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From Competition to Sport Specific Preparation in Handball

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Abstract: *Many factors influence the performance in elite handball, amongst them being the game actions' efficiency. The performance in handball game is influenced by a series of factors: specific preparation, physical fitness, constitution, anthropometry, nutrition, individual specific abilities, efficiency, team work, and ability to perform under pressure and to adapt to the changing conditions of the game, team tactic, social and cognitive factors. The aim of the study is to determine how the performance is influenced by the game actions' efficiency during the top competitions and if there is any statistical significance between the European teams and the rest of the participating teams and to identify a benchmark of efficiency for specific game actions' that will be useful for handball coaches. For the analysis of our data, we used descriptive statistics (mean, standard deviation), analysis of variance (ANOVA) (the threshold was set at 0,05) and linear regression for identifying a pattern of connections amongst data collected in our study. 21 out of 36 situations achieved statistical significance for 0.05 level of p. The linear regression supports the statistical results of the variance analysis. These findings are useful for persons involved in handball training that they can use as a reference to assess the team and the individual performance, to plan the team's training in order to achieve values close to the mentioned ones in our study.*

Keywords: *game actions, competition, performance, significance, analysis.*

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Introduction

The competition it is the role model to design in a proper manner sport training / preparation in order to achieve the goals.

Handball is a worldwide spread sport. World and continental championships are organized for national teams, being also an Olympic sport. Handball is a collective sport that requires performing fast and intermittent actions with high intensity along another specific movements like running, jumping, throwing and blocking; also, body contact is allowed in order to stop the opponents' actions and to be effective in defense (Wagner et al., 2014; Hermassi et al., 2019). The main task of the team in offense is to score goals by using different types of specific actions and for defense the objective is to avoid the opponent team to score.

The sport training it is an educational activity addressed to the individuals with a very good physical fitness and specific skills for a sport branch. The final purpose of the sport training it is to participate in competition where athletes must achieve very good results.

As part of the physical education and sport system, sport training contributes to the preparation of the athletes in order to qualify and participate in major competitions, as: Olympic Games, World Championships, and Continental Championships.

Iconic athletes with great results at major competitions are role models for children and young generation in order to practice sport activities with an educational purpose / meaning.

In top handball competitions, marked by efficiency and performance, there is needed to analyze the teams and the individuals from different perspectives in order to identify the trends of the game.

The game actions' efficiency and the trends of the game are strong indicators that must be considered for the design of the training in order to achieve performance in competitions.

The aim of the study is to determine how the performance is influenced by the game actions' efficiency during the top competitions and if there is any statistical significance between the European teams and the rest of the participating teams and to identify a benchmark of efficiency for specific game actions' that will be useful for handball coaches.

Literature review

The literature review it is focused on studies that approach the topic of competition in handball, the efficiency of the game actions during the

matches, the tactical and strategically decisions of the coaches in order to achieve a better efficiency and to win the match. All these elements connected to the competition must be a benchmark for training sessions where handball players must prepare according to the requirements of the competition.

The performance in handball game is influenced by a series of factors: specific preparation, physical fitness, constitution, anthropometry, nutrition, individual specific abilities, efficiency, team work, ability to perform under pressure and to adapt to the changing conditions of the game, team tactic, social and cognitive factors (Wagner et al., 2014; Leuciuc et al., 2022).

The shots' efficiency has a main importance for performance, being a key factor in elite handball where the velocity and accuracy of throwing are essential in order to accomplish the competition objectives and to win the matches (Vila et al., 2020).

The handball experts analyzed the teams and the individual efficiency in different manner, according to the shots' efficiency and team's efficiency (Taborski, 2008; Krawczyk et al., 2024a), the shooting areas (Pokrajac, 2008), the playing positions (Ohnjec et al., 2008; Costa et al., 2017), the influence of specific factors on different situations of shots' efficiency (Foretic & Papic, 2013), the influence of the tactics on shots' efficiency (Rogulj & Srhoj, 2009).

The team and individual efficiency could be improved by specific training, acting in two major directions: offensive phase where players must act according to the team tactics with a very high speed and efficiency of the specific actions under the opponents' pressure and in defensive phase where the training tasks must help players anticipate the attacker's actions and find proper solutions to stop them or to reduce their effectiveness (Mendes et al., 2021; Śliż et al., 2025).

The analysis made at the World Championship (WCh.), European Championship (ECh.), Olympic Games (OO.GG.) showed significant differences amongst the top 8 ranked teams and the rest of the participating teams, concerning the game actions' efficiency, for fast break, pivot and back court players' shots, assists, goalkeeper-blocked shots (Bilge, 2012; Saavedra et al., 2017).

Another factor that could boost the efficiency and also the players' confidence is the team timeout (TTO). Coaches asked for TTO when the difference on the scoreboard was increasing in the favor of the opponents or when the results were tight and the effect was positive concerning the scored goals and efficiency up to 5 ball possessions (Gutierrez-Aguilar et al., 2016; Prieto et al., 2016; Granero-Gallegos et al., 2017).

