



Non-linear Pedagogy in Handball: the Influence of Drill Constraints

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Cite this article:

Flores-Rodríguez, J., & Ramírez-Macías, G. (2021). Non-linear Pedagogy in Handball: the Influence of Drill Constraints. *Apunts. Educación Física y Deportes*, 143, 73-83. [https://doi.org/10.5672/apunts.2014-0983.es.\(2021/1\).143.08](https://doi.org/10.5672/apunts.2014-0983.es.(2021/1).143.08)



Editor:

© Generalitat de Catalunya
Departament de la Presidència
Institut Nacional d'Educació
Física de Catalunya (INEFC)

ISSN: 2014-0983

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Section:

Sport Pedagogy

Original language:

Spanish

Received:

6 February 2020

Accepted:

8 July 2020

Published:

1 January 2021

Cover:

Handball Spain:
Ademar León and Liberbank
Sinfin play the first match
with masks during a
Sacyr Asobal league game
in October 2020, to
comply with the regional
regulations of COVID-19.
J.Casares/(EPA) EFE/
lafototeca.com

Abstract

The manipulation of drill constraints facilitates the performance of certain sports behaviours and according to non-linear pedagogy is the main tool with which coaches can accomplish their proposed objectives. The objective of this paper was to ascertain the influence exercised by certain constraints (no-bounce rule, compulsory passing and receiving while running and making at least five passes to be able to score) in handball players' offensive behaviours. The study participants were the 14 members of a men's U-15 team with ages ranging between 14 and 15 years ($M=14.6$ years, $SD=0.4$). Using a specific/nomothetic/multidimensional technique design, 24 matches were studied in a modified game situation in the course of six training sessions to which the constraints studied were applied. Moreover, the use of an individual defensive system was obligatory. An ad hoc observation instrument was designed and was input into the Dartfish 5.5 program, which was used as the recording instrument; intra- and inter-observer concordance and sequential delay analysis was performed using the GSEQ 5.1 program. The HOISAN 1.2 program was used for the polar coordinate analysis, which demonstrated the emergence of different behaviours in order to retain ball possession, progress towards the opponent's goal and finish the attack according to the constraints applied. These findings may indicate the most suitable drill constraints for accomplishing the proposed objectives and avoiding the selection of drills on the basis of subjective criteria.

Keywords: handball, offensive behaviours, polar coordinate analysis, individual defence.

Introduction

Non-linear pedagogy is one of the main precursors of the teaching models based on the complexity sciences (Chow et al., 2007). Using it may deliver better results in the training of certain skills in team sports as opposed to those obtained through the use of methodologies based on behavioural and/or cognitive learning theories (Roberts et al., 2019). For non-linear pedagogy, learning is seen as a process of self-organisation that emerges from the interaction between the player and the drill, since as the player acts they create new behaviour patterns or modify existing ones to meet the constraints present (Balagué et al., 2014).

The role of the constraints introduced into the drills is key since reducing the number of behaviours available enables the sportsperson to perform certain technical and tactical skills to the detriment of others (Renshaw & Chow, 2018). Hence, the action performed is the result of the interaction between the three types of constraints present: environmental (weather conditions, the presence of spectators, etc.), the player's own (skill level, psychological and anthropometric characteristics, etc.) and the drill's (objectives, rules, playing area, etc.) (Chow et al., 2015). The manipulation of drill constraints is viewed as the main tool available to coaches in the teaching of team sports, since manipulating them can provide guidance in the player's self-organisation process in order to accomplish the proposed learning objectives (Renshaw & Chow, 2018).

More empirical knowledge about the influence brought to bear by certain constraints applied to the drill in the learning of individual and group behaviours specific to team sports needs to be generated (Correia et al., 2018). However, there are no papers that address the influence of drill constraints in the teaching-learning process in handball from the standpoint of non-linear pedagogy.

In this respect, the use of observational methodology has been shown to be particularly appropriate since it makes it possible to study sports actions in the context in which they take place (Anguera & Hernández-Mendo, 2013). In handball, several papers have applied this methodology for the analysis of elite competition (Flores & Anguera, 2018; González et al., 2013; Lozano et al., 2016; Lozano & Camerino, 2012; Montoya et al., 2013; Sousa et al., 2015; Trejo & Planas, 2018), although it is seldom used in the study of training stages. In fact, training stages in handball have been investigated from other methodological standpoints. Hence, the papers by Antúnez et al. (2013) and García et al. (2008) focused on the performance indicators of teams that won the Spanish Championships in the U-13 and U-15 categories. Meanwhile, Antón (1998) and Feu (2006) made proposals for the organisation and development

of the teaching-learning process based on relating teaching objectives and contents to the principles of the game.

