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Original Article

Evaluating teaching methods for learning basketball offensive sub-phases

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Abstract:
In recent years, there has been a growing emphasis on developing motor skills through an ecological dynamics approach. This approach integrates insights from various disciplines such as psychology, sociology, and physiology to understand the relationship between individuals and their environment. However, traditional sports training methods often adopt a reductionist viewpoint, focusing solely on technical aspects. Recognizing this discrepancy, there is a need to translate the ecological dynamics approach into practical strategies for enhancing tactical behaviors. To address this, we have developed a targeted approach called the "complex method" for collaborative-opposition sports, drawing inspiration from ecological dynamics principles. Two groups of 8 Under-11 years old basketball players underwent 40 minutes of practice in 2 sessions per week over 5 weeks. One group practiced offensive skills using the complex method, while the other utilized the traditional method. Both groups were assessed before and after the intervention using the Game Performance Assessment Instrument. The results demonstrated that in the interaction between groups, the group trained with the complex method showed significant improvements ($p<.05$) in decision-making and support variables as compared to the group that practiced with the traditional method. Similarly, in the interaction between period of time (pre-test and post-test), the evaluation revealed that the complex method-trained group exhibited significant improvements ($p<.05$) across all measured variables. In contrast, the group trained with the traditional method only made progress in decision-making, skill execution, and base. In conclusion, the variability and dynamic environment provided by the complex method can offer valuable strategies for learning an offensive system in basketball.
Key Words: basketball, learning method, offensive system, team sports.

Introduction

By adopting an ecological dynamics approach to sports behavior, the emphasis is ultimately placed on the intricate interplay between athletes and their environment. In sports contexts, this implies shifting away from “skill acquisition”, featured by an enriching connotation, to skill adaptation, where sport performers engage on an ongoing adjustment with the game environment that prompts a better use of information sources and respective action solutions (Araujo and Davids, 2011). Hence, this approach examines the interplay among individual constraints, task constraints, and environmental constraints, in the process of motor learning (Moy et al., 2020).

When discussing skills adaptation, it encompasses not only the manner in which an individual's structure and predispositions allow him or her to solve a particular task, but also other constraints that influence movement behaviors, such as emotional task instructions and perceptual information (Warren, 2006). As individuals interact with various constraints, their degrees of freedom of movement are manifested (Newell and Liu, 2021). Thus, it becomes evident that there is a necessity to cultivate environments that facilitate the degrees of freedom in the athlete (Torrents et al., 2021).

From a practical perspective, coaches are challenged to design training tasks that carefully preserve the interaction between athletes and their competitive environments, by taking into account the constraints and action opportunities (Araujo and Davids, 2011). This stands as an important challenge nowadays, as mainstