Analysis of the 'Zero Step' IHF Handball Rule 7.3.d. in Open and Closed Motor Performance Program

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Abstract: Handball is a dynamic team sport game in which a series of actions can take place in a short period of time and in a small space, without the human eye being able to follow it. In this paper, the 'zero step' in open (matches) and closed (training) motor performance program was analysed and an attempt was made to prove that it is not possible to simultaneously land on two feet, which significantly changes the rules of the handball game. The matches of the European Handball Championship 2024 held in Germany were analysed in the matches that ended in a draw, and whether referee errors related to unjudged steps during the performance of the 'zero step' could have affected the final result. 18 senior players of the Kozala handball club, aged 16 to 24, participated in the research. For the purposes of the research, a motor task was composed in which, in the first phase, there was a jump to the 'zero step' from a standing position and a run, and in the second phase, a given feint and a shot at the goal. The results showed that no player jumped on both feet at the same time. A qualitative analysis of the matches of the European Championship in 2024 came to the conclusion that the final outcome could have been different, if there were no refereeing errors during the performance of the zero step. According to the obtained results, the anthropometric characteristics do not affect the difference in the time between the contacts of the left and right foot with the ground during the performance of the closed structure of the 'zero step' from the initial stance and after the run-up.

1 INTRODUCTION

Handball belongs to complex polystructural sports activities in which cyclic and acyclic movement structures alternate. Handball today is much more dynamic than it used to be, mostly due to the use of the fast centre rule. More modern principles in the technical, tactical and physical development of the handball game require players to possess new technical and motor skills and characteristics. Modern handball requires speed, dynamism, versatility in defence and attack, technical skill, good perception of the game and the ability to play in multiple positions, at least for a limited time (Pokrajac, 2007; Taborsky, 2008). During the handball game, players often use *feints* or *tricks*, with phases divided into real and fake. This technical element of individual play is used with the aim of gaining a spatial/temporal advantage over the defender to get an unobstructed scoring opportunity. What binds all versions of the feint with steps is - landing on the ground with the feet in a parallel or diagonal position, i.e. 'zero step', after receiving or dribbling the ball, and followed by the execution of the feint (modified from Zvonarek, 2005). The problem of controlling this technical element lies in the judge's assessment, which opens numerous controversies and questions regarding the perception of 'zero step'. With the historical development of handball, the rules of the handball game also changed. Newer technologies including VAR, the introduction of rules relating to the last 30 seconds of the game and many other changes greatly improve objectivity and reduce the chances of refereeing errors. However, there are segments of the game where it is difficult to see with the naked (even trained) eye whether there has been a violation of the rules or not. One of such segments of the game is certainly the 'zero step', which is still difficult to assess whether the player has landed on both of his feet. The rule 7.3.d. of the game of the highest umbrella handball organization (IHF) say that “It is permitted to: … take a maximum of 3 steps with the

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ball (13:1a); one step is considered taken when … a player after a jump *touches the floor with both feet simultaneously*, and then lifts one foot and puts it down again, or moves one foot from one place to another.”). The problem with this rule arises at the beginning, where it is difficult for the referees to see whether the contact was made at the same time, because if it is not, it significantly changes the result and leads to the subjective assessment of the referee, which means that the same technical element will not always be judged equally.