For all these reasons and due to the need for greater empirical knowledge about the influence of drill constraints in the teaching-learning process in handball, this paper set out to ascertain the influence exercised by certain drill constraints (no-bounce rule, mandatory passing and receiving the ball while running and the obligation to make at least five passes to be able to score) on the behaviour of handball players during the attack phase. Obtaining evidence in this respect could help to optimise training programmes by preventing coaches from manipulating drill constraints subjectively (Renshaw & Chow, 2018).

Methodology

This research is based on a specific/nomothetic/multidimensional (S/N/M) (Anguera et al., 2011) design: specific in analysing the records of the different sessions overall; with inter-session monitoring, since behaviour in the course of the sessions is recorded; nomothetic in that the players were assigned to two teams and the behaviours of several units are studied (blue team and orange team), and finally, multidimensional in that different response levels were studied.

Participants

The study involved the 14 players of a handball team, all the team members, competing in a men's U-15 provincial league in the region of Andalusia. The participants had a mean age of 14.6 years (SD=0.4), and in the course of the research they played various matches in a modified game situation to which the constraints being studied were applied. The research was performed in accordance with the ethical standards applicable to observational methodology established in the Declaration of Helsinki and with the consent of the Research Ethics Committee of the Virgen Macarena-Virgen del Rocío University Hospitals with code 0723-N-20. The parents also gave their consent for their children to participate in this study.

Instruments

Observation instrument

An ad hoc observation instrument (Table 1) was constructed to record the most relevant behaviours with respect to the proposed objective. Due to the lack of theoretical constructs

and the multidimensional nature of the behaviours to be studied, a design combining the field format with mutually exclusive and collectively exhaustive categories systems was chosen. This combination leverages the strong points of both components since the categories system provides theoretical consistency, while the field format affords flexibility in

recording the specific behaviours to be studied (Anguera & Hernández-Mendo, 2013).

The purpose was to build an instrument that would make it possible to record the most relevant behaviours in the accomplishment of the three objectives of the attacking phase: maintaining possession of the ball, progressing

Table 1
Observation instrument.

Criterion	Category and code	Description
Constraint (CON)	Bounce (NBR)	The game is played with a no-bounce rule.
	Movement (MVT)	There is also the obligation to receive and pass in movement.
	Five passes (PS5)	The game is played with the obligation to make at least five passes before taking a shot on goal
Team (TEA)	Orange (ORA)	The orange team attacks
	Blue (BLU)	The blue team attacks
Beginning (INI)	Goalkeeper (GOA)	The attack begins with a goal throw
	Recovery (RCU)	The attack begins after the ball is recovered
	Free throw/throw-in (FTT)	The attack begins after a throw-in or free throw
Number of players (NPL)	One (ONE)	One player has possession of the ball during the attack
	Two (TWO)	Two players have possession of the ball during the attack
	Three (THR)	Three players have possession of the ball during the attack
	Four (FOU)	Four players have possession of the ball during the attack
Number of passes (NPA)	From zero to two (P02)	Between zero and two passes are made during the attack
	From three to five (P35)	Between three and five passes are made during the attack
	From six to eight (P68)	Between six and eight passes are made during the attack
	Nine or more (P99)	Nine or more passes are made during the attack
Moving the ball (MTB)	Long pass (LPA)	The opponent's half is reached after a long pass
	Short pass (SPA)	The opponent's half is reached after a short pass
	Movement with ball (BSE)	The opponent's half is reached after a player executes a movement with the ball
	Opponent's half (AOH)	The attack begins when the team is already in the opponent's half
Collective behaviours (TAC)	Own half (NOT)	The attack does not reach the opponent's half ***
	Pass and move (PAM)	The first tactical resource used by players is pass and move
	Cross (CRO)	The first tactical resource used by players is the cross
	Exchange (EXC)	The first tactical resource used by players is the exchange
	Block (BLO)	The first tactical resource used by players is the block
	Force switch of defender (FSD)	The first tactical resource used by players is to force a switch of defender
	Free play (NTR)	Free play, using no tactical resource

Table 1 (Continuation)
Observation instrument.

Criterion	Category and code	Description
Finishing (FIN)	Shot (SHO)	The attack ends after a shot
	Loss (LOS)	The attack ends after a ball loss
	Interruption (INT)	The attack ends with an interruption, without the team losing possession of the ball: free throw, throw-in or referee intervention.
Finishing zone (ZON)	Left (LZO)	The attack ends in the left sector of the opponent's half
	Right (RZO)	The attack ends in the right sector of the opponent's half
	Centre (CZO)	The attack ends in the central area of the opponent's half
	Own half (OWH)	The attack ends in the team's own half
Finishing action (FAC)	Feint (FET)	The player finishing the attack executes a feint just before taking a shot, losing the ball or there is an interruption
Finishing action (FAC)	Lose marker (LOM)	The player finishing the attack loses their marker just before taking a shot, losing the ball or there is an interruption
	Movement with ball (MOB)	The player finishing the attack executes a movement with the ball just before taking a shot, losing the ball or there is an interruption
	Pass or reception (POR)	The player finishing the attack makes a passing reception error just before taking a shot, losing the ball or there is an interruption
	Solo attacker (SOL)	The player finishing the attack takes a shot on goal after receiving the ball without the presence of a defender.

