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Physical demands and physiological aspects in elite team handball in Germany and Switzerland: an analysis of the game

Abstract

Team handball is one of the fastest indoor Olympic sports, played in over 150 countries all over the world, but especially in Europe and northern Africa. Players must be athletic, flamboyant, and inventive and, above all, must work together as a team.

A team consists of seven players in the field and substitution of players is unlimited. The tasks of the individual players in the team are very specific, depending on their position in the field, but all act both as an attacker and a defender. The goal of this study was to detect the physical demands and physiological aspects of this sport.

Method: the websites of all elite German and Swiss handball teams, competing in the 2004/2005 top league competitions in their countries (Handball Bundesliga and Swiss Handball League), were searched for the team players anthropometric data. The average anthropometric teams' data and the ranking of the team in the national competition were presented in a graph. Also, individual players were observed during a game. Seven years later (2011/2012 competition), the scoring data of the Bundesliga teams were analysed and compared with their ranking in the league. The physiological aspects were estimated from the analysis of games.

Results: Although great differences appear, the average player in the 2004/2005 season was heavily build (91,29kg), tall (190cm) and had a good anaerobic capacity level. In 60 minutes, all field players run about 60 times back and forth, change directions 5 times per minute and travel around 6000m. There seems to be a strong correlation between the average bodyweight/height of a team and the team performance in competition in both Germany and Switzerland

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Karel Hendrik Madou[1,2]
[1]School of Exercise, Biomedical and Health Sciences, Edith Cowan University, Western Australia
[2]Physio Madou GmbH, Switzerland

Correspondence: Karel H. Madou, Master of Exercise Science, BcPT, CSCS, Physio Madou GmbH, Barzstrasse 3, 5330 Bad Zurzach, Switzerland, Tel 041562490924, Email PhysioMadou@gmail.com

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Introduction: Short history of the game, rules and character

Handball is one of the fastest indoor sports. It is played in over 150 countries. According to Wikipedia[1] and the International Handball Federation (IHF)[2], team handball has origins reaching as far back as the antiquity, and had its Olympic debut as field handball in 1936.

After that it was removed from the list of sports, to return as indoor team handball in 1972 for the Summer Olympics in Munich. Women's team handball was added as an Olympic discipline in 1976 at the Summer Olympics in Montreal.

The biggest national federation of the world is the "Deutscher Handballbund" (DHB) with over 826.000 members, more than 5000 clubs and 34.000 teams. The IHF reports to have 150 member federations representing approximately 800,000 teams and more than 19 million sportsmen and -women.

The game is played on a 40x20m indoor field and the game consists of two 30-minute time periods and a team has up to 14 players, with 6 field players and one goalkeeper on the field, which may be substituted without any restriction.

As there is only 28 meters distance between the two 6-meter goal circles, surrounding the goalkeeper area, in which no player is allowed to step into, the teams switch from defence to attack within seconds. Every player has his role as an attacker and as a defender but has his own position in the field with different skills required and tasks to do. Passing the ball and moving forward without the ball are most common and effective techniques.

Attacks are divided into waves. The first wave (= counterattack, fast break) is mostly started by a wing player, who sprints away as soon his team has intercepted the ball. Normally around the midfield line he will look for the ball. If no long throw is possible, he steps back to join the second wave. Players of the second wave start for their attack as soon their team has the ball. The third wave is a standardized attack as soon as the opponent's defence has been organized. The attacking team must take a shot on the goal withing 30 seconds, or the opposing team gets the ball (time rule).

(Official rules, published by the International Handball Federation (IHF) can be obtained on www.handballaustralia.org.au/pdfs/handballrules AHF[3] or www.ihf.info/federations IHF[4]).

Table 1 Average distance covered by player in DHV Bundesliga 2004

Without ball	<4750m
sprint	<450
.moderate	<3500
walk	<700
with ball	<66m
Sprint	<24
Moderate	<34

Physical demands and properties

The player's position requires certain physical properties. The right wing and right back are normally and preferable left-handed. The right wing normally takes a shot on the goal from a small angle to the goal and mostly must accelerate and jump within 2 steps. He is the player making a jump into the 6-meter goalkeeper area and takes a shot on the goal before landing. He therefore must be an explosive type of player. Small or great makes no big difference. The back players should be long and prefer to throw on goal over the defenders' line. The centre player mostly is the leader and playmaker of the team, preferable, but not necessarily long in posture, the pivot a strong, difficult, highly agile and disturbing player in the midst of the defenders of the opposing team.

Srhoi et al.[5] investigated the morphological characteristics of elite male handball players.49 handball players were measured. Average weight was 91.29kg (65-106) and height 190.79cm (175.3-205). The players of TVEndingen (TVE) (a semi-professional team in Switzerland) showed similar, somewhat lower, variables: 84.5kg (70-99) and 186.06cm (178-198).

Furthermore, Srhoi et al.[5] compared backs and goalkeepers, as one group, with line players (wing players and pivots), where the latter showed greater homogeneity. TVE showed for line players 183.3cm (178-193) and 82.1kg (70-99) and backs 190.5cm (179-198) and 89.2kg (75-99).

Shroj et al.[6] included sitting height and other variables as well in his comparison. Wing players were 187cm with 85.1 kg and 96.5cm sitting height, pivots 183.8cm, 92.58kg and 95.5cm, respectively.

The backs were in average 194.4cm, 94.28kg and 100.5 sitting height with the goal keepers191.8cm, 91.8kg and 98.99cm.

Method section

To obtain anthropometric and league data of elite handball players, the websites of all elite German and Suisse league handball teams, competing in the 2005/2006 top league competitions in their countries (German and Swiss Handball League), were searched for the team players anthropometric data and age, which normally are mentioned in the section, where players are presented. The average anthropometric teams' data (weight, height, and age) and the ranking of the team in the national competition are presented at the end of this paper. Six years later (2011/2012), the scoring data of the actual German teams were obtained, analysed, and compared with their final position in the League 2011/2012.

A comparison of some anthropometric data between THW Kiel (2004 leader in German Bundesliga) and TVE (Table 2a) and the scoring data of the 2011/2012 German Handball League (Table 2b) are presented below.

Also, a league play between Amicitia-Zürich against TVEndingen played in the 2005/2006 Swiss Handball League play-offs and a game between THW Kiel-TUSEM Essen was analysed using a play statistic form and briefly compared (Tables 3-5). In addition, a back right player of TVEndingen was video recorded, and his play performance was analysed as well.

Table 2a Player's profile comparison THV Kiel and TVEndingen (2004)

	Age		**Height**		**Weight**	
Back/Centre	Kiel	TVE	Kiel	TVE	Kiel	T\'E
Average	26.6	27.7	194	191	97.9	89.2
Max	*35*	31.0	200	198	102.0	99
Mm	22	21.0	186	179	*91.0*	75
Wing						
Average	25.0	27.7	188	182	88.5	79
Max	28.0	28.0	190	185	*91.0*	84
Min	21.0	18.0	185	178	85.0	70
Pivot						
Average	28.5	27.7	197	187	100.5	89.3
Max	20.0	29.0	200	193	106.0	99
Min	17.0	27.0	194	181	95.0	80
Goal Keeoer						
Average	*27.3*	26.5	195	187	95.7	82.4
Max	31.0	29 .0	2 10	189	107.0	90
Min	23.0	24.0	185	185	89.5	*75*

Table 2b Scoring data of the 2011/2012 German Handball League. Highest percentage is not first on the list, but team with most throws is