Each team recorded strong and weak points in attack and defense, but the winning excelled and scored significantly higher, registering much stronger points than the defeated teams and also less weak points, these differences decisively contributing to the final match outcome (Vuleta et al., 2017; Milanovic et al., 2018; Vazne et al., 2018; Krawczyk et al., 2024b).

Daza et al. (2017) identified the game actions that could predict the victory in a handball match and also the team performance: goalkeeper's efficiency, technical fouls, steals. So, the efficiency is a key factor for performance in handball and also in all collective games.

The shots' speed is an important factor for the team and the individual efficiency and also for the match outcome. Usually, the speed of the ball, launched by using different type of throwing's, from various positions of the court, is between 24 and 27 m/s (Zapardiel et al., 2019; Pueo et al., 2022).

The analyzed studies present facts and data from limited number of competitions (at national or international level), with some limits. In our study we want to collect data from 4 consecutive World Championships (2017, 2019, 2021, 2023), where are participating 24 to 32 teams from all over the World in order to have a large and documented perspective concerning the trends of the handball game in order to make practical, useful and objective recommendations for coaches.

Methodology

Participants. The participants in the study are athletes, members of the teams that are qualified at World Championships (WCh.) organised by International Handball Federation (IHF). Our study included teams qualified at the Men's Handball WCh. in 2017 (24), 2019 (24), 2021 (32), 2023 (32), according to the specific criteria of IHF in order to participate at final tournaments. At WCh. 2017 (held in France) from 24 teams: 14 were from Europe, 4 from America, 3 from Asia and 3 from Africa. 24 teams participated in 2019 (Germany and Denmark hosted the competition): 13 from Europe, 4 from America, 4 from Asia, 3 from Africa. Egypt was the organizer of the 2021 edition, when the number of participating teams increased at 32; the competition involved 17 teams from Europe, 4 from America, 4 from Asia and 7 from Africa. At WCh. 2023 (held in Poland and Sweden) participated 17 teams from Europe and 15 from America, Asia, and Africa. According to the place in the final hierarchy, each team played 5 to 7 matches (the teams ranked in the second part of the final hierarchy) and 9-10 matches the top 4 teams.

Research Design. We used 9 indicators to determine the game actions' efficiency (6m shots, wing shots, backcourt shots, 7m shots, fast break shots, overall shots, blocked shots, interception and goalkeepers' efficiency) during the 4 editions of WCh. The data were collected from the official statistics of the International Handball Federation (IHF) including all the matches played during the Men's World Handball Championships. All the statistical data were collected by the Pictorial Handball Match Statistics v5.3 (PHMS) system and Swiss Timing. Data used in our study were collected from IHF website, where are available.

Statistical Analysis. For the analysis of our data, we used descriptive statistics (mean, standard deviation), analysis of variance (ANOVA) to determine the statistical significance (the threshold was set at 0,05) and linear regression for identifying a pattern of connections amongst data collected in our study.

Results

We used the following indicators in order to make the statistical analysis: shots' efficiency (for each playing post, 7m, fast break and overall), goalkeepers' efficiency, interception and blocked shots for the European teams and the rest of the participating teams. The data were collected from the last 4 editions of the WCh. and included the most used indicators concerning the game actions' efficiency in order to obtain reliable data for our study. The results were compared to the benchmark (Taborski, 2001), representing the minimal efficiency of the game actions for teams participating at the most important handball male competitions (table 1).

Table 1. Game actions' efficiency in our study compared to the benchmark

Game actions efficiency	Benchmark efficiency	Efficiency for European teams	Efficiency for rest of participating teams
backcourt shots	40% ≥	44,60%	**37,41%**
wing shots	55% ≥	65,27%	56,99%
6 m shots	60%≥	66,81%	62,83%
fast break shots	70%≥	80,80%	74,31%
7 m shots	75%≥	76,99%	**73,70%**
overall shots	60%≥	63,72%	**56,90%**
goalkeepers saved shots	35%≥	**30,89%**	**25,45%**

For the European participating teams, the minimum requirements were achieved for 6 (backcourt, wing, 6m, fast break, 7m, overall shots and goalkeepers' efficiency) out of 7 indicators when we compared the efficiency to the benchmark. For the rest of the participating teams, only 3 indicators (wing, 6m, fast break shots efficiency) met the minimal requirements.

For all indicators analyzed in our study differences were recorded between the European teams and the rest of the participating teams at WCh., but the differences were not always statistically significant. At 2017 WCh. there were recorded close values for 7m shots and interceptions. In 2019 for 3 indicators the values were close for: 6m shots (66.08% versus 62.09%), 7m shots (77.46% vs. 72.18%) and fast break (81.77% vs. 77.73%); the same situation being at WCh. 2021. At the 2023 Wch. edition close values were only for 7m shots (75.65% vs. 75.53%). We used 9 indicators in our study for each of the 4 editions of WCh., generating a total of 36 situations where we made statistical data analysis. In 21 out of 36 situations there were achieved statistical significance for 0,05 level of p (table 2).