towards the opponent's goal and finishing (Antón, 1998; Feu, 2006). The instrument was constructed in three phases. 1) Two national handball coaches, one with experience in observational methodology and the other the coach of the team being studied, constructed an initial version from the theoretical review performed in which the work by Feu (2006) and Lozano et al. (2016) was particularly useful. 2) Subsequently, three matches not included in the sample with similar characteristics to those involved in the study were recorded. As no new behaviours in any criterion were detected, the level of caution was deemed achieved. 3) The instrument was submitted to the judgement of five experts, university handball teachers and national coaches. Following the reading and explanation of the observation instrument, the experts completed an assessment template in which they were asked to state whether or not they agreed with each criterion and category. Five experts were polled, and agreement with all the criteria and categories defined in the observation instrument surpassed 79% in all cases.

The observation instrument was ultimately comprised of 10 criteria and 40 categories. The observation units were

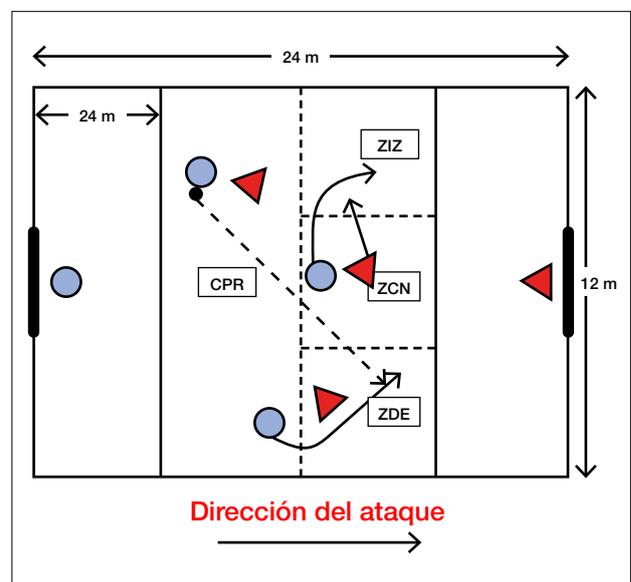


Figure 1
Modified game situation match to which the constraints studied were applied.
Note. OWH: own half; LZO: opponent's half left side; CZO: opponent's half centre; RZO: opponent's half right side

the attacks executed in the matches. It began when one team took possession of the ball and ended when a shot was made, the ball was lost or the referee stopped play.

Recording instruments

The observation instrument was input into the Dartfish 5.5 program to record and code the actions. Prior to this, each of the sessions was recorded with a Sony FDR-AX33 camera located at a height of 4 metres behind one of the goals.

Intra- and inter-observer concordance was calculated with the GSEQ program version 5.1 (Bakeman & Quera, 2011). In order to ascertain the behaviours of the players in the presence of the different constraints analysed, the polar coordinate analysis was applied using the HOISAN 1.2 program (Hernández-Mendo et al., 2012). Prior to the calculation of the polar coordinates, and as a prerequisite, the sequential delay analysis was performed, considering delays of +1 to +5 for the prospective perspective and -1 to -5 for the retrospective perspective, using the GSEQ 5.1 program. For this purpose, the records of both teams were merged into the same pool. Finally, the significant associations obtained with HOISAN 1.2 were represented graphically with the Snowflake 0.2 program.

Procedure

The study was performed in the course of six sessions conducted in the team's regular training facility and timetable. All the sessions presented the same structure: a warm-up (10 minutes), followed by a main part (40 minutes) and finally a cool-down drill (10 minutes). The main part of the training involved matches played in a modified game situation (Fig. 1). Each match lasted eight minutes with a two-and-a half minute rest between matches, making a total of four matches per session and 24 matches in the research overall.

With regard to match organisation, the players were divided randomly into two teams that did not change in the course of the study. It ought to be emphasised that the teams were obliged to use an individual defensive system in all matches. It should also be mentioned that, according to Chow et al. (2015), modified game situations, in that they conserve the structure and essence of real-life sport, allow players to develop the individual and interaction behaviours specific to the sport being taught, in this case handball.