DHV Handball Leaque 2011/ 2012	Team	Throws	Goals scored	goals missed	Score % 2011/ 2012	Throws on goals for game	Goals scored per game
1	THW Kiel	1454	1131	124	77,79%	42,76	33,26
2	SG Flensburgh-H	1421	1060	93	74, 59%	41,79	31,18
3	Fuchse Berlin	1326	1016	84	76,62%	39,00	29,88
4	HSV Hamburg	1355	1069	106	78,89%	39,85	31,44
5	Rhein-Neckar L	1331	1044	103	78,43%	39,15	30,71
6	SC Magdeburg	1340	997	125	74,40%	39,41	29,32
7	TBV Lemgo	1362	995	120	73,05%	40,06	29,26
8	Fr A Goppingen	1205	915	104	75,93%	35,44	26,91
9	TuS N- Lubbecke	1376	944	125	73,98%	37,53	27,76
10	MT Melsungen	1124	947	89	77,37%	36,00	27,85
11	Gummersbach	1328	1019	124	76,73%	39,06	29,97
12	Grosswallstadt	1179	865	113	73,37%	34,68	25,44
13	Hannover-B	1387	980	154	70,66%	40,79	28,82
14	Balingen-Wei	1176	857	139	72,87%	34,59	25,21
15	HSG Wetzlar	1162	857	114	73,75%	34,18	25,21
16	Beraischer HC	1221	921	132	75,43%	35,91	27,09
17	TV Huttenberg	1193	883	131	74,02%	35,09	25,97
18	Hildesheim	1211	865	141	71,43%	35,62	25,44

Also a league Play between Amicitia-Zürich and TVEndingen played in the 2005/2006 Swiss Handball League play-offs and a game between THW Kiel against TUSEM-Essen was analysed using a play statistic form and briefly compared (table 3 and 5). In addition, a back right player of TVEndingenwas Video recorded and his play performance was analysed as well.

Table 3 Brief analysis of TVEndingen's 2006 Play-Off game: Efficiency of attacks based on Play Statistic Form

Score 27-33	Amicitia(home)	TVEndinigen
Date	29.03.2006	
Play	2nd Play-Off Game	
	Semi-Finals	
	(best of 3)	
Half time	14-14	
Full time	27-33	Play Statistic is attached

	Attacks (second and third wave)	Goals scored	Counter attacks (first wave)	Goals scored	Total 1iumber of attacks	Total number of goals
I half :	21	14	3	3	24	14
2 half	23	13	7	6	30	19
total:	44	27	10	9	54	33
% completed		54		90		61.1

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Table 4 Games analysis of a back right player

Action: Back Right	5'	1 half	full time
walk forward	75m	600m	1200m
Wa1k backward	14m	112m	224m
Sprint/Run	93.5m	748m	2656m
Average Run Velocity	3.5m/s		
High Velocity	5.3m/s		
Low Velocity	3.lm/s		
Change of direction	67	536	1072
Passes	11	88	176
Throw	l(missed)	8	16
Jumps (129.8° angle)	1	8	16
Contact *in* defense	17	136	272
Contact *in* attack	1	8	18
Side steps in attack	14	112	224
Side steps in defense	48	384	768

Table 5 Efficiency of Attacks of the Kiel-Essen Play and Amicitia-TVEndingen Play

	Kiel	Score	%	Essen	score	%
Total Attacs	54	33	61.l	55	34	61.8
Counter/pass	16	10	62.5	15	10	66.6
Position Attck	38	23	60.5	40	24	60
	Amicitia			TVEndingen		
Total Attacs	54	27	50	54	33	61.l
Counter/pass		no data		10	9	90
Position attack		no data		*44*	0.24	54

Game and team analyses of TVEndingen (2005/2006 Swiss Handball League)

As handball is a very physical game with scores of 30 goals and more per team, the number of runs to attack and back into defence are even more. Not every attack is a goal (Tables 3-8) Analysing the season of TVE 2005/2006 following data can be noticed. TVE plays in the National League against 11 club teams and additionally one time against the U21 national team. The team played 23 games in the competition and additionally the semi-finals of the play-offs. By winning TVE automatically was qualified for the promotion games against the 2 last of the Swiss Handball League and the finals against RTV Basel for the national championship in the National League. That indicates that at least 8 more top level games were added to the season's regular plays, which brings the total to 33 in the 2005/2006 season.

In the regular first 25 games (ended 31 March 2006) the team made 754 goals (30.16/game) from which 75 out of 7m-penalty (3/game). The pivot players (2 players)) scored 79 goals, the left wing (4 players) scored 122 goals, the right wing (2 players) 116 goals. The centre (2 players) scored 194 times from which 182 (7.6/game) were scored by the top scorer. The back right (2 players) scored 163 and the back left (2 players) 78 times. Dividing the throwers into left and right hander, playing respectively on the right and left position in the field, and centre positions, scores were as follows: left hander (4 players) scored 279 times, the centre (2 players) 194 times and the right hander (8 players) 281 times. 2 field players of the team did not score but were only active in one play.

