (p>0.05) whereas significant difference is obtained for Pull ups as p-value is less than 0.05 (p<0.05).

Hence, significant effect of independent variables on dependent variables was obtained, post hoc analysis was employed for pair wise comparison. For this study researcher has employed High significant difference test i.e., Bonferroni Correction and comparison model because of its unique strength to tolerate type 1 error and its efficiency to deal with large sample size.

Three pairwise comparison was done further, firstly physical fitness variables are compared according to the nature of the gender wise. Secondly physical compared game wise and for the third and final comparison was done gender wise for every game for selected physical fitness variables.

Table 6: Pair wise comparison of physical fitness variables for gender

Dependent Variable	(I) Male/Female	(J) Male/Female	Mean Difference (I-J)	Std. Error	Sig.
Speed.	Male	Female	.051	.086	.558
	Female	Male	-.051	.086	.558
Abdominal Strength Endurance	Male	Female	-.210	1.073	.845
	Female	Male	.210	1.073	.845
Agility.	Male	Female	.182	.110	.101
	Female	Male	-.182	.110	.101
SBJ	Male	Female	-.130	2.471	.958
	Female	Male	.130	2.471	.958
Pull ups	Male	Female	12.330*	.939	.000
	Female	Male	-12.330*	.939	.000

Based on estimated marginal means

*. The mean difference is significant at the .05 level

b. Adjustment for multiple comparisons: Bonferroni

Table 6 represents the dependent variable i.e., physical variable comparison for independent variable i.e., selected gender. From table 6 and 7 it can be seen that significant difference is obtained for Pull ups as p-value is less than 0.05 (p<0.05) it can also be seen that insignificant difference is obtained for Speed, Abdominal Strength Endurance, Agility and SBJ as p-value is more than 0.05 (p>0.05). In overall comparison for Males and Females, the pull ups of Males was significantly greater than Females with mean difference (12.330, p<0.05).

Table 7: Pair wise comparison of physical fitness variables for selected game

Dependent Variable	(I) Handball/Throwball	(J) Handball/Throwball	Mean Difference (I-J)	Std. Error	Sig.
Speed.	Handball	Throwball	.007	.086	.935
	Throwball	Handball	-.007	.086	.935
Abdominal Strength Endurance	Handball	Throwball	4.050*	1.073	.000
	Throwball	Handball	-4.050*	1.073	.000
Agility.	Handball	Throwball	.338*	.110	.002
	Throwball	Handball	-.338*	.110	.002
SBJ	Handball	Throwball	.250	2.471	.920
	Throwball	Handball	-.250	2.471	.920
Pull ups	Handball	Throwball	1.510	.939	.109
	Throwball	Handball	-1.510	.939	.109

Based on estimated marginal means

*. The mean difference is significant at the .05 level

b. Adjustment for multiple comparisons: Bonferroni

Table 7represents the dependent variable i.e., physical variable comparison for independent variable i.e., selected game. From table 7and 8 it can be seen that significant difference is obtained for Abdominal Strength Endurance and Agility as p-value is less than 0.05 (p<0.05) it can also be seen that insignificant difference is obtained for Speed, pull ups and SBJ as p-value is more than 0.05 (p>0.05). In overall comparison for Handball and Throwball player, the Abdominal Strength Endurance of Handball player was significantly greater than Throwball player with mean difference (4.050, p<0.05), the Weight of Agility player was significantly greater than Throwball player with mean difference (0.338, p<0.05).

Table 8: Pair wise comparison of physical fitness variables for selected game, gender wise

Dependent Variable	Handball/Throwball	(I) Male/Female	(J) Male/Female	Mean Difference (I-J)	Std. Error	Sig.
Speed.	Handball	Male	Female	.078	.122	.522
		Female	Male	-.078	.122	.522
	Throwball	Male	Female	.023	.122	.851
		Female	Male	-.023	.122	.851
Abdominal Strength Endurance	Handball	Male	Female	-1.540	1.517	.311
		Female	Male	1.540	1.517	.311
	Throwball	Male	Female	1.120	1.517	.461
		Female	Male	-1.120	1.517	.461
Agility.	Handball	Male	Female	.302	.156	.054
		Female	Male	-.302	.156	.054
	Throwball	Male	Female	.062	.156	.693
		Female	Male	-.062	.156	.693
SBJ	Handball	Male	Female	.120	3.494	.973
		Female	Male	-.120	3.494	.973
	Throwball	Male	Female	-.380	3.494	.914
		Female	Male	.380	3.494	.914
Pull ups	Handball	Male	Female	10.200*	1.328	.000
		Female	Male	-10.200*	1.328	.000
	Throwball	Male	Female	14.460*	1.328	.000
		Female	Male	-14.460*	1.328	.000

Based on estimated marginal means

*. The mean difference is significant at the .05 level

b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments)

Table 8 represents the dependent variable comparison for independent variable i.e., game and gender. From table 8 and 4.6 it can be seen that insignificant difference is obtained for Speed, Abdominal Strength Endurance, Agility, SBJ and Pull ups as p-value is more than 0.05 ($p>0.05$) whereas significant difference is obtained for Pull ups as p-value is less than 0.05 ($p<0.05$). For Pull ups of Handball players Males were having significant greater arm length when compared to Females with mean difference of (10.20, $p<0.05$) whereas Pull ups of Throwball players Males were having significant greater arm length when compared to Females with mean difference of (14.60, $p<0.05$).

Discussion on Findings

As per results obtained from table 4 (multivariate analysis) the selected physical fitness variables of the study differ at different comparison levels such as gender wise, game wise and Gender * Game. Handball is a to and fro game where, a lot physical fitness is required when compared throwball game as its dynamic is limited by net separation. According to the novel results of the study Handball player had significant greater agility and abdominal endurance when compared to throwball players. Showket Ahmad Khan in 2021 identified handball players outperformed football player (similar dynamic of handball) in terms of agility. (Clark M, Lucett S, McGill E, 2018; Costil L. David, 2012; Singh Hardyal, 1991) [1, 2, 18] Both handball and throwball requires jumping skill but no significant difference was obtained for Standing broad jump but significant difference obtained for abdominal endurance as Handball players had greater values, this might be because of different kind of jumps performed in handball or it can be interpreted as throwball jumping is consistent in one direction whereas multiple direction jump are performed by Handball players.

Conclusion

The purpose of this research was to compare national level performing Handball and Throwball players on the basis of selected Physical Fitness Variables. For this study Arm and Shoulder strength, Abdominal Strength, Agility, Explosive Power, Speed, Endurance was selected as the physical fitness variables. For this comparative study 200 national level players (N = 200) were chosen using a probability sampling technique called simple random sampling (lottery method). Out of 200 players, (n1=100) were Handball players and (n2= 100) were Throwball players. Out of 100 handball players, 50 were male and 50 were female; similarly, there were 50 men and 50 females among the 100 Throwball players. Age ranges of subjects was 19 to 25 years. According to the findings from the above table, the study's chosen physical fitness variables vary at several comparison levels, including gender, game, and gender + game. When compared to throwball, handball is a to-and-fro game where a lot of physical conditioning is needed since the game's dynamism is restricted by net separation. The study's unique findings suggest that handball players significantly outperformed throwball players in terms of agility and abdominal endurance. In terms of agility, handball players outscored football players (a sport with a comparable dynamic to handball). Jumping ability is necessary for both handball and throwball, but no discernible difference was found for standing broad jump, but there was a significant difference for abdominal endurance, with handball players having higher values. This could be due to the different types of jumps performed in handball, or it could be interpreted as throwball players consistently jump in one direction, whereas handball players jump in multiple directions.

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