Table 2. Game actions' efficiency analysis (descriptive statistics and ANOVA) for the participating teams at Men's Handball World Championships

Statistical parameters / Game actions	Shot's efficiency (%)						Goalkeepers efficiency	Interception (no.)	Blocked shots (no.)
	6m	wing	backcourt	7m	Fast break	Overall			
2017									
X±SD (Europe)	63,64± 6,28	65,00± 11,26	43,50± 3,78	76,71± 13,34	82,43± 5,52	62,14± 3,61	32,21± 4,58	23,57± 9,78	17,86± 6,99
X±SD (rest of the teams)	58,00± 8,35	54,80± 6,70	37,70± 3,40	72,20± 7,45	71,60± 10,83	54,60± 4,20	26,70± 4,57	20,30± 6,02	8,80± 5,03
F (1, 22)	3,580	6,508	14,097	0,930	10,365	22,253	8,475	0,875	12,194
p	0,071	0,018*	0,0008***	0,345	0,004**	0,0001***	0,008**	0,360	0,002**
2019									
X±SD (Europe)	66,08± 6,61	65,38± 5,84	44,62± 6,64	77,46± 6,12	81,77± 5,83	62,69± 4,29	31,23± 3,37	31± 10,66	20,15± 8,43
X±SD (rest of the teams)	62,09± 4,91	57,18± 6,08	36,82± 5,38	72,18± 8,33	77,73± 5,75	56,27± 2,20	25,82± 3,25	25,82± 3,08	12,91± 7,149
F (1, 22)	2,72	11,33	9,73	3,2	2,12	20,09	15,87	1,61	5,02
p	0,11	0,003**	0,005**	0,09	0,16	0,0001***	0,0006***	,22	0,04*

				2021					
X±SD (Europe)	71,94± 6,37	65,71± 5,98	43,82± 6,15	78,12± 10,98	77,94± 6,94	63,88± 4,77	30,47± 2,96	24,12± 10,17	16,12± 6,55
X±SD (rest of the teams)	70,13± 11,98	54,87± 10,97	35,13± 8,24	74,40± 12,64	72,40± 9,70	58,80± 7,02	24,73± 4,50	20,20± 9,92	8,57± 5,21
F (1, 30)	0,293	12,45	11,62	0,793	3,54	5,86	18,60	1,21	12,20
p	0,592	0,001**	0,002**	0,380	0,07	0,021*	0,0001***	0,28	0,001***
				2023					
X±SD (Europe)	65,59± 4,72	65,00± 8,46	46,47± 11,16	75,65± 11,58	81,06±7,98	66,18± 5,11	29,65±3,53	4,12± 10,6	13,88± 5,48
X±SD (rest of the teams)	65,00±6,5	61,13± 9,74	40,00± 5,88	75,53± 8,61	75,53± 8,70	57,93± 3,79	24,53±3,60	15,67± 9,15	7,60± 5,40
F (1, 30)	28,27	0,34	4,04	0,009	3,26	26,22	16,38	5,72	10,63
p	0,001***	0,566	0,053	0,975	0,080	0,001***	0,001***	0,023*	0,002**

X – mean; SD – standard deviation; (*p < 0.05; **p < 0.01; ***p < 0.001); F - MS factor/MS residual; p - statistical significance.

Data analysis

Table 3 presents shots and goals distribution for all teams participating at WCh. editions analyzed in our study. Most of the shots were launched from backcourt and 6m line, followed by fast break, wing, 7m and breakthrough. Concerning the goals scored, the leading positions are backcourt and 6m line.

Table 3. The distribution of shots and goals by the playing position and situation

WCh. edition	Total shots	6m	Wing	Backcourt	7m	Fast break	Breakthrough
2017	7852	2206	1005	2514	614	1111	402
	100%	28,09%	12,80%	32,02%	7,82%	14,15%	5,12%
2019	8694	2032	1132	2947	686	1085	812
	100%	23,37%	13,02%	33,90%	7,89%	12,48%	9,34%
2021	9461	1952	1308	3072	744	1031	1146
	100%	20,63%	13,83%	32,47%	7,86%	10,90%	12,11%
2023	10199	3801	1315	2326	806	1093	858
	100%	37,27%	12,89%	22,81%	7,90%	10,72%	8,41%

	Total goals	6m	Wing	Backcourt	7m	Fast break	Breakthrough
2017	4643	1341	624	1030	450	869	329
	100%	28,88%	13,44%	22,18%	9,69%	18,72%	7,09%
2019	5239	1306	709	1231	519	869	605
	100%	24,93%	13,53%	23,50%	9,91%	16,59%	11,55%
2021	5863	1380	805	1234	568	791	865
	100%	23,54%	13,73%	21,05%	9,69%	13,49%	14,75%
2023	6555	2309	842	1020	609	862	703
	100%	36,39%	13,27%	16,08%	9,60%	13,59%	11,08%

The distribution of shots and shots saved by goalkeepers according to the playing position and the game situation showed that the best efficiency was achieved from backcourt and 6m line (table 4).