Table 6 Profile of THW Kiel (2006)

THW Kiel Players nationality	Number	National Team Players
Germany	5	:3
Sweden	6	6
Austria	1	1
France	1	1
Nonvay	1	1
SloYenia	1	1

Table 7a Some interesting data on attack characteristic

30% of goals by counter attack/quick throw off
Every 3rd goal scored per speed game.
Every 4th attack ends with counter attack/quick throw off Every 2nd attack ended/interrupted after 10 sec.
30% Of all attack-actions are ended/interrupted after 20 seconds
31% of playing time the ball is NOT played.

Table 7b Some interesting data on attack characteristic

Number of attack actions	**176**	**completed attack 62.6% % of total**	**interrupted 37.3%**
Throws on Goal(incl 7m)	67	38.1	
missed throws	26	14.8	
technical foul	17	9.7	
Foul/free throw	62		35.2
interruption by referee	4		2.2

Table 7c Some interesting data on attack characteristic

Number of interruptions	**Attacks**	**%**
5	1	0.9
4	1	0.9
3	4	3.7
2	8	7.3
1	30	27.5
0	65	59.3

Table 8 Research data of the DHV on play characteristics (comparing 1996 with 2004)

Bundesliga		
Year of Comptition	1996	2004
Number Attacks/Game	55.4	61
Score efficiency	53%	54%
Throws on Goal	47	52
Goals	29.3	32.9
Effective Play time	48'	53'
Start per player	44- *50*	72
Ball contacts per player	90	135

Table Continued...

In General	
Total Distance	<7000m
without ball	<4750m
sprint	<450
moderate	<3500
walk	<700
with ball	<66m
sprint	<24
moderate	<34
change of speed	212
change of direction	300
Jumps	20

The goal keepers also did not score. 124 2-minute penalties (4.96/game) and 3 disqualifications were registered against TVE.

Play analysis of a team and individual analysis of a back right player

In 2006 the Swiss semi-professional handball team of TVEndingen played in the play-offs against Amicitia /Zürich. The play was analysed using a play statistic form. Also, one back player was video recorded, and his play performance was analysed as well.

Over one game with 2 x 30 minutes play time the team scored nearly every 2 minutes of the real playing time. Including interruptions, the total game was 2 x 40 minutes. By video recording the back right (BR) player (29 years old, 198cm and 97kg), with a record of 72 goals and 27 2-minute suspensions in 25 games in the running season so far, the real demands on a player could be estimated.

In the first 5 minutes, before his first 2-minute suspension, he was involved in 4 attacks and 4 defence plays, passed the ball 11 times, and had 1 shot on the goal. He walked 99 steps forward, and 22 steps backward. In the attack he made 14 side steps and in defence 38. Otherwise than the wing player, who must run from base line to base line, the back player stands in the defence on the 6-meter circle and runs up to approximately the 9-meter line during attacks (25-meter distance). During the first 5 minutes the back-right player ran 200 meters. Based on his appearance in the field during the first 5 minutes (Table 4) estimations of physiological demands can be made. (Beware, that almost every player has some minutes of recovery time being substituted temporally).

Analyses of the 2006 cup game THW Kiel-TUSEM Essen (33-34)

(http://www.tusemessen.de/ and http://www.thw-provinzial.de/thw/)

TUSEM Essen won the 2005 European Cup, but got no license for the Bundesliga (2006), because of financial problems. As on this moment (April 2006) they were undefeated leader in the Regionalliga West with 883 (35,3/game):638 (25,5/game) goals in 25 games. THW Kiel was the current leader in the German Bundesliga with 876 (36.5/game):685 (28.5/game) goals in the first 24 games (situation on 1 April 2006) of the season.

The main data are subtracted out of a play statistic form and can be analysed to determine the efficiency of attacks.

Physical properties and physiological aspects of elite handball players

As in all team ball sports, the physical properties are not the only factor in being a good handball player. Team handball is however a very demanding physical game. Wing players should be fast because of their role in the first wave and should have excellent acceleration and jumping abilities because of their place in the field during the attack play. Balance in the air and throwing abilities are other important properties. The back and centre players should have extremely high throwing capacities and jumping abilities, especially if they have no great body height. The pivot should have great agility and ball technique.