The previous researches covered the findings on different indicators of the game in attack and defence. Rogulj (2001) determined at the World Cup in Egypt 1999 that the result performance and general situational efficiency are best explained through the effective collective counterattack, a successful positional attack against the opponent's organized defence, minimizing technical errors in the attack, effective application of non-contact defence and situational efficiency of the goalkeeper in defending shots from back positions. Gruić et al. (2003) after analyses 59 matches of the Women's World Handball Championship held in Croatia, determined very different factors among groups which can influence success in preliminary phase of the competition. Different approaches to analysis of ‘success’ were performed on different competition levels. E.g. on case studies for Croatian national team few contributions depicted various very different approaches. At the World Championship in Portugal in 2003, Smajlagić (2007) studied the situational performance indicators in which the Croatian handball team reached the podium and won the gold medal, and Perkovac (2007) in his work analysed the situational performance indicators of the Croatian men's handball team at the World Championship in 2007 in Germany, followed by Balažinec (2020) who analysed indicators of the situational effectiveness of the Croatian handball team at the 2020 European Championship. Šibila et al. (2011) study various factors of situational efficiency through five consecutive European championships held from 2002 to 2010. They analysed 237 matches as a sample for their research. In their work, they investigated various variables, including the number of goals scored in positional attacks, the number of dismissals, blocks, attacks, assists, goals, goals scored on the counter attack, steals, yellow cards and goalkeeper defence. During those years of the European Championships, trends in efficiency changes in various parameters were noticed. For example, the number of repeated attacks and goals scored from counter-attacks increased until 2010. Likewise, with the development of goalkeepers and players, the ability to shoot, defend the goalkeeper and block has remained stable or similar. From this it is concluded that this analysis of situational parameters shows how handball is increasingly developing into a fast sport, with players moving faster in attack, requiring less time to prepare and organize attacks. Foretić (2012) classifies research on situational efficiency in handball into five different groups. The first three groups focus on the analysis of individual segments of situational effectiveness in the handball game: study of standard indicators of situational success, analysis of the presence of individual technical-tactical elements, and the effectiveness of individual playing positions. Next, expert assessment for team sports and situational confrontation with the opponent are investigated. The author points out that certain parameters of situational efficiency can be compared, including the successful performance of technical or tactical elements, the final outcome of the match, the placement in the competition and the activity of the opponent during the confrontation. The comparison of parameters of situational efficiency focuses on the final outcome of the match, either victory or defeat, efficiency in the performance of specific technical-tactical elements, placement in the competition and the activity of the opponent during the match. Based on his research, Foretić (2020) concludes that it is important to observe playing time in the context of specific playing positions instead of in the context of the overall sample of handball players. His research linked certain variables that showed a negative impact on the attacking efficiency of top handball players with the time the players spent on the court. Although the reasons for this can only be speculated on the basis of research data, it is clear that playing time directly affects the increase in the number of missed shots and technical errors in top handball. Management and control of game time, as well as a more careful approach in the integral fitness training of handball players, can benefit from such studies and their results. Future research should be more detailed in terms of including more variables of situational efficiency and physiological load of players in order to enrich the specific-situational knowledge of fitness coaches in handball. Also, it is important to investigate the effect of cumulative fatigue caused by the time spent on the field - whether the efficiency decreases from match to match. This is especially important for tournament systems in competitions such as the World and European Championships or the Olympic Games.

Although interesting, most analyses of situational effectiveness did not deal with 'borderline'

manifestations of the application of handball rules. The change is introduced by the research of Tuquet et al. (2022) who studied the men's European Championship 2018, World 2019, and European 2020 teams that were ranked 1st to 4th. After analysing 12 games in which their goal was to see how many steps players take before kicking from different positions. On a sample of 174 players, the results were obtained that players in the zone between 6-9 meters use 3 steps, with the assumption that they want to get as close as possible to the opponent's goalkeeper, in the zone outside 9 meters they use 2 steps in order to send a shot towards the goal as soon as possible and reduce the possibility for defensive players to prepare well for the block, and in the 6-meter zone, players use no more than zero or one step.

The aim of the research is to determine the parameters of the performance of the 'zero step' according to rule 7.3.d. of the IHF in an intentional closed experimental environment (test) and an open situational competitive environment (match), in order to assess the value and sustainability of the existing interpretation of the same rule.

The first partial goal is to determine the physical limitations of the rule that interprets the 'simultaneous' landing with both feet on the ground, and then to determine whether there are statistically significant differences in the performance of the closed structure of the 'zero' step between the performance from the initial stance and the take-off, as well as that there is a statistically significant correlation between the anthropological characteristics of the subjects in the difference in time between the contact of the left and right foot with the ground during the performance of the closed structure of the 'zero step' from the initial stance and from the take-off. Another partial objective is to determine whether there is a difference in the outcomes of tied matches based on awarded and non-awarded steps when performing a 'zero' step.

2 METHODS

2.1 Entities

The sample of subjects for evaluating the closed structure of the 'zero step' performance consists of 18 handball players from MRK Kozala, Rijeka, who compete in the 1st Croatian Handball League in the 2023/2024 season, average height (M+/-SD) 186.11+/- 6 ,26 cm, average weight 88.89 +/- 8.98 kg, average BMI 25.60, while the average age is 20+/- 2.59 years.