The course of the matches was conditioned by the presence of the three constraints being studied: 1) no-bounce rule (NBR), applied in the matches played in sessions one and four; 2) obligation to pass and receive in movement (MVT), applied in the matches pertaining to sessions two and five, and 3) the obligation to make at least five passes

before scoring (PS5), applied in the matches pertaining to sessions three and six.

Finally, it should be stressed that the coach did not issue any type of instructions related to behaviour before, during or after the matches.

Observational analysis

Data quality

The actions were recorded and coded by two observers (national handball coaches). Both of them participated in a training process to optimise observation reliability. The training comprised two phases: the first, particularly for one of the observers who did not participate in the production of the observation instrument, in which the criteria and categories of the observation instrument were explained and studied in theoretical terms; and the second, more practical phase, in which the different matches that were not included in the sample were recorded. The training process concluded when concordance levels above 0.80 were obtained in Cohen's Kappa statistical test for all the criteria both at intra-observer level, the same session recorded by the same observer at two different times (after 16 days), and also at the inter-observer level, the same session recorded by the two observers.

Once the training phase had ended, the behaviours obtained in each of the six study sessions were recorded and coded. The intra-observer and inter-observer concordance levels were calculated, yielding in both cases a Cohen's Kappa coefficient above 0.95 in all the criteria. In accordance with Landis and Koch (1977, page 165) the level of agreement displayed in both tests may be regarded as "almost perfect".

Polar coordinate analysis

Polar coordinate analysis makes it possible to ascertain the behaviour patterns that emerge during the performance of sports and is used in an increasing number of research papers (Castañer et al., 2016, Castañer et al., 2017; López-López et al. 2015; Sousa et al., 2015). This analysis permits the vectorial representation of associations, whether activation or inhibition, between the behaviours being studied.

As a prerequisite for their calculation, the sequential analysis of perspective and retrospective delays has to be performed (Sackett, 1980). For this purpose, the same number of delays in both perspectives is considered, using positive delays of 1 to 5 for prospective and negative delays of -1 to -5 for retrospective. In the prospective perspective, a type of behaviour called focal behaviour is proposed, regarded as

“forward-generating” a series of relationships with the other categories, which are seen as conditioned behaviours. The retrospective perspective seeks to ascertain to what extent there are significant “backward” relationships between focal and conditioned behaviours.

Using the prospective and retrospective sequential analyses, the polar coordinate analysis integrates both of them by applying the $Z_{sum} = \frac{\sum Z}{\sqrt{n}}$ (Sackett, 1980) statistic, a powerful data reduction technique. Each prospective and retrospective “Zsum” may be positive or negative, meaning that the combination of the signs will determine in which one of the four possible quadrants (I, II, III, IV) the associations obtained between focal and conditioned behaviours will be located. Quadrant I indicates a relationship of mutual activation between focal and conditioned behaviour; quadrant IV indicates that the focal behaviour activates the conditioned behaviour, while it is inhibited by it; quadrant III points to a relationship of mutual inhibition between both behaviours, and finally, quadrant II means that focal behaviour inhibits conditioned behaviour, whereas conditioned behaviour activates focal behaviour (Anguera et al., 2011).

Results

Following the application of the polar coordinate technique, the significant associations, i.e. those with a length >1.96 ($p < 0.05$), between focal behaviour and the conditions were graphically represented in figures 2, 3 and 4. The constraints entered into the course of the matches acted as focal behaviours since it was necessary to ascertain the influence exercised by each constraint in order to meet the objective of this research. The other categories of the observation instrument acted as conditioned behaviours and were distributed as follows: in Figure 2, those pertaining to the criteria related to the principle of retaining the ball (beginning, number of players and number of passes). Figure 3 shows the categories of the criteria related to the principle of progressing towards the rival goal (movement of the ball and collective skills). Finally, in Figure 4 the categories of the criteria related to the principle of finishing the attack were used as conditioned behaviours (finishing area, finishing action and finishing). The relationships located in quadrant 1 will be studied to facilitate comprehension of the results. Figure 2 shows how the no-bounce rule (NBR) presented a relationship of activation with attacks begun with a goal throw

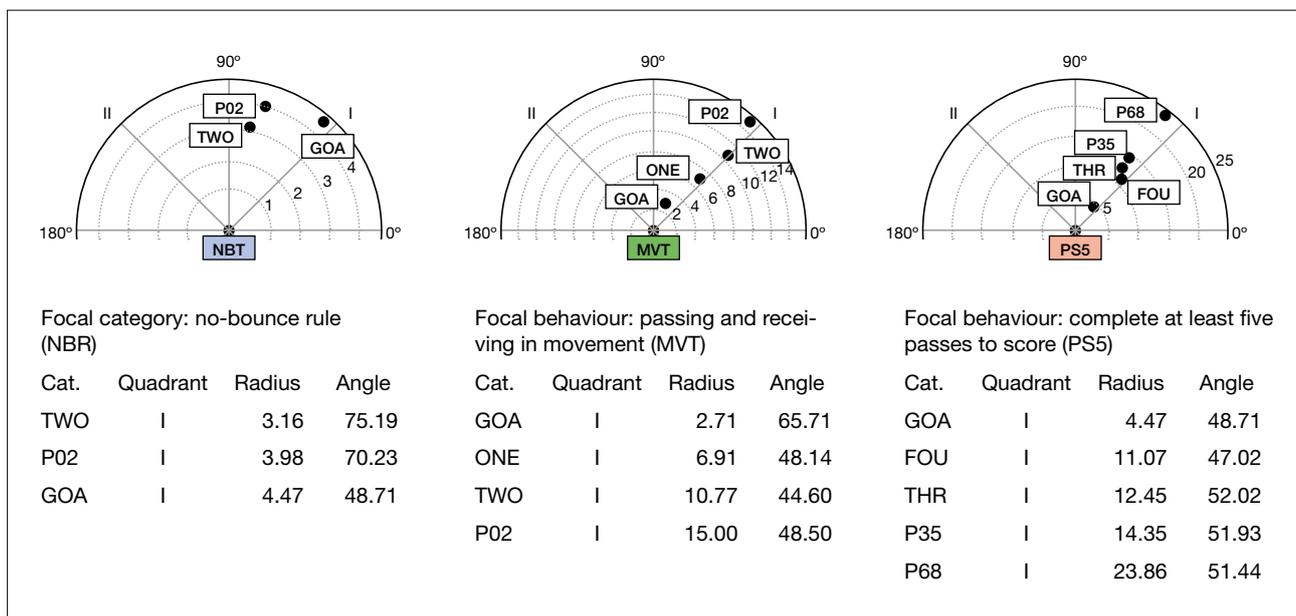


Figure 2
Relationships of activation between focal behaviour and criteria related to the principle of retaining the ball.

Note. Cat.: category; TWO: Two players are involved; P02: zero to five passes are made; GOA: the attack begins with a goal throw; ONE: one player is involved; FOU: four players are involved; THR: three players are involved; P35: three to five passes are made; P68: six to eight passes are made

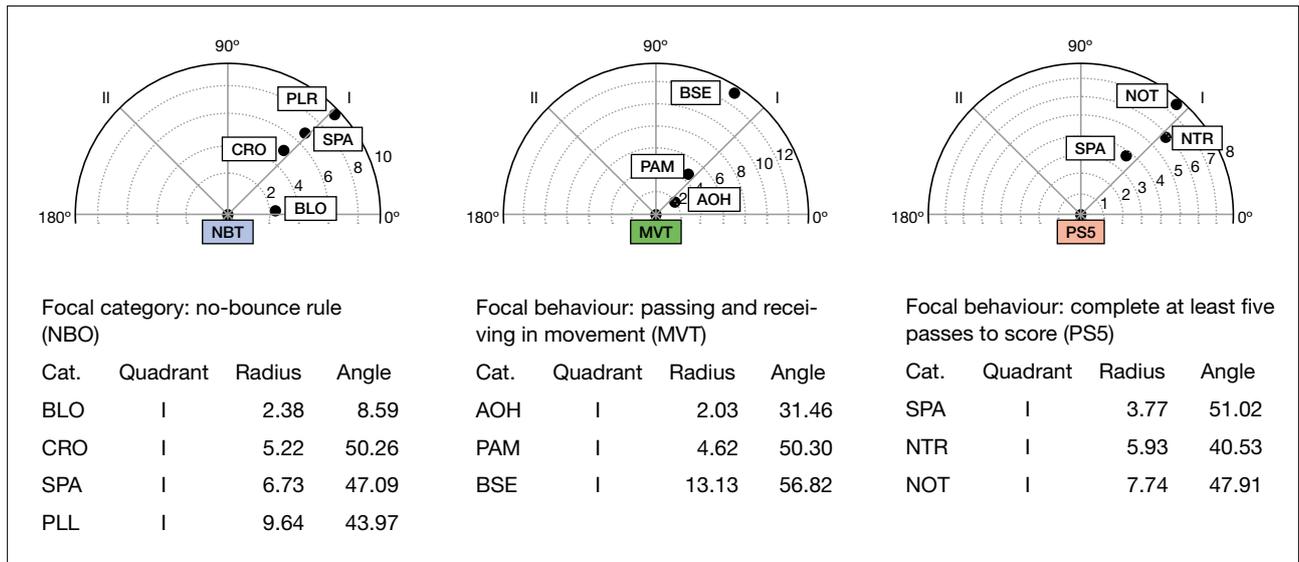


Figure 3

Relationships of activation between focal behaviour and criteria related to the principle of progressing with the ball

Note. Cat.: category; BLO: block; CRO: cross; SPA: short pass; LPA: long pass; AOH: the attack begins in the opponent's half; PAM: pass and move; BSE: movement with ball; NTR: free play; NOT: do not cross into the opponent's half

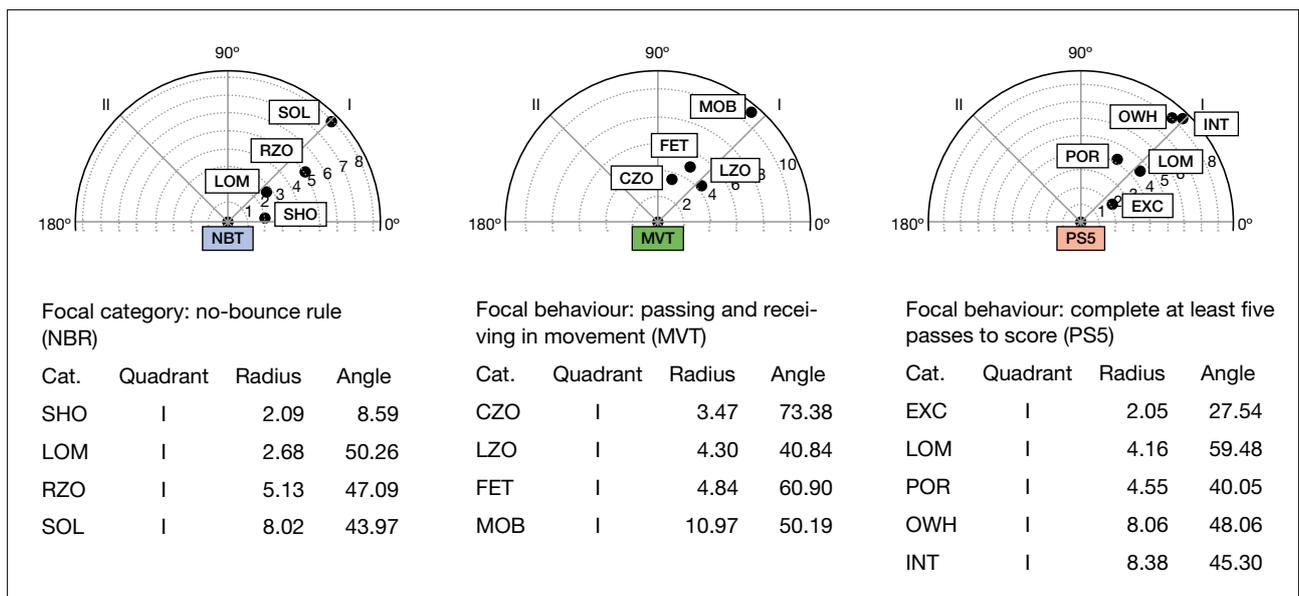


Figure 4

Relationships of activation between focal behaviour and criteria related to the principle of finishing

Note. Cat.: category; SHO: the attack ends in a shot; LOM: lose marker; RZO: right area; SOL: solo shot; CZO: central area; LZO: left area; FET: feint; MOB: movement with ball; LOS: the attack ends with loss of possession; OWH: the attack ends in the opponent's half; INT: the attack is interrupted; POR: the attack ends with a pass or receiving error

(GOA), with attacks in which two players had possession of the ball (TWO) and with attacks which were completed with zero to two passes (P02). The same behaviours, albeit with a different radius and angle, were activated in the matches in which it was obligatory to receive and pass

while running (MVT); similarly, this constraint presented a relationship of activation with attacks in which one player had possession of the ball (ONE). The obligation to make at least five passes before scoring (PS5) had a very different effect, since it presented a relationship of activation with

attacks involving possession of the ball by three players (THR), with attacks involving possession of the ball by four players (FOU), with attacks completed in three to five passes (P35) and finally with attacks involving between six and eight passes (P68).

Figure 3 shows the categories related to the principle of progressing towards the opponent's goal. The matches played with the no-bounce rule (NBR) presented a relationship of activation with the use of long passes (LPA) and short passes (SPA) to progress towards the opponent's goal, as well as with attacks in which the first tactical resource used by the players was the cross (CRO) and the block (BLO). On the other hand, the obligation of passing and receiving in movement (MVT) gave rise to the activation of attacks which began in the opponent's half (AOH), of attacks involving progression towards the opponent's half by means of movements with the ball (BSE) and of attacks in which the first tactical resource implemented was pass and move (PAM). Moreover, the obligation of completing at least five passes before scoring (PS5) presented a relationship of activation with attacks involving progression by means of short passes (SPA), attacks that did not reach the opponent's half (NOT) and with attacks in which the players did not use any tactical resource (NTR).