As they all as a team must attack and defend, the physiological demands are similar. Only the wing players run, often as a sprint, longer distances (35-40 meters versus 25 meters for the back and centre players) from defence into attack. On the other hand, the back players run more from left to right during attacks. Every field player is expected to be able to score. In average, 57 % of all goals are scored by the 3 centre players. 10.5% by the pivot and 32.5% by the wing players.

Looking at the data in table 8, it seems obvious, that the character of the play is changing. Especially recovery of the game changed. The "quick throw of" or "fast middle" ('schnelle Mitte") is a common attack variation, which makes the game extremely fast and it gives the opponent no time to organize its defence.

The change in the game is reflected also by the number of attacks. 61 attacks per team means that every minute an attack is lounged, and a defence situation has occurred, because normally the number of attacks is equal to the number of defence situations.

As the distance between the goal circles (6m) is 28 meters and considering that the left wing must run more (from back line to back line is up to 40m), the pivot exacts this distance (from half defender to pivot point on the 6-meter circle) and the back right/back left somewhat less (from 6m circle to 9m circle being 25m) it seems to be justified that the average distance is about 2 x 28m per attack (attack and return into defence). That means a distance of at least 61x56m= 3094m must be covered per game. The back-right player of TVE made approximately 992 side steps (side hops) with an average of 1,5m which makes an additional 1488m.[6]

Rannou[7] came to the conclusion, that national and international handball players had similar VO2 max, anaerobic power (using the Wingate anaerobic Test (WanT))[9] and lactate values as trained sprinters.

Searching for evidence of changing physiological aspects and physical demands in the game following website: http://www.brasilhandebol.com.br [10] revealed some interesting analysis of the so called 'quick throw off" used by many elite handball teams. Also, the DHB (Deutscher Handballbund) did some research on several aspects of the game comparing the 1996 and 2002 season. Unfortunately, these data were obtained without references, but as they seem to confirm the data of the two German Bundesliga teams (Kiel and Essen), analysed and mentioned above, it seems to be justified to present them (Table 7a, 7b, 7c and Table 8).

Profile of a modern handball player

Regarding all this it seems to be justified that, as Bergemann[11] stated, that a modern elite handball player (1996) is about 188cm and weighs about 92kg. He has an arm span of 99cm and a hand breadth of 24cm. He throws a ball with a speed of 23.1 m.s (Bergemann,Tillaar[11,12]), can sprint 2.99 seconds on the 20m dash and can jump vertically between 46.7 (not dominant leg) and 54cm (dominant leg).[11]

The 2006 handball player tends to be bigger and heavier whereas there seems to be a linear correlation between level of handball, body weight and height. The average Bundesliga player of THW Kiel (leader in the 2005/2006 competition) is: 26.7 years old, 193cm and 95.7kg. SC Magdeburg (4th of the season) 26.8years, 193cm and 92.7kg.

In Switzerland TVEndingen (top 10 team in Switzerland) players are 25.9 years of age, 186cm and 84.5kg. The players' data of GC Zurich (leader in Swiss Handball League) are 25.7, 191 and 90.5, respectively.

The modern 2006 player must cover up to 6000m, runs back and forth about 60 times and must be able to push and/or hold an opponent around 270 times during a game. He changes direction 300 times per game, which is in average 5 times per minute.

