ATTACKING PERFORMANCE ANALYSIS DURING 2-MINUTE SUSPENSIONS IN FEMALE HANDBALL GAMES AT THE RIO 2016 OLYMPIC GAMES

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Abstract:

The aim of this study was to analyse the effect of the IHF 2016 rule change on attack efficacy during the different numerical asymmetry scenarios associated with 2-minute suspensions at the Rio 2016 OG. A total of 328 exclusion scenarios that were sanctioned during the 38 matches played at the Rio 2016 OG female handball tournament by 12 national teams were analysed using observational methodology. Chi-square test was applied to identify associations between the variables. Chi-square automatic interaction detection trees (CHAID) were used to identify which attacking performance variables during exclusions were associated with the different types of numerical asymmetry (superiority, inferiority with the goalkeeper at goal and inferiority with the empty net). Results during contexts of superiority showed that scoring in 58.0% of the total attacking finalizations (i.e., attack efficacy) ($p<.001$; ASR 8.2); playing fast transitions ($p<.001$; $x^2 = 17.692$) and using a 2:4 (with two pivots) offensive system were predictors of the attacking performance of the teams. Substitution of the goalkeeper for a court player during inferiority context was a predictor for teams ranked 9 to 12 and also for those playing for medals ($p<.001$; $x^2=26.590$) but conceding, as a consequence of their finalizations, a counterattack ($p<.001$; $x^2=112.107$). Despite teams showing similar attacking performance during numerical superiority compared to previous studies, findings in this study revealed a tendency for empty goals during numerical inferiority context. Coaches should therefore consider training retreat strategies when playing without a goalkeeper when faced with a numerical disadvantage.

Keywords: *exclusions, numerical inequality, empty goal, classification tree, offensive performance in elite handball*

Introduction

Analysts and coaches are using performance indicators (PIs) to assess team and athletes' performance, which enables them to assess their trainees quality of performance (Hughes & Bartlett, 2002). Performance analysis seeks to quantify sports performance (O'Donoghue, 2010), and can consider, for example, combination of physical, technical, or tactical parameters during competition (Rein & Memmert, 2016). Data collected during competition are relevant, as they allow for coaches to model and subsequently adapt athletes' performance (Franks & Goodman, 1986) according to training and match interventions (Prieto, Gomez, & Sampaio, 2015a).

Factors influencing players' performance are not easy to identify, particularly when considering

complex and multifactorial team sports like handball (Wagner, Finkenzeller, Wurth, & von Duvillard, 2014). Notational analysis allows researchers to analyse the competition from an ecological view (Vilar, Araújo, Davids, & Button, 2012) that considers dynamic and complex systems, including individual and collective decision-making under different contexts (Araújo & Davids, 2016; Ortín, Olmedilla Zafra, & Lozano Martínez, 2003) in team sports (García Ordoñez & Touriño González, 2021; Gómez-Ruano, Serna, Lupo, & Sampaio, 2016; Low, et al., 2020; Prieto-Lage, et al., 2023). In handball, approaches have considered the type of competition (Bilge, 2012; Hansen, et al., 2017; Saavedra, Thorgeirsson, Chang, Kristjansdottir, & Garcia-Hermoso, 2018); a descriptive analysis of best-ranked teams (De Conti-Texeira, et al., 2017; Hansen, et al., 2017); and finally, attempting to discriminate winning from losing teams (Ferrari, Dias, Sousa, Sarmento, & Vaz, 2020; Þorgeirsson, et al., 2022a). However, academic advances in women's handball are less than in male handball (Wagner, et al., 2019). In particular, research on anthropometric parameters (Moss, McWhannell, Michalsik, & Twist, 2015; Rios, et al., 2023) and relative age effect (Bjørndal, Luteberget, Till, & Holm, 2018; Ferragut, Vila, Fernández, & Saavedra García, 2021; Rubia, et al., 2020) was done. Match analyses, studies comparing men's and women's performance indicators (Gómez-López, Rivilla-García, González-García, Sánchez-López, & Angosto, 2023; Þorgeirsson, et al., 2022a, 2022b) and analyses of only women's tournaments (de Paula, et al., 2020; Karalić, 2020; Trejo-Silva, Feu, Camacho-Cardenosa, Camacho-Cardenosa, & Brazo-Sayavera, 2022; Trejo-Silva, Gomez-Ruano, Feu, & Brazo-Sayavera, 2023; Yamada, Aida, Fujimoto, & Nakagawa, 2014) have been developed in recent years.

Gréhaigne (1991) indicated that team sports can have three categories of problems, relating to: i) space and time; ii) information; and finally, iii) the organization. In the latter, one player may deal with issues related to his/her behaviours in coordination with teammates, needing a constant adaptation to constraints brought by the dispute on the court. Actions that affect the numerical balance in the number of players on the court are seen as one of these constraints. Previous studies considering temporal numerical inequalities in team sports such as water polo (Bernardi, Davis, Graham, & Mayberry, 2022; Canossa, et al., 2022; Gómez-Ruano, et al., 2016; Sabio Lago, Argudo-Iturriaga, Guerra-Balic, & Cabedo-Sanromà, 2021), futsal (Gomez, Mendez, Indaburu, & Travassos, 2019), and ice hockey (Bedford & Baglin, 2009) have shown the importance of analysing these scenarios of the games. In handball, players' exclusions as a consequence of a 2-minute suspension generate a temporal numerical inequality in the on-court number of players, leading to two numerical asymmetry contexts (superiority context: the attacking team has at least one player more than the opponent; inferiority context: the attacking team is outnumbered by at least one player), these moments being a situational context of research. Attacking while suffering an exclusion needs a reorganization of the technical–tactical aspects in order to afford the limited number of players (Pueo & Espina-Agullo, 2017). Previous studies revealed that a team's performance during superiority and inferiority affects the final result of a match (Saavedra, Þorgeirsson, Kristjánsdóttir, Chang, & Halldórsson, 2017; Schucker, Hagemann, & Strauss, 2013; Trejo-Silva, A. Camacho, M. Camacho, González-Ramirez, & Brazo-Sayavera, 2020). Despite the fact that some studies have analysed the relationship between final outcome and final ranking in the number of exclusions, research about performance during 2-minute suspensions is scarce (Oliveira, Gomez, & Sampaio, 2012).

The Rio 2016 Olympic Games (OG) was the first tournament played under the new rule scenario, which allows the sanctioned team to substitute the goalkeeper (GK) with a field player, playing then with an empty goal (EG) (IHF, 2018). These changes in handball rules may affect the context of exclusions. Krahenbühl, Sousa, Leonardo, and Costa (2019) have studied the effect of playing inferiority attacks with EG in this new context during the knockout stages of the male Rio 2016 OG tournament. Results showed that changing the GK for an on-court player did not affect the attacking efficacy. Despite playing with EG during inferiority can be seen as a rule that goes against the "spirit of the game" and basic principles of teaching the game (Antón, 2019, p. 306), coaches have declared to use it the most in the intention to maintain numerical balance in inferiority situations (Krahenbühl, Menezes, & Leonardo, 2019). In addition, Krahenbühl, Pereira, Pombo-Menezes, Amazonas, and Leonardo (2021) confirmed this statement at the 2017 female World Championship (WCh) where teams often substituted the GK with a court player to maintain numerical symmetry. Therefore, in order to test the offensive performance during this specific context, the analysis from a multivariate approach is required (Gómez, Moral, & Lago-Peñas, 2015).

Assuming that this new numerical relationship scenario would be of interest to both coaches and academics, studying the performance during 2-minute suspensions in an elite female tournament would be needed. Thus, the aim of the present study was to analyse the effect of the IHF 2016 rule change on attack efficacy during the different numerical asymmetry scenarios associated with 2-minute suspensions in the female handball tournament at the Rio 2016 OG.

Methods

Sample

The inter-sessional sample consisted of all exclusions (n=328) sanctioned during the total number of matches (n=38) played at the Rio 2016 OG women's handball tournament. The intra-sessional sample consisted of every attack finalization during those 2-minute suspensions' offensive sequence, which involved numerical asymmetry in the court players' relationship. Antúnez, García-Rubio, Sáez, Valle, and García-Martín' (2013) definitions of the offensive sequence were considered. It was determined from the instant when one team recovers or gets possession of the ball until one of the following occurs: a) the opposite team gets possession; b) the team in possession of the ball gets to make a valid throwing, and immediately after regains ball possession or must restart the game from the side-line. Every attacking action of the game executed while at least one exclusion has been previously sanctioned was observed and registered. No attacking action was registered after a 2-minute suspension was sanctioned during the time of the previous exclusion. Actions that happened while both teams had the same number of court players (i.e., 6 vs 6, 5 vs 5, or 4 vs 4), and GK at goal, were not registered. No attacking sequence was registered when once the 2-minute exclusion time ended.