Figure 4 shows how the no-bounce rule (NBR) presented an association of activation with attacks that ended in the right side of the opponent's half (RZO), with attacks that ended in a shot (SHO), with a player losing their marker before finishing the attack (LOM) and with a shot after receiving the ball alone without the presence of a defender (SOL). Moreover, the obligation of passing and receiving in movement (MVT) presented activation in attacks completed after a feint (FET) and after a movement with the ball (MOB). With regard to the finishing area, the activation of two areas was observed, central (CZO) and left (LZO). Finally, the obligation of making at least five passes before scoring (PS5) presented activation with attacks that ended in the own half (OWH), with attacks that ended after an interruption (INT), attacks that ended with loss of possession after a passing and/or receiving error (LOS) and with attacks that ended after the player lost their marker (LOM).

Discussion

The objective of this study was to ascertain the influence exercised by certain constraints entered into the course of matches in a modified game situation on the attacking behaviours performed by handball players. Following the proposals of Feu (2006) and Antón (1998), the behaviours

studied have been linked to the principles of play with different behaviour patterns being found for keeping possession of the ball, progressing towards the rival's goal and finishing attacks depending on the constraint introduced into each of the matches.

With regard to the principle of keeping possession of the ball, research that studied the dynamics of play in handball training stages (Antúnez et al., 2013; García et al., 2008) found that the winning and best-placed teams in the National U-13 and U-15 Championships lost fewer balls. Moreover, the importance of this principle is also underlined in elite competition since lost ball possession can generate counter-attacks, the most effective and one of the most commonly-used tactics by winning teams (González et al., 2013; Lozano & Camerino, 2012). The results obtained in this research show that the obligation of making at least five passes in order to be able to score (PS5), while being the constraint that prompted the performance of a greater number of passes and the involvement of a greater number of players, activated the appearance of ball losses. Apparently, this constraint allowed the rival team to direct their behaviour towards the recovery of possession, obtaining a certain degree of success in this respect. On the other hand, the obligation of passing and receiving in movement (MVT) was the constraint that prompted the performance of fewer passes and the involvement of fewer players in attack. One explanation in this regard may be related to attacking players' perception and action difficulties (the player with the ball could not stop to weigh up the opportunities available to them), which promoted a more individual and direct play dynamic.

With respect to the behaviours performed to progress towards the opponent's goal, Sousa et al. (2015) indicated that one of the main functions of tactical resources is to create opportunities to finish attacks. More specifically, tactical resources involving two or three players are the ones most commonly used against open defences (Lozano et al., 2016). Here it is important to specify the most appropriate tactical resources depending on the context of play. Thus the results obtained show that the no-bounce rule (NBR) was conducive to the performance of blocks and crosses as well as to the performance of short and long passes in order to progress towards the opponent's half. These results appear to indicate that this constraint offers good opportunities for performing off-the-ball actions.

Moreover, the obligation to pass and receive in movement (MVT) was conducive to pass and move as well as to progression towards the opponent's half through moving with the ball. Therefore, in line with what was observed in behaviours intended to maintain ball possession, this constraint generated situations in

which actions involving ball possession predominate. However, the obligation to make at least five passes before scoring (PS5) did not facilitate the implementation of any basic tactical resource, perhaps because this constraint prioritised behaviours seeking to retain the ball with respect to those performed with a view to progressing towards the opponent's half and creating opportunities to finish the attack.

In terms of the finishing of attacks, Montoya et al. (2013) found in elite sport that the finishing percentages of wingers were greater in winning and best-placed teams. Moreover, Antúnez et al. (2013) and García et al. (2008) demonstrated that the winning teams in training categories took more shots from a distance of six metres. This information is very relevant, yet as pointed out by Lozano et al. (2016) it would be a good idea to study the dynamics of play that permit different types of finishes. In this respect, this study found that the no-bounce rule (NBR) is conducive to taking shots after off-the-ball actions such as losing one's marker and receiving the ball without being marked. These results seem reasonable since this constraint places important limitations on movements with the ball, meaning that off-the-ball actions become one of the main finishing tools. On the other hand, the obligation of receiving and passing in movement (MVT) generated a very different dynamic since it activated the use of on-the-ball actions such as feints. The requirement of receiving the ball while running appears to facilitate individual actions geared towards overcoming the defender, which is perhaps due to the advantage enjoyed by the attacker in receiving a ball while moving fast. Moreover, the obligation to make at least five passes before shooting was conducive to attacks ending in passing and/or reception errors.

Finally, the paper emphasises that the results obtained are consistent with one of the core ideas of non-linear pedagogy since the manipulation of drill constraints can guide player behaviour (Chow et al., 2007). Consequently, the challenge to coaches consists of selecting the right constraints that help to accomplish the proposed learning objectives (Correia et al., 2018). For this purpose, and following Feu (2006), when designing training drills coaches must contend with the difficult challenge of foreseeing their players' behaviour. The findings obtained in this paper may partially contribute to optimising this process.