Importance of physical and motor performance in talent identification

In a 2005 published study Lidor[3] identified motor, physical, and skill variables that could provide coaches with relevant information in the selection process of young team handball players. In total, 405 players (12 and 13 years of age at the beginning of the testing period) were recommended by their coaches to undergo a battery of tests prior to selection to the Junior National Team. The battery included physical measurements (height and weight), a 4 x 10-m running test, explosive power tests (medicine ball throw and standing long jump), speed tests (a 20-m sprint from a standing position and a 20-m sprint with a flying start), and a slalom dribbling test. Comparisons between those players eventually selected to the Junior National Team about 2-3 years later with those not selected demonstrated that only the skill tests served as a good indicator. In Germany Schoerer et al.[13] from the university of Heidelberg came to similar conclusions. The most important predictor of later selection in representing teams were BKT (Ball and Body balance on a wobble board) and handball throwing distance, but gave warning, that physical abilities should not be forgotten. Motor tests however are not a satisfying basis for talent identification. In the same study the subjective talent identification by handball trainers were evaluated also. Schorer[15] et al. stated, that a talent identification based on observations during games of 2x3:3 and 6:6 (a 3 against 3 and a 6 against 6 game) correlated for 74% with the conclusions from the throwing/body balance tests. In other sports similar findings are reported. In 2004 Falk[15] came to the same conclusion regarding talent detection of water polo players. The tests included: freestyle swim for 50, 100, 200 and 400 m, 100-m breaststroke, 100-m 'butterfly' (with breast-stroke leg motion), 50-m dribbling, throwing at the goal, throw for distance in the water, vertical 'jump' from the water, and evaluation of game intelligence by two coaches. A comparison of those players eventually selected to the team and those not selected demonstrated that, 2 years before selection, selected players were already superior on most of the swim tasks (except for breaststroke and 50-m freestyle), as well as dribbling and game intelligence. This superiority was maintained throughout the 2 years.

Anthropometric data, ranking and conclusive consequences

The skill tests served as a good indicator for identification of talent. However, if skills are comparable the anthropometric data of the top teams and their ranking seem to correlate to a great extent. In Germany as well as in Switzerland the teams with the longest and heaviest players were at the top of the ranking. (Tables 9,10) In Switzerland only one team (Pfadi) seemed to be an exception, because average length and weight did not correlate so well with their ranking. The average length and height however were highly influenced by their top player (197cm and 98kg), who could not play most of the season due to injury.

Table 9 2006 ranking (Zürich leader) and anthropometric data in the Swiss Handball League

Ranking	Team Name	Age	Height	Weight
1	Zurich	25.7	1,908	90.5
2	Schaff hausen	27.1	189	90
3	Thun	28.3	1,889	89.7
4	Otmar SG	26.1	1,881	87.2
5	Bern	26.5	1,872	86
6	Zentral S	26.8	1,863	84.8
7	Pfadi	23.8	1,892	89.1
8	Suhr	23	1,869	85.9
9	Basel (NHL B)	24.3	1,865	85.2
10	TVE (NHL B)	25.6	186	84.5
	Mean	25.72	1,879	87.29
	Max	28.3	1,908	90.5
	Min	23	186	84.5

Table 10 2006 ranking and anthropometric data in the ``Handball Bundesliga`` (Germany)

Ranking	Team Name	Age	Height	Weight
1	Kiel	26.7	1,933	95.7
2	Flensburg	30.1	1,905	95.1
3	Gummersbach	29.2	1,924	94.0
4	Magdeburg	26.6	1,927	92.8
5	Lemgo	28.2	1,952	93.1
6	Nordhorn	26.7	1,900	90.1

Table Continued...

Ranking	Team Name	Age	Height	Weight
7	Kronau	28.3	1,910	93.8
8	Grosswallstadt	27.6	1,899	92.5
9	Goppingen	27.4	1,932	92.0
10	Hamburg	27.9	1,920	93.4
11	Liibeck	27.6	1,913	91.8
12	Melsingen	29.2	1,884	90.3
13	Minden	25.6	1,907	92.2
14	W ilhelmshaven	27.8	1,910	91.0
15	Diisseldorf	26.0	1,882	90.7
16	Wetzlar	27.7	1,912	88.0
17	Pfullingen	27.0	1,880	87.0
18	Delitsch	19.0	1,884	80.7
	Mean	27.16	1,912	91.7
	Max	30.1	1,952	95.7
	Min	19	1,882	80.7

Looking at the anthropometric graph in figure 10 and 11 it could be concluded, that the team with the longer and heavier players will reach the top of the ranking, provided that the technical skills of all players are comparable. Regarding training and selection of (new) players, this would mean, that physical training (strength and power) and the selection of players based on their anthropometric data should play an extremely important role in modern handball.

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Conflicts of interest

None.

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