Instrument

Observational methodology procedures were followed for collecting data (Chacon-Moscoso, et al., 2018). An *ad-hoc* instrument consisting of a combination of field format and category systems was created. Criteria and their respective categories respected exhaustiveness and mutual exclusivity in the system of categories (Table 1). Categorical cores (n=60) and their corresponding register codes were generated and grouped into eight criteria (team, game time, type of asymmetry, match status, game phase, offensive system, finalization, and consequence of the finalization).

Procedures

The research team reviewed game footage and collected the data using the Lince 1.2.1 software (Gabin, Camerino, Anguera, & Castañer, 2012). The steps to verify the quality of the data followed Anguera and Hernández-Mendo (2014) indications. Five experts (all of them coaches with a minimum of 10 years of experience at a club level and at least one experience as a national coach; three of them with postgraduate qualifications) received a questionnaire and arrived at a 95% of agreement. Intra- and inter-observer reliability concordance was verified using Cohen's Kappa coefficient (Cohen, 1960) obtaining values rated as very good ($K \geq 0.89$). The game outcome (winner, loser, draw) and the final ranking of the teams (1 to 12) were directly inserted in the registration sheet, being part of the studied variables. Teams were grouped into three groups: teams ranked 1st to 4th; teams ranked 5th to 8th, and teams ranked 9th to 12th. Finalizations were clustered into three groups: i) Goal (finalizations registered as G [goal] and GE [goal and exclusion in the same action]); ii) No goal (finalizations registered as P [throws on post], S [goalkeeper's save], B [throws blocked by defenders]), Out (throws wide or high, neither post nor goalkeeper's save), and iii) Turnovers (finalizations registered as I [defender intercepts a pass], BP [error in passing the ball, not get by the defender], or RTE [regulatory or technical error]). Types of numerical asymmetry were gathered in three groups: i) Superiority (all finalizations registered as 6 vs 5, 5 vs 4, or 6 vs 4); ii) Inferiority with the goalkeeper at goal (GK at goal) (all finalizations registered as 5 vs 6, 4 vs 5, or 4 vs 6 and the team kept their GK at goal), and iii) Inferiority with empty goal (Empty goal) (all finalizations registered as 5 vs 6, 4 vs 5 or 4 vs 6 and the team played with EG). Game time, based on previous studies which found critical moments of the game for the exclusions being sanctioned (Prieto, et al., 2015b; Trejo-Silva, et al., 2020), was grouped into two groups: Critical moments (game time 2,4,5) and Non-critical moments (game time 1,3,6). Ethical principles established in the Helsinki Declaration (WMA, 2013) were followed.

Statistical analysis

Crosstabs command between the type of asymmetry (superiority, inferiority played with GK at goal and inferiority played with EG) and contextual indicators (game outcome, finalization, consequence of the finalization, phase of the game, offensive system, game time, match status, final ranking grouped in three groups) was used to study the relationship among them. Pearson's Chi-square test was performed. First, the effect size (ES) and the independence of the variables' cross-section were analysed via Cramer's V test and adjusted standardised residual (ASR; critical value = 1.96 and $p=.05$). When the expected frequency distribution was lower than 5 or the count of cases in one cell was lower than or equal to 5, Fisher's exact test was applied (Field, 2013). Secondly, an exhaustive CHAID (Chi-squared automatic interaction detection) classification tree analysis was used to determine the differences between the performance in the three types of numerical asymmetry and contextual indicators. All analyses were run using SPSS (v25, IBM, Corp., Armonk, NY, United States) statistical software package. A statistically significant relationship was established when $p<.05$ (confidence interval set at 95%).

Table 1. Observational tool to analyse offensive actions during 2-minute suspensions at the Rio 2016 OG female handball

Criterion	Categories	Categorical core
Team	RUS, FRA, NOR, NED, BRA, SPA, SWE, ANG, ROM, KOR, MNE, ARG.	In order of final ranking, from 1st to 12th: RUS: Russia; FRA: France; NOR: Norway; NED: Netherlands; BRA: Brazil; SPA: Spain; SWE: Sweden; ANG: Angola; ROM: Romania; KOR: South Korea; MNE: Montenegro; ARG: Argentina.
Game time	T1 T2 T3 T4 T5 T6 T7 T8	Minute 0 to 9:59 Minute 10:00 to 25:59 Minute 26:00 to 30:00 Minute 30:01 to 39:59 Minute 40:00 to 54:59 Minute 55:00 to 60:00 First period of extra time Second period of extra time
Match status	≥5, 4, 3, 2, 1 0 ≤5, -4, -3- 2, -1	Observed team leads by 5 (or more), 4, 3, 2 or 1. Teams are tied when behaviour is registered Observed team is down by 5 (or more), 4, 3, 2 or 1.
Type of asymmetry	6x5, 5x4, 6x4 5x6, 4x5, 4x6 EG	Numerical superiority of 1 or 2 players. Inferiority of 1 or 2 players with GK at goal Inferiority of 1 or 2 players with empty goal
Game phase	FB CA PA 7M	Fast break attack (1st wave) Counterattack (2nd and 3rd wave) Positional attack 7m throw
Offensive system	3:3 3:3 (2) 2:4 3:2 (0) 3:2 (1) NS	3:3 with 1 pivot and 2 wings 3:3 with 2 pivots and 1 wing 2 backs, 2 pivots, 2 wings 3 backs, no pivot, and 2 wings 3 backs, 1 pivot and 1 wing No system (counterattacks and 7m throws)
Finalization	G P S Out B GE I BP RTE	Goal Throw on post Goalkeeper's save Throw wide or high (not post, not goalkeeper's save) Throw blocked by a defender Goal and exclusion (in the same action) Defender intercepts a pass Error in passing the ball (not get it by a defender) Regulatory or technical error (attacking foul, double dribbling, steps, error while changing players, other sanctions)
Consequence of the finalization	NC CNG CG	Observed team concedes no counterattack Observed team concedes counterattack but no goal Observed team concedes goal via counterattack

Results

A total of 1.065 actions during the 328 exclusions sanctioned in 38 games were registered, resulting in an average of 8.6 ± 3.6 exclusions per game. A total of 590 actions were registered under the superiority context and 475 under inferiority. Playing with EG represented 35.0% of the total actions registered during the inferiority context and playing with GK at goal represented 65.0%. Table 2 presents the frequency distribution of attacking situations in numerical asymmetry contexts. The game outcome, finalization, consequence of the finalization, game phase, and offensive system presented a statistically significant relationship with the type of asymmetry. Winning teams presented a statistically significant relationship ($p<.05$; ASR -2.0) to not playing with EG during inferiority contexts. Attack efficacy (AE), which reached a level of 58.0% during the superiority context, showed the strongest statistically significant relationship to all finalizations ($p<.01$, ASR 8.2 and 2.1). AE when playing with EG was 37.5% and with GK at goal 30.3%. Turnovers (26.7% during GK at goal and 25.6% during EG) showed a statistically significant relationship ($p<.01$, ASR 3.6 and 2.1). In addition, being sanctioned with a 7m throw for, and playing 1st, 2nd and 3rd wave phases of the attack were statistically significantly related ($p<.01$; ASR 8.1, 2.9, and 7.9) with the context of superiority. The positional attack presented a statistically significant relationship ($p<.01$; ASR 7.1) to the context of inferiority. Using the 3:3 (with one pivot) offensive system appeared with a statistically significant relationship, specifically during the context of playing with EG under inferiority situations ($p<.001$; ASR 8.0).

Table 2. Frequency distribution of offensive situations under inequality during the Rio 2016 Olympic Games