Conclusions

The most important conclusions obtained with regard to the study objective are:

a) The no-bounce rule was conducive to the performance of off-the-ball actions, more specifically: the use of short and long passes to progress, crosses and blocking as basic tactical resources and finishing by means of losing one's marker and marking errors.

b) The obligation of passing and receiving in movement activated the performance of actions with the ball: attacks were executed with fewer passes and the involvement of fewer players than in the presence of other constraints, there was progression towards the opponent's half through possession, the use of pass and move and finishes after a feint.

c) The obligation of performing at least five passes before scoring a goal: this facilitated lost balls and passing and/or receiving errors and also hampered progression towards the opponent's goal and the implementation of basic tactical resources.

One of this study's main limitations is that the influence of individual characteristics was not taken into account when explaining the behaviours performed. For future research it would be advisable to verify the influence of the constraints studied on other players (different age, category, gender, etc.) as well as to analyse matches in which both teams use zone defence systems. Similarly, it would be worthwhile to study progressively the influence of these and other constraints on the behaviours in other game phases.

Moreover, the polar coordinate analysis technique, known to be a powerful tool to study elite handball, can also provide very valuable information about the training process in training stages since it reports on the type of self-organisation generated by the training drills proposed. This information could add to any obtained through the use of other tools applied to control training load.

Practical applications

The results obtained may contribute partially to optimising the design of training drills in handball, providing information that will help to select the most suitable drill constraints for the accomplishment of the objectives proposed and thereby avoiding subjective manipulation.

By way of example, three tasks in which the conclusions obtained are applied are presented below:

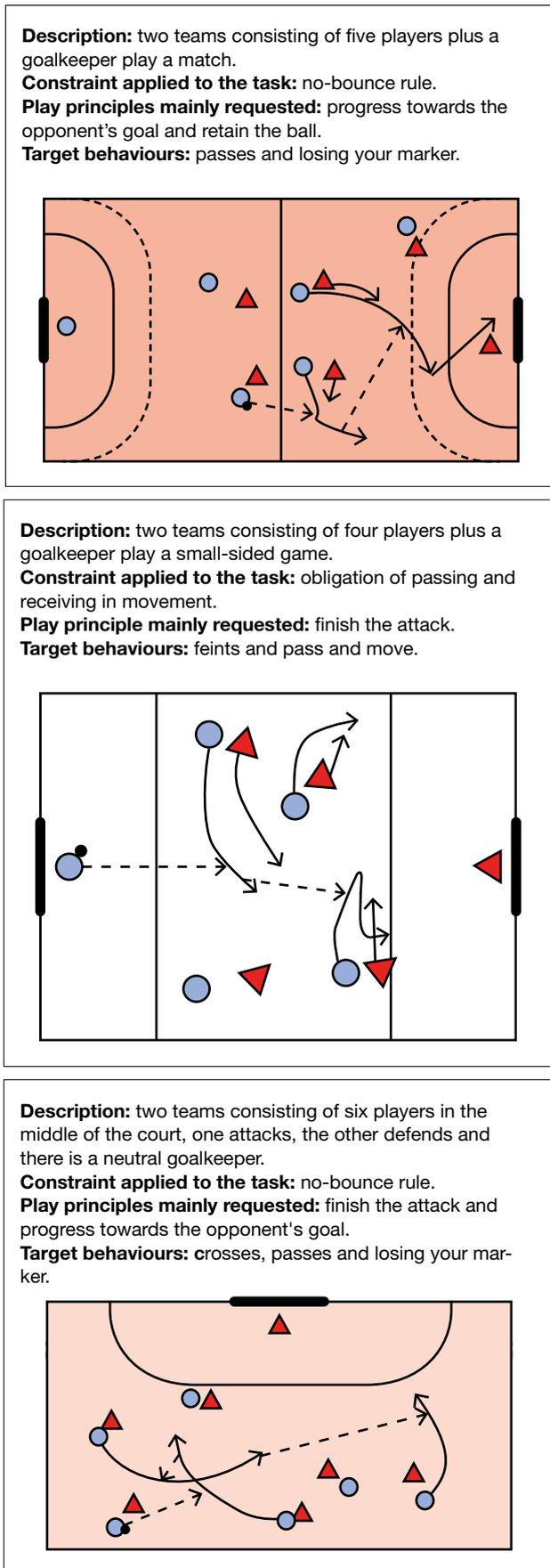


Figure 6
 Constraints applied to three tasks and target behaviours.

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Conflict of Interests: No conflict of interest was reported by the authors.



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