Table 4. The distribution of shots and shots saved by goalkeepers

WCh. edition	Total shots	6m	Wing	Backcourt	7m	Fast break	Breakthrough
2017	6619	1929	892	1817	583	1011	387
	100%	29.14%	13.48%	27.45%	8.81%	15.27%	5.85%
2019	7381	1821	1020	2153	643	996	748
	100%	24.67%	13.82%	29.17%	8.71%	13.49%	10.13%
2021	8067	1795	1163	2216	695	959	1079
	100%	22.25%	14.42%	27.47%	8.62%	11.89%	13.38%
2023	8843	3321	1196	1705	767	1037	817
	100%	37.56%	13.52%	19.28%	8.67%	11.73%	9.24%
	Total saved sho	6m	Wing	Backcourt	7m	Fast break	Breakthrough
2017	1976	588	268	787	133	142	58
	100%	29.76%	13.56%	39.83%	6.73%	7.19%	2.94%
2019	2142	515	311	922	124	127	143
	100%	24.04%	14.52%	43.04%	5.79%	5.93%	6.68%
2021	2264	415	358	982	127	168	214
	100%	18.33%	15.81%	43.37%	5.61%	7.42%	9.45%
2023	2498	1012	354	685	158	175	114
	100%	40.51%	14.17%	27.42%	6.33%	7.01%	4.56%

Comparing the shots of tables 3 and 4, there are some differences: table 3 presents all shots and table 4 only shots on target (goal), being a difference of 17-18% - representing the missing shots.

Table 5 shows the share of goals by the playing position and the situation for the two analyzed groups. At WCh. 2017 – 14 European teams scored 2898 goals, meaning an average of 207 goals per team or 29 goals per game comparing to an average of 174,5 goals per team or 25,66 goals per game for the rest of the participating teams (10). At 2019 edition – 13 European scored 3157 goals (242,85 goals per team or 28,44 goals per game) compared to an average of 189,27 goals per team or 25,72 goals per game for the rest of the participating teams (11). 32 teams played at 2021 WCh. (17 from Europe and 15 from the rest of the World), but due to the Covid 19 pandemic and cases appeared during the competition, 6 games were concluded 10-0. European teams recorded an average of 203,35 goals per team or 29,56 goals per game and rest of the participating teams – 160,4 goals per team or 24,30 goals per game. At 2023 edition those 17 European teams scored 3724 goals (219,06 goals per team or 31,84 goals per game) compared to an average of 174,60 goals per team or 26,45 goals per game for the rest of the participating teams (15).

Table 5. The share of goals by the playing position and the game situation for two analyzed groups

WCh. edition	Group	Total goals	6m	Wing	Backcourt	7m	Fast break	Breakthrough
2017	E.T.	2898	833	435	622	256	581	171
			28.74%	15.01%	21.46%	8.83%	20.05%	5.90%
	R.P.T.	1745	508	189	408	194	288	158
			29.11%	10.83%	23.38%	11.12%	16.50%	9.05%
2019	E.T.	3157	733	474	746	301	552	351
			23.22%	15.01%	23.63%	9.53%	17.48%	11.12%
	R.P.T.	2082	573	235	485	218	317	254
			27.52%	11.29%	23.29%	10.47%	15.23%	12.20%
2021	E.T.	3447	832	504	752	322	484	464
			24.14%	14.62%	21.82%	9.34%	14.04%	13.46%
	R.P.T.	2356	548	301	482	246	307	401
			23.26%	12.78%	20.46%	10.44%	13.03%	17.02%
2023	E.T.	3724	1322	511	594	353	531	413
			35.50%	13.72%	15.95%	9.48%	14.26%	11.09%
	R.P.T.	2619	987	331	426	254	331	290
			37.69%	12.64%	16.27%	9.70%	12.64%	11.07%

E.T. – European teams; R.P.T. – rest of the participating teams

If we compare the share of goals scored by position and situation for these two groups there are not major differences, the same situation being for saved shot by goalkeepers. The differences consist in number of scored goals (2898 vs. 1745; 3157 vs. 2082; 3447 vs. 2356, 3724 vs. 2619) and also for saved shots (1240 vs. 736; 1320 vs. 822; 1376 vs. 888; 1477 vs. 1013).

The distribution of the saved shots by goalkeepers at each edition and for each group revealed that the goalkeepers from European teams had a better efficiency – they saved more shots (2017 – 12,40 per game; 2019 – 11,89 per game; 2021 – 11,76 per game; 2023 - 12,79 per game) than those from the rest of the participating teams (2017 – 10,82; 2019 – 10,56; 2021 – 8,97 per game; 2023 - 10,23 per game (table 6).