	Superiority *n* = 590		GK at goal *n* = 307		Empty goal *n* = 168		x^2	p	ES	ES p
	(%)	ASR	(%)	ASR	(%)	ASR				
Game outcome							17.250	<0.05	0.90	<0.05
Winner	48.6	*0.7*	49.8	*0.9*	40.5	-2.0				
Loser	47.8	*-0.6*	48.9	*0.1*	51.2	*0.7*				
Draw	3.6	*-0.2*	1.3	*-2.6*	8.3	*3.5*				
Finalization							70.634	<0.01	0.18	<0.01
Goal	58.0	*8.2*	30.3	*-6.9*	37.5	*-2.6*				
No goal	27.6	*-4.5*	43.0	*4.2*	36.9	*1.0*				
Turnover	14.4	*-4.9*	26.7	*3.6*	25.6	*2.1*				
Consequence										
No counter attack	94.4	*13.8*	61.9	*-8.6*	55.4	*-8.1*	197.474	<0.01	0.35	<0.01
Counter attack no goal	3.2	*-9.2*	21.2	*6.6*	20.8	*4.3*				
Counter attack goal	2.4	*-9.2*	6.9	*4.8*	23.8	*6.5*				
Game phase							161.039	<0.001	0.28	<0.001
Positional attack	56.1	*-12.1*	87.6	*7.5*	94.0	*7.1*				
1st wave	8.6	*2.9*	6.5	*-0.1*	0	*-3.8*				
2nd and 3rd wave	14.2	*7.1*	2.6	*-4.5*	0.6	*-4.1*				
7 meter	21.0	*8.1*	3.3	*-6.2*	5.4	*-3.3*				
Offensive system							357.739	<0.001	0.58	<0.001
3:3_1_Pivot	61.4	*-3.1*	58.3	*-3.1*	92.3	*8.0*				
2:4_2 Pivots	5.1	*5.0*	0	*-3.5*	0	*-2.4*				
3:2_No Pivot_1wing	0	*-11.2*	29.3	*15.3*	1.2	*-3.7*				
3:2_1 Pivot_1 wing	0.0	*-3.4*	2.6	*5.0*	0	*-1.0*				
No system	33.6	*9.8*	9.8	*-6.3*	6.0	*-5.6*				
Final ranking										
1st to 4th	94.4	*1.8*	61.9	*-2.0*	55.4	*0.1*	28.600	<0.01	0.12	<0.01
5th to 8th	3.2	*-3.4*	21.2	*5.2*	20.8	-1.8				
9th to 12th	2.4	*1.5*	6.9	*-3.0*	23.8	*1.7*				
Match status							0.657	>0.05	0.02	>0.05
2 goals	46.8		48.9		48.8					
3-4 goals	28.0		28.0		27.4					
5 or more goals	25.3		23.1		23.8					
Game time grouped							0.453	>0.05	0.02	>0.05
Periods 2,4,5	75.9		77.5		75.0					
Periods 1,3,6	24.1		22.5		25.0					

Note: Data presented as absolute frequencies (percentage). ES: effect size (Cramer's V for asymmetric tables and contingency coefficient for symmetric tables); ASR: adjusted standardized residual, calculated only for those variables that presented a statistically significant relationship (p<.05).

Figure 1 shows the decision tree model results (exhaustive CHAID) predicting the attacking performance during exclusions according to the type of asymmetry. The model presented an estimation of 94.7% for superiority, 40.1% for inferiority with GK at goal, and 35.7% for inferiority with EG (69.7% of the variance; estimated risk 0.30; SD 0.14). Specifically, Node 6 predicted that the transition phases (2nd and 3rd waves) and positional attacks were the main phases that predominated in superiority contexts (p<.001; x^2=17.692) followed by the 1st wave (Nodes 5 and 7). In addi-

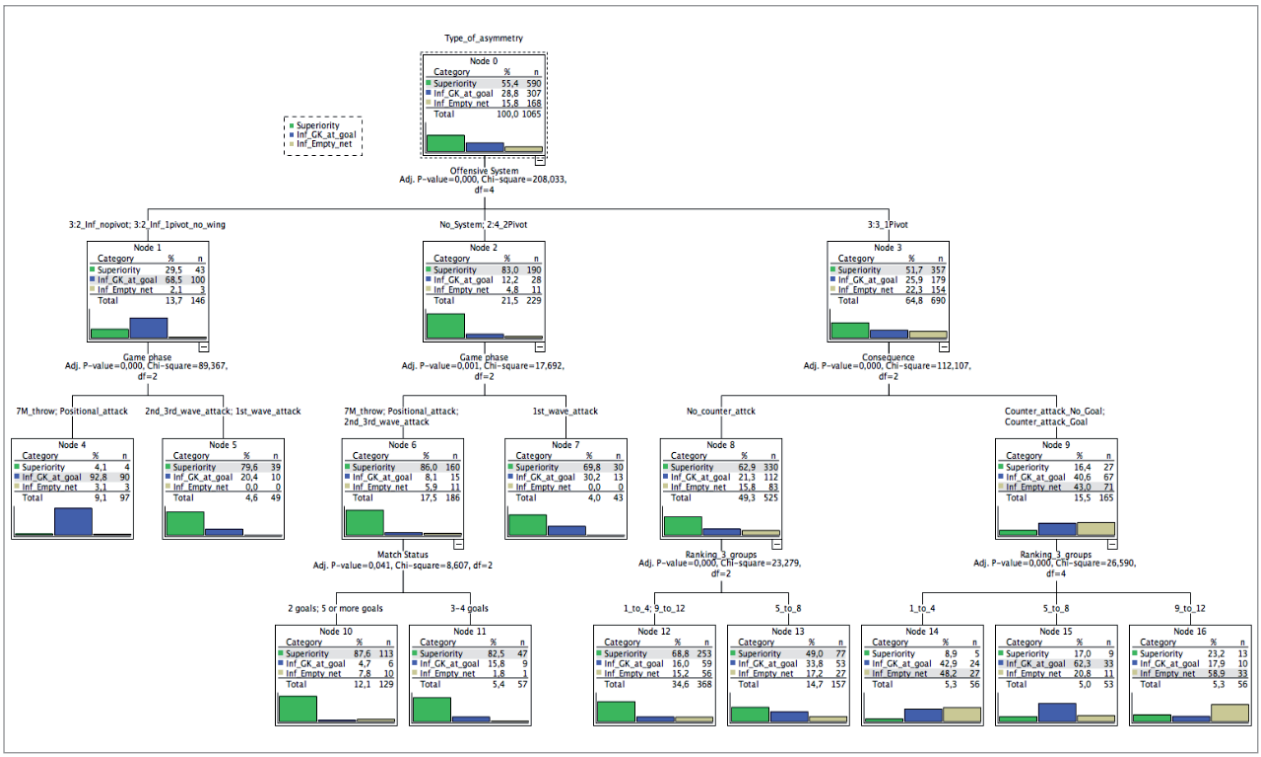

Figure 1. Exhaustive CHAID decision predicting the offensive performance during numerical asymmetry as a consequence of exclusions according to types of asymmetries.

tion, Node 2 predicted teams using a 2:4 offensive system and the use of NS, while Node 3 predicted the use of the 3:3 classic formation within the context of superiority ($p<.001$; $x^2=208.033$). Moreover, Node 4 predicted that the positional attack was the phase used the most when playing with GK at goal ($p<.001$; $x^2=89.367$). Moreover, Node 1 predicted that the offensive system with three backcourt players (3:2[0] with no pivot and 3:2[1] with one of the wings moving to the pivot position) was the preferred form when leaving the GK at goal during the inferiority context ($p<.001$; $x^2=208.033$). However, in the same numerical asymmetry context of inferiority, node 16 predicted that teams ranked 9 to 12 tend to play with EG ($p<.001$; $x^2=26.590$) but conceded, as a consequence of their finalizations, a counterattack (node 9; $p<.001$; $x^2=112.107$). Lastly, Nodes 14 and 16 predicted a similar use of the EG strategy for those teams playing to win a medal as opposed to those placed at the bottom of the ranking ladder.

Discussion and conclusions

This study aimed to analyse the effect of the IHF 2016 rule change on attack efficacy during the different numerical asymmetry scenarios associated with 2-minute suspensions at the Rio 2016 OG women's handball tournament. Findings in the present study showed that 8.6 ± 3.6 exclusions per game were sanctioned, meaning that around 17 minutes out of 60 were played either in numerical superiority or inferiority. Those results are similar to previous studies which found that around 30% of the game time is played under numerical asymmetries as a consequence of exclusions in elite handball matches of OG (Saavedra, et al., 2017) and Panamerican Games (PPGG) (Trejo-Silva, et al., 2020). However, exclusions at women's handball occurred to be slightly fewer than in men's handball, coinciding with previous studies where hostile aggression appeared to be more frequent in male than in female competitions; indeed, the upper the level the higher the difference (Coulomb-Cabagno & Rascle, 2006). This could be due to the difference in the criterion used by referees of male and female tournaments at the moment of sanctioning with exclusions those situations where the use of strength in one-to-one situations is evaluated, as found in previous studies in invasive team sports (Zhang, et al., 2022).

When a team is sanctioned with an exclusion, they are facing a numerical disadvantage for a period of time with the opposite team having possession of the ball in order to restart the game (an exception is when game time is stopped). Since finalization actions were collected solely during moments when an exclusion had been sanctioned in a match, the first finalization in each exclusion scenario corresponded to a team playing in a superiority context. This led to 55.4% of all actions occurring in the superiority context and 44.6% in the inferiority context. Recent studies have confirmed these differences in the number of possessions across both

contexts of numerical asymmetry (Ferrari, et al., 2022). In competition contexts, psychological crises during certain moments or situations of the game are associated with exclusions or dismissals (Bar-Eli, Tenenbaum, & Elbaz, 1990; Bar-Eli & Tractinsky, 2000). However, players tend to have control over their actions and attitudes in order not to be excluded in balanced games (Bar-Eli, et al., 1990; Bar-Eli & Tractinsky, 2000; García-Martín, Argudo Iturriaga, & Alonso Roque, 2015). This body of research may explain why losing teams tend to play in inferiority during imbalanced contexts (namely when the difference in the score was five or more goals).

Context of superiority

Key Performance Indicators (KPIs) are often used in handball, examples include AE, Throwing Efficacy (TE), Turnovers, Throwing Position on the Court, and GK Saves. However, the relationship of KPIs with other contextual factors is limited, as well as when studying other collective aspects of the game. In particular, transitions can be performed in two main ways: a "fast-break" or the 1st wave of a counterattack and a "collective fast-break" or "2nd and 3rd waves". In both, the intention is to create and use open spaces and quick actions to throw from the 6m line, relying on players' quality and strategic spatial distribution. The offensive system aims to distribute players in the space using a 3:3 setup with one pivot or 2:4 (with two pivots), fundamentally during set (or the so-called positional) attacks.

During superiority situations and when playing positional attacks, teams may choose to keep a balanced use of the depth and width of the court (using the 3:3 with one pivot offensive system) or locate more players near the 6m line, getting then a deeper use of the court (the 2:4 offensive system). The classification tree model linked the 2:4 system with the positional attack, and having no system with 7m throws and collective fast-break (2nd and 3rd waves). Therefore, it may be argued that teams preferred to play fast transitions rather than set-piece attacks during superiority. They tried to use this numerical advantage in order to position players in a better situation for scoring (that is to say near the 6m zone), facing a duel with an advantage against the GK, coinciding with previous research made on female elite handball in the same numerical context (Amatria, Lapresa, Martín Santos, & Pérez Túrpin, 2020). It is also corroborated by Lozano, Camerino, and Hielino (2016) who state that the favourable situations for attackers that appear on 1st wave counterattacks entail scoring or optimal selection of throws from 6 metres. On the other hand, when playing positional attack, the tactical option of playing with two pivots (again intending to throw via easy breakthroughs, from pivot's, or wing's positions with a higher throwing angle) was the one that prevailed in this numerical context. Particularly, performance at the 2010 female Euro tournament showed that winning teams realized more counterattacks than losing teams where wings and pivots increased their participation between 70% and 76%, improving the AE in those phases (Ohnjec, Vuleta, Dizdar, & Milanovic, 2015).

All these facts can support the high level of AE (58.0%); indeed, scoring (among all types of finalizations selected in this research) was the type of finalization that had the strongest statistically significant relationship to both contexts (superiority and inferiority). Results in these specific contexts are sustained by a required aspect of the game which is to locate a player in open and clear situations allowing them to throw, heavily related to the concepts of depth and throwing's angle (Laguna, 2019, pp. 55-56). It could also be pointed out that, despite throwing from the 6m line led to better TE than from the 9m line (Gómez-López, et al., 2023; Hatzimanouil, 2019; Piovesan, Geremia, Luz, Pombo-Menezes, & Saravia, 2020), teams tried to throw from this zone of the court. The tactical intention of throwing from the 6m zone in superiority is also highlighted by Sierra-Guzmán, Sierra-Guzmán, Sánchez Sánchez, and Sánchez Sánchez (2015) when studying the performance of the Spanish national team at Euro 2012 and 2014 and finding that transforming one of the back players to the pivot position was one of the main means of playing superiority.

AE obtained during the superiority context was higher than in previous studies in female Pan American Games (Trejo-Silva, et al., 2020). AE could also be affected by an increase in the TE as a consequence of the quality and characteristics of players (Wagner, et al., 2014); then by the throwing distance (the closer the throw, the higher the TE) and the relation to the type of throw (Tuquet, Lozano, Antunez, Larroy, & Mainer-Pardos, 2021); by the improvement of the players' strength which is directly related to the success of the throws (De Conti, et al., 2020) as well as the throwing skill (variable and adaptive) of players (Vila, Zapardiel, & Ferragut, 2020).

Context of inferiority

The AE can be considered a KPI due to its association with the overall attacking performance of a team. Results at the Rio 2016 OG showed that performance during the inferiority context was negatively affected since AE presented a reduction from 58% in the superiority context, to 37.5% during EG and to 30.3% with GK at goal. The statistically significant findings of turnovers as a consequence of poor handling of the possession affected the chances of scoring during the numerical disadvantage context. The set-piece was the game phase that presented a tendency to be used by teams playing at a numerical

disadvantage at the Rio 2016 OG, adopting preferably a 3:2 offensive system (with no pivot or with one pivot and without one wing) leaving their GK at goal coinciding with Antón (2010). Despite being a game phase where speed of the plays is slower than in the transition phase, the mishandling of the ball (registered at levels of 25% or higher) affected negatively the AE. These results of turnovers and AE are similar to the findings in the 2007 to 2017 female world championships (de Paula, et al., 2020).