The sample of entities, which were presented with the open structure of the 'zero step' performance, consists of the performances of the 'zero step' version through the foot jump into the parallel/diagonal stance of the players in 5 matches of the preliminary part of the international competition in which the regular part of the match (60 minutes) ended in a draw

Table 1: Overview of the national teams in preliminary groups after the group stage matches.

gr	rank	team	points	draw
A	1.	France	5	Switzerland
	2.	Germany	4	/
	3.	North Macedonia	2	/
	4.	Switzerland	1	France
B	1.	Croatia	5	Austria
	2.	Austria	4	Croatia, Spain
	3.	Spain	3	Austria
	4.	Romania	0	/
C	1.	Hungary	6	/
	2.	Island	3	Serbia
	3.	Montenegro	2	/
	4.	Serbia	1	Island
D	1.	Slovenia	6	/
	2.	Norway	3	Faroe Islands
	3.	Poland	2	/
	4.	Faroe Islands	1	Norway

2.2 Variables

Basic and derived anthropological characteristics of handball players were measured (BH, BW, BMI, etc.)

A - The difference in time between left and right foot contact with the ground during the execution of the closed structure 'zero step' from the initial stance (s)

B - Time difference between left and right foot contact with the ground when performing a closed structure 'zero step' from take-off (s)

N - Number of performances of 'zero steps' per game in total/per team (n1 - ruled, n2 - not ruled)

O - Expert assessment of the correctness of the judge's assessment of compliance with the rules of the 'open’ competition performance of the 'zero step' version of the foot jump (0/1).

2.3 Protocol

The experimental procedure took place in two phases. The first phase involved slow-motion recording of the

players' task, which included the performance of a 'zero step', while the second phase included a video analysis of the matches of the last European Men's Handball Championship and the registration of a 'zero step' after which no steps were ruled/awarded. The recording protocol took place in the evening after 9 p.m. The content of the warm-up before the recording was through handball games and the players have had one trial attempt for both tasks before the recording. Jump-shot at the goal was performed trough two variables: 1) *from the spot* after a take-off with both legs and catching the passed ball while in flight phase, with simultaneously both feet landing into paralel stance followed by execution of three steps and a one-legged reflection to a jump with one, and 3) the same task *after a short run-up*. The position of the camera was at the level of the surface behind the player. The examinee's position in the first part of the task was 1.5 m behind the 9 m line, while in the second part it will be 3.5 m behind the 9 m line. Duration of the task was between 5-10 seconds and the examinees registered one attempt. The recording frequency was 120 Hz. The analysis of the matches of the European Championship was assessed on 9 matches that ended in a draw result. The analysis was focused exclusively on isolated events involving a parallel or diagonal jump into a 'zero step' and haven't considered situations in which the delegate could have judged. Isolated events were slowed down with slow motion tools and reviewed several times to make the correctness assessment as accurate as possible. An expert evaluation of the correctness of the judge's assessment of compliance with the rules of the 'open competitive performance of the 'zero step' version with a foot jump was carried out to agree on the inclusion of the observed situations in n1 or n2.

In the first shown kinogram (Figure 1) the player took a total of 6 steps without dribbling the ball after 3 steps and the game continued, because the referees started count steps only after jumping to 'zero step'. In the second shown kinogram (Figure 2) we see the phase of jumping into the 'zero step' and preparations for the jump shot. It is clear the difference between the jump of the left and right leg. The task was given, and the player knew what he had to do, and the difference is clearly noticeable in controlled and closed setup, contrary to competitive open environment i.e. matches with a high speed of cutting movement and a short decision time frames.

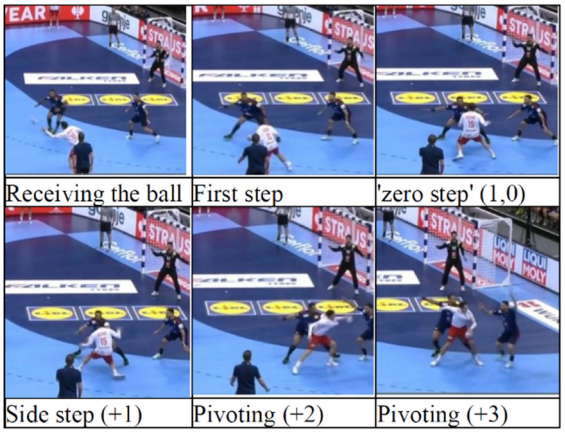

Figure 1: Kinogram - open motor performance program.

Figure 2: Kinogram - closed motor performance program.

Roles when taking steps within the 'zero' step rule are usually divided into three categories: 1) the player who performs (in senior handball, players are expected not to make many technical mistakes, so they are not expected to do more than the allowed three steps, however, there is a *'big compromise*' in which the player takes a step or two and only then jumps with his feet into the zero step, while those steps before the jump go *'under the radar'* for the judges who start counting the steps only after the jump), 2) defensive player in front of the performer (although today there are so-called defence specialists, it is extremely difficult to prevent a player who uses the 'grey zone' and gains an advantage. And 3) those who enforce the rules (referee on the field, line referee, delegate, var system, and competition organization committee).

2.4 Data Processing Method

Microsoft Excel was used to create spreadsheets that were later used for further analysis in the Statistica 14.0.0. program. Descriptive statistics (arithmetic mean, standard deviation, etc.), offered insight into the structure related to the observed sample of subjects (average height, weight and age). Normality of distributions were tested by Kolmogorov-Smirnov test. The t-test for dependent samples was used to determine the differences between variables A and B, while Pearson’s correlation coefficient was used for the influence of anthropological characteristics with variables A and B. Qualitative analyses were used to analyse the matches that ended in a draw, recorded awarded and non-awarded steps during the jump to the 'zero step'.

3 RESULTS

Table 2: Descriptive parameters and correlation.

	AS	SD	MIN	MAX	KS TEST (d)
A	0.28	0.24	0.07	1.09	0.25; p = 0.22
B	0.17	0.09	0.06	0.37	0.18; p = 0.61
BH	186.11	6.26	177	200	0.16; p = 0.77
BW	88.89	8.98	75	102	0.15; p = 0.81
Age	20	2.59	16	24	0.11; p = 0.98

Table 3: Correlations.

	A	B	BH	BW	Age
A	1.00	0.19	0.73*	0.61*	0.14
B	0.19	1.00	0.16	0.37	-0.19
BH	0.73*	0.16	1.00	0.86*	0.15
BW	0.61*	0.37	0.86*	1.00	0.16
Age	0.14	-0.19	0.15	0.16	1.00

*p<0,05

The t-test for dependent samples between variables A and B is t=1.84; df=17; p=0.08.

The interpretation of the results of the conducted analyses can be standardly placed within the framework of two standard levels of statistical inference (99% and 95%), but also one non-standard one (90%) for which the term - tendency to statistical significance will be used in the rest of the paper. Namely - "Type 1 error" (alpha error) refers to the rejection of the hypothesis H0 which is correct (i.e., no differences or influence). Type 2 error is reversed (beta error), and refers to the acceptance of the hypothesis H0, which is not true. In various medical studies whose results may have consequences for the quality of human life or human life in general, the level of significance is significantly lower than the standard (even p<0.001 and less). On the contrary, if it is a procedure that is not expensive and dangerous, and could have a positive impact on a certain situation, it can be operated with milder criteria (0.05, and even 0.10 and 0.20)" (in Gruić , 2011, according to Kolesarić, Petz, 1999). Therefore, in this case too, p<0.08 should be linked to the analysis of sample size and statistical power (0.59 for n = 18; and 0.80 for n= 31). With very large dispersions, e.g., SD in variable A almost as AS, the power and level of statistical inference and generalization are satisfactory.

Table 4: Qualitative analysis of handball matches from the European Championship 2024 with Result ‘X’ (draw).

x	n1	n2
1	6	3
2	1	0
3	6	4
4	3	1
5	2	0

4 DISCUSSIONS

There are physical limitations of the rule 7.3.d. that interprets the 'simultaneous' landing with both feet on the ground, there are statistically significant differences in the performance of the closed structure of the 'zero step' between the performance from the initial stance and the take-off. There is a statistically significant correlation between the anthropological characteristics of the subjects in the difference in time between the contact of the left and right foot with the ground during the performance of the closed structure of the 'zero step' from the initial stance, as well and after a run-up. There is a difference in the occurred and expected outcomes of tied matches based on awarded and non-awarded steps when performing a 'zero step’.

Qualitative analysis proved that a different end result would affect the further course of the competition, i.e., a different order on the table and thus the transition from the preliminary to the main stage of the competition. In preliminary phase (tables 1 and 4), in matches that ended in a draw, e.g. between:

a) France and Switzerland - the expert assessment concluded that due to the undecided steps after the 'zero step', France was more damaged (although, if the outcome had been different, rank on the table would

not have changed much as far as these two teams are concerned).

b) Croatia and Austria different outcome may have occurred - one situation in which Austria was not awarded steps after the erroneous 'zero step'. If the outcome had been different, Croatia could have taken one more point, thus having 6 points at the end of the group stage and transferring 2 points to the next stage of the competition, while in this way they transferred 1 point due to the draw with Austria.
c) Spain and Austria - no unjudged steps were found during the performance of the 'zero step'. However, if Austria have had lost from Croatia, the situation on the table would have been different, and in that case, Spain would have had the same number of points as Austria.
d) Iceland and Serbia - Serbia was ‘damaged’ by the number of unjudged technical errors due to the islander’s performance of the 'zero step', and the outcome could have been different. If that had been the case, Serbia would have taken one more point, while Iceland would have had one less point, and Iceland, Montenegro and Serbia would have tied on points.
e) Norway and Faroe Islands - analysis did not find referee errors during the performance of the 'zero step', so the final standings on the table would not change.

Although, during the analysis of the match, not all situations were monitored, jumps on one leg were not included in the analysis, which is also considered a 'zero step', but only situations with jumps on two legs were analysed. Mathematically, different scenarios could have happened where in Group B Spain could have passed to the main stage if it had beaten Austria, and then Croatia would have transferred 2 points instead of 1. A situation in which the team that goes on would be decided according to the point difference and the mutual ratio was in group C where Serbia would be decided according to goal difference and mutual ratio to Montenegro and Iceland, who would go further. In that case, Serbia, which would have the smallest goal difference, would have the most likely situation to advance. There were no draw results in groups E and F, so the final result on the table based on the analysis of the referee's errors would not change.

Limitations of the research. One of the limitations is the impossibility of ad-hoc calculation of statistical power and determination of the sample size because there are no previously comparable studies on this topic, and in this study a post-hoc statistical power of p=0.59 was determined for a sample of N=18. Mathematically, there could have been more result scenarios, but in this paper the focus was on the 'zero step' and the scenarios that resulted from referees' mistakes during unjudged steps after the 'zero step'. Although ‘tendency to statistical significance’ is not a term that the 2016 ASA statement would recommend, this reference should, within broader perspective (when using a larger sample in the experiment), added value to the understanding of related phenomena should focus on all matches, not just those that ended in ‘draw’.

Future research on this or a topic similar to this can study the referee's perception and how much the referee's 'eye' is ready to follow the course of the situation, that is, how much the seen situation and the speed of decision-making affect the further course of the attack so that the action of action is as effective as possible when making decisions and so that these rules would not call into question the passing of the group stage, or the winner of the competition.

5 CONCLUSIONS

The obtained results confirmed that it is physically and mathematically impossible to land on the ground with both feet at the same time. The rule of "zero step" due to the perceptive barriers, insufficient attention when counting steps, or simply due to difficulties to see the leap - leads to a ‘grey zone’ in handball game where numerous outcomes are ignored, which from a mathematically proven rule can lead to an unfair result, and even not advancing to the next stage of the competition. This all leads to numerous controversies between referees, delegates, coaches, players and the audience where big mistakes are allowed. Despite the advanced technology (VAR), if this rule is not changed, the benefits resulting from the jump will continue to be used (more steps than allowed, changing the tactics of the game, inability to place a defender). The analysis of matches has often seen situations in which players take a step or two before leaping into the 'zero step', where the referees do not see it or do not address attention to that part, so the steps start to be counted only after jumping to 'zero step'. We can call such situations a 'big compromise' where judges are focused on correct execution of steps and players at a high level of competition are expected not to make such mistakes.

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