Table 6. The share of saved shots by the playing position and the situation for the two analyzed groups

WCh. editio	Group	Total saved shot	6m	Wing	Backcourt	7m	Fast breal	Breakthrough
2017	E.T.	1240	344	172	549	82	59	34
			27.74%	13.87%	44.27%	6.61%	4.76%	2.74%
	R.P.T.	736	244	96	238	51	83	24
			33.15%	13.04%	32.34%	6.93%	11.28%	3.26%
2019	E.T.	1320	310	178	614	74	61	83
			23.48%	13.48%	46.52%	5.61%	4.62%	6.29%
	R.P.T.	822	205	133	308	50	66	60
			24.94%	16.18%	37.47%	6.08%	8.03%	7.30%
2021	E.T.	1376	241	201	650	71	89	124
			17.51%	14.61%	47.24%	5.16%	6.47%	9.01%
	R.P.T.	888	174	157	332	56	79	90
			19.59%	17.68%	37.39%	6.31%	8.90%	10.14%
2023	E.T.	1497	589	183	461	105	95	64
			39.35%	12.22%	30.79%	7.01%	6.35%	4.28%
	R.P.T.	1013	423	171	224	53	90	52
			41.76%	16.88%	22.11%	5.23%	8.88%	5.13%

In both situations (scored goals and saved goals) we must keep in mind that the number of the European teams (14; 13; 17) is a little bit higher than that of the rest of participating teams (10; 11; 15), but with differences in absolute values (average for each indicator used in our study).

We made linear regression analysis for shots' efficiency of the European teams and the rest of the participating teams; the graphical representation of the data for this indicator showed a large distribution,

meaning a low degree of connection between data sets and also confirming the results obtained by ANOVA.

The situation is more polarized for goalkeepers' efficiency, being recorded a major difference between data sets, which means a low degree of connection. In both cases, the results suggest differences in terms of efficiency between the European teams (figure 1) and the rest of the participating teams (figure 2) at WCh. for the analyzed period. The linear regression applied only for the shots' efficiency of the European teams showed a strong connection for the collected data (figure 3) comparing to the shots' efficiency of the rest of the participating teams where the data distribution was wide and the degree of connection was poor (figure 4). The same analysis applied for goalkeepers' efficiency of the European teams (figure 5) and the rest of the participating teams (figure 6) showed a strong connection in both cases, the difference being for the predicted level where this is around 31% for goalkeepers' efficiency of the European teams and only 25% for goalkeepers' efficiency of the rest of the participating teams.

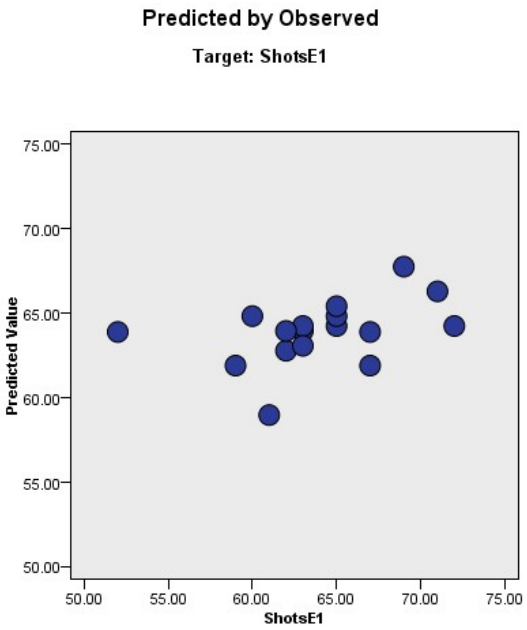


Figure 1. Linear regression analysis - shots' efficiency of the European teams versus the rest of the participating teams

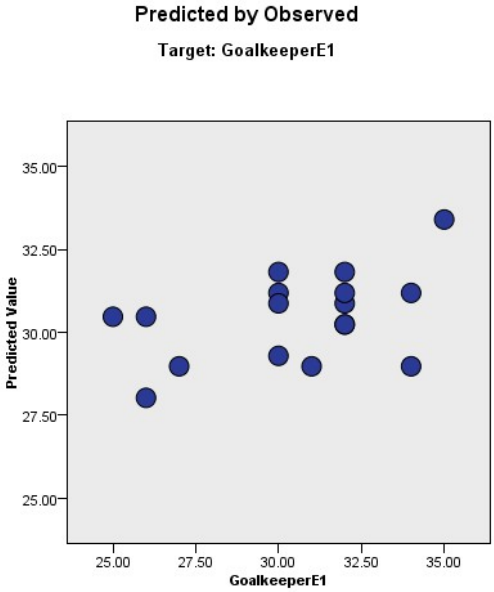


Figure 2. Linear regression analysis - goalkeepers' efficiency of the European teams versus the rest of the participating teams

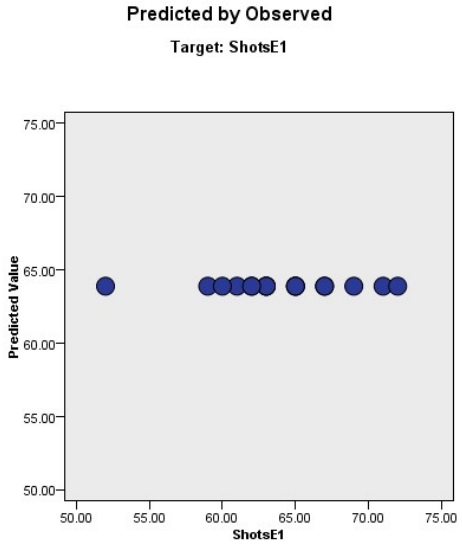


Figure 3. Linear regression analysis - shots' efficiency of the European teams

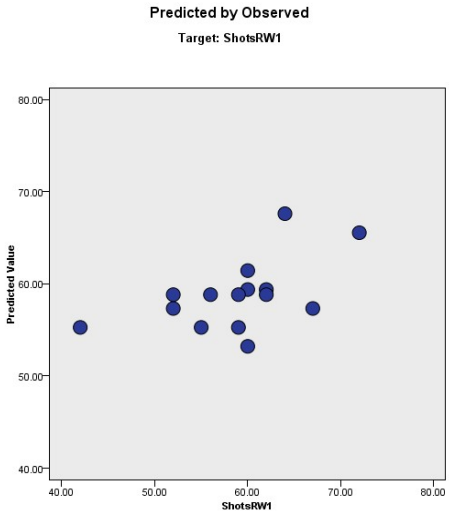


Figure 4. Linear regression analysis - shots' efficiency of the rest of the participating teams

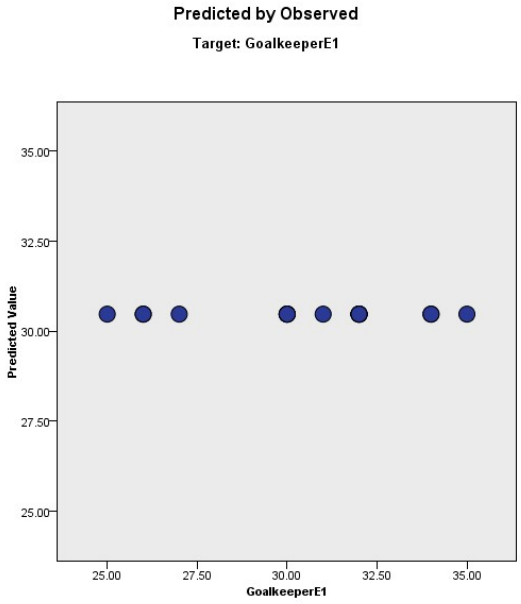


Figure 5. Linear regression analysis - goalkeepers' efficiency of the European teams

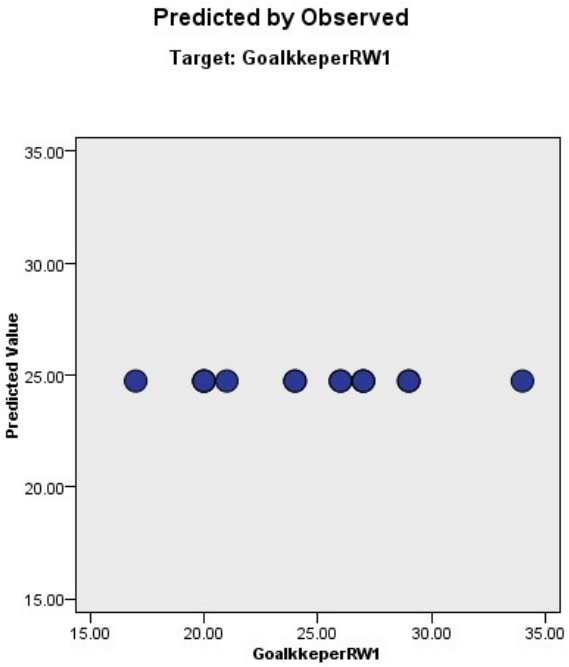


Figure 6. Linear regression analysis -goalkeepers' efficiency of the rest of the participating teams

Discussions

The aim of the study is to determine how the performance is influenced by the game actions' efficiency during the top competitions and if there is any statistical significance between the European teams and the rest of the participating teams and to identify a benchmark of efficiency for specific game actions' that will be useful for handball coaches.

For 6m line shots' efficiency, the European teams reached average values between 63,64% and 71,94% compared to values between 55% and 70,13% for the other participating teams; no statistical significance (by applying ANOVA) for 2017, 2019 and 2021 editions of the WCh. (when were obtained following values: 0,071 in 2017, 0,11 in 2019, 0,592 in 2021), only a significant values 0,0001 in 2023 (Meletakos et al., 2011; Bilge, 2012; Gomez et al., 2014; dos Santos-Afonso et al., 2024).

Wing shots' efficiency was around 65% for the European teams compared to the other participating teams where average values were

between 54,80% and 61,13%. These differences concerning actions efficiency were statically significant at each edition: 0,018 (2017), 0,003 (2019), 0,001 (2021) and 0,566 in 2023 (Bilge, 2012; Gutierrez-Aguilar et al., 2015; Leuciuc, 2018; dos Santos-Afonso et al., 2024).

Backcourt shots' efficiency - statistical significance data were registered between the two analyzed groups at each edition of the WCh. (0,0008; 0,005; 0,002; 0,053), being obtained an average value around 44% for the European teams and around 37% for the other participating teams (Bilge, 2012; Leuciuc, 2018; Przednowek et al., 2019; dos Santos-Afonso et al., 2024).

Close values for 7m shots' efficiency between groups (76,99% vs. 73,70%) showed no statistical differences for 0,05 threshold for each analyzed edition of the WCh. (Pokrajac, 2008; Bilge, 2012; Gutierrez & Ruiz, 2013a).

Fast break shots recorded a statistical significance only for one edition (2017) – 0,004; for other the three editions the p value was 0,16 in 2019, 0,07 in 2021 and 0,08 in 2023 (Milanovic et al., 2017; Vuleta & Vuleta, 2017; Almeida et al., 2020; Tuquet et al., 2021; Tejero-Pastor et al., 2024), but the values were a little bit higher for the European teams.

For all type of shots' efficiency analyzed in our study, there was obtained the highest statistical significance as follows: 0,0001 in 2017, 0,00001 in 2019, 0,021 in 2021 and 0,0001 in 2023. Shot's efficiency was between 62,14% and 66,18% for the European teams, between 54,60% and 58,80% for other participating teams at WCh. (Gutierrez & Ruiz, 2013a; Vuleta & Vuleta, 2017; Uzelac-Sciran, 2017; Almeida et al., 2020; Tuquet et al., 2021; dos Santos-Afonso et al., 2024; Tejero-Pastor et al., 2024).

The shots' efficiency is primarily influenced by the distance - wing shots and 6m shots' efficiency being better than backcourt shots' efficiency (where the distance is 9 m or more). For the European teams the efficiency of wing shots' and 6m shots situated between 63,64% and 71,94% comparing to the backcourt shots' efficiency where the values were between 43,50% and 46,47%. For the rest of the participating teams the situation is similar, but with lower efficiency: wing shots' and 6m shots' efficiency – the range of the values was between 54,80% and 70,13%; backcourt shots' efficiency – average values were between 35,13% and 40% (Tuquet et al., 2021; Bühren & Gabriel, 2023).

Although there were not statistical differences for 7 m shots and fast break, but the European team manage to record an efficiency between 75,65% and 82,43% comparing to the rest of the participating teams where average values were between 71,60% and 77,73%. At these two indicators

(fast break and 7m shots) there was recorded the highest level of efficiency for both groups analyzed in our study, but we must keep in mind that in the moment of the shot there is no opposition from the adverse player, only the goalkeepers try to defend the goal (Gutierrez & Ruiz, 2013a; Milanovic et al., 2017; Vuleta & Vuleta, 2017; Almeida et al., 2020; Tuquet et al., 2021).

The goalkeepers' efficiency is determinant for the team performance and usually, top teams excel both in shots and goalkeepers' efficiency. The efficiency of the European teams' goalkeepers was between 29,65% at 2023 edition and 32,21% at 2017 edition comparing to the other analyzed group where values were between 24,53% and 26,70%, being registered a very good level of statistical significance: 0,008 in 2017, 0,0006 in 2019 and 0,0001 in 2021 and 2023 (Bilge, 2012; Espina-Agullo et al., 2016; Cvenic, 2019; Gomez-Lopez et al., 2021; Angulo et al., 2022; Bühren & Gabriel, 2023).

The efficiency for all shots and for goalkeepers achieved the most statistically significant results, these two indicators being decisive for team performance. The summed value is around or over 100 for top teams at these two indicators, comparing to the lowest ranked teams where the value is between 75 and 82. The summed values of these two indicators could be used as predictor for the position in the final hierarchy of the tournament – usually, a higher value means a better position.

The interceptions helped the defending team score easily, being registered some differences between the two analyzed groups (European teams had an average between 23,57 and 31 interceptions comparing to the rest of the participating teams where the average was between 15,67 and 25,82), but not statistically significant. The blocked shots by the defenders improved the defense and goalkeeper's efficiency, being recorded significant differences between the European and the other teams at each edition: 0,002 in 2017, 0,04 in 2019, 0,001 in 2021 and 0,023 in 2023 (Gutierrez & Ruiz, 2013b; Milanovic et al., 2017; Vuleta & Vuleta, 2017; Uzelac-Sciran, 2017; Almeida et al., 2020; Keisuke et al., 2022). The average number of blocked shots per game is almost doubled for the European teams comparing to the rest of the participating teams: at 2017 edition - 17,86 vs. 8,80, 2019 – 20,15 vs. 12,91 2021 – 16,12 vs. 8,57 and in 2023 – 13,88 vs. 7,60.

Regarding the ANOVA univariate analysis for 6 out of 9 indicators there was obtained statistical significance (1 indicator for $p < 0.05$, 3 for $p < 0.01$ and 2 for $p < 0.001$) between the European and the rest of the participating teams at WCh. in 2017 and for 5 out of 9 indicatorsthere was obtained statistical significance at WCh. 2019, 2021 and 2023 editions (Vuleta et al., 2017; Uzelac-Sciran, 2017; Tuquet et al., 2021).

At those 4 World Championship (WCh.) editions analyzed there were constantly few indicators recording statistical significance (overall shots' efficiency, goalkeepers' efficiency and blocked shots). No statistical significance was registered for 7m shots' efficiency. Fast break, 6m shots' and interceptions recorded statistical significance for one out of four editions; backcourt and wing shots recorded statistical significance for three out of four editions. 21 out of 36 situations achieved statistical significance for 0.05 level of p.

The efficiency in competitions is influenced by the team tactics, experience, physical fitness, personal skills and the ability to use them throughout the game. A balance is needed to be between the offense and defense actions, but the rules of the game encourage the attack and due to this aspect, there is a very good efficiency of the offensive actions negatively influencing the goalkeepers' efficiency. To achieve a good level of the efficiency there is needed to perform at all indicators (offense and defense) during competition, especially in knockout stage when each success contributes to achieving a better position in the final standing (Milanovic et al., 2017; Leuciuc, 2018; Przednowek et al., 2019; Bühren & Gabriel, 2023).

The differences, in terms of efficiency, between top teams and the lowest ranked teams, in our case between the European teams and the rest of the teams participating at the World Championships, were made at each indicator (for offense and defense) used in our study, but not always with statistical significance.

Overall, we can state that the linear regression supports the statistical results for the analysis of variance (ANOVA) and there is a double confirmation concerning the reliability for the indicators used in our study.

The development of the technology allowed to collect and analyze data from handball matches with high accuracy and to design studies concerning the topic of performance for players and teams from different perspectives.

Many European teams usually rank in the first half of the final hierarchy at WCh.: in 2017 - 14 teams from Europe participated and 11 European teams ranked in top 12 and only one from the rest of the world – Qatar – 8th place; at 2019 edition - 13 European teams participated and 10 of them were in top 12 and 2 from other continents – Egypt – 8th place and Tunisia – 12th place; at 2021 edition - 14 European teams ranked in top 16 and 2 from the rest of the world - Egypt – 7th place and Qatar – 8th place; at 2023 edition - 14 European teams ranked in top 16 and 2 from the rest of the world - Egypt – 7th place and Bahrain – 16th place.

A World Championship is the most representative handball competition by the number of the participating teams (24/32) and diversity (teams for 4 or 5 continents). The most powerful national championships are in Europe and the European club competitions are the strongest for club teams. The most important and valuable players from Europe and all over the world play for European club teams.

Practical implications for sport specific preparation

These studies are necessary because they allow monitoring the evolution of these differences amongst teams from all over the world. These findings are useful for people involved in handball training that they can use as a reference to assess the team and the individual performance, to plan the team's training in order to achieve values close to the mentioned ones in our study.

With collected and analyzed data from the study, we propose a benchmark concerning game actions' efficiency for top handball male competitions: backcourt shots 40%≥, wing shots 60% ≥, 6 m shots 65%≥, fast break shots 75%≥, 7 m shots 75%≥, overall shots efficiency 60%≥, goalkeepers' efficiency 30%≥.

During the trainings the mentioned indicators and other that are considered relevant by coaches it is recommended to be used to monitor the preparation of the handball players in order the achieve the training and competition goals (Popescu et al., 2022).

Conclusions

We can state there is a statistical significance between the European and the rest of the participating teams in terms of efficiency at Men's Handball World Championships from 2017 to 2023. The team's efficiency is determinant for top teams, usually the top 4 teams recording close value for actions efficiency and also the highest values, essential for performance in elite male handball.

These study findings suggest that the European male handball is the most effective, important, providing the best teams and players who achieved performance in top competitions.

For future studies other specific indicators could be used and monitored during top competitions being relevant for team performance in order to bring more accuracy and relevance to the specific handball preparation.

To obtain performance in elite handball, the game actions efficiency had an important role, but there are other factors (experience, individual

skills, specific physical fitness, mental strength, ability to coordinate with teammates) that contribute to reaching the competition goals of the team.

According to the level of sport preparation, handball coaches must have an objective assessment of the training and the proposed benchmark could be a useful tool to reach the competition goals.

Due to the significant differences for certain game actions' efficiency between European teams and rest of the World teams there are imperative to implement in training sessions the minimum requirements of the proposed benchmark and the trends of the modern handball in order to improve the results in competitions.

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