The handball tournament at the Rio 2016 OG was the first tournament where a player (wearing a court player outfit) could substitute the GK at any moment of a match. This change of the rules allows teams sanctioned with an exclusion to equalize (or even reduce in case they have more than one player excluded) the numerical asymmetry of players in attack. Coaches have stated that the main use of this new rule is under this context of inferiority so that they can play in *numerical equality* (Krahenbühl, Menezes, et al., 2019) but leaving EG. The use of this strategy (35.0% of the total in the context of inferiority) represented an increment from previous international tournaments played before (Beiztegui-Casado, Oliver-Coronado, & Sosa-González, 2019; Trejo-Silva, et al., 2020). Results showed that female teams at the Rio 2016 OG started to explore the effect of the change in the rules related to GK substitution, mainly during exclusion contexts.

The CHAID model, however, revealed that lower-ranked teams employed this strategy with statistically significant frequency. Given that these weaker teams need to enhance various aspects of their performance to achieve better outcomes, leveraging the element of surprise could explain their frequent use of the (EG) strategy during the championship. Previous research in futsal, a sport that also permits the substitution of the goalkeeper with a field player, supports this finding (Mendez, Goncalves, Santos, Ribeiro, & Travassos, 2019). Additionally, teams competing for medals at the Rio 2016 Olympics displayed a similar tendency to use the EG tactic, consistent with studies indicating that higher-ranked teams strategically employ the goalkeeper substitution as a surprise element in closely contested games (Gómez, et al., 2019). Interestingly, the results of this study differ from those observed in the men's tournament at the Rio 2016 Olympics, where 86.7% of inferiority actions in the knockout stages were played with the EG tactic (Krahenbühl, Sousa, et al., 2019). Indeed, some studies suggest that male team coaches are more inclined to employ this tactic compared to female team coaches (Krahenbühl, Menezes, et al., 2019). The occurrence of counterattacks (ending in goals scored or not) was the consequence of the finalization that appeared the most when playing with EG during the inferiority context. This tendency showed that teams playing with EG are more likely to concede fast transitions immediately after their finalization, whether they have succeeded in scoring or not. Similar results were found for men's handball clubs competitions (Gümüs & Gençoğlu, 2020). This could be due to poor decisions taken by attacking players when attempting to keep longer possession of the ball (Korte & Lames, 2019), reflected in having the ball intercepted or not being able to throw (Prudente, Cardoso, Rodrigues, & Sousa, 2019). Finally, it can be argued that coaches at the Rio 2016 OG opted to start exploring maintaining the equality of court players during inferiority in attack, even though they took the risk of leaving the EG while their players developed individual and collective actions in this new offensive game structure (Musa, et al., 2017).

Some limitations were identified in this research and need to be addressed in further research: i) the different zones where final actions (throws or turnovers) occurred; ii) the level of opposition (whether the attacking player was facing no defender or a certain degree of defense action); iii) include other tournaments to have a longitudinal perspective; and iv) analyse the influence of unequal scenarios of play different than the 2-minute exclusions on team's effectiveness and the game outcome. Upcoming studies may consider those variables, especially considering the EG rule's impact on the game throughout the last Olympic games (2016-2020-2024) as well as continental or world championships. Addressing coaches' and players' opinions might be also an important input to get a deeper knowledge of the exclusion context in handball matches.

In conclusion, during the Rio 2016 OG handball tournament, playing with EG reached 35% of the total actions registered during inferiority, being a predictor of a tactical predictable factor for teams ranked 9 to 12 but also for those teams playing for winning a medal. However, teams playing with EG conceded, as a consequence, more counterattacks from their opponents. Moreover, the AE when using this strategy was higher than playing with GK at goal (37.5% vs 30.3%). Additionally, 2:4 (with two pivots) was the offensive system associated with superiority context, as well as the use of fast transitions via 1st, 2nd, and 3rd waves.

Coaches may consider the results of this study to develop team game solutions affecting their player's actions. Either during games or training sessions, focused on the numerical asymmetry (during exclusions scenarios), and especially when training to play inferiority situations with EG, given that teams tend to concede counterattacks immediately after the ball possession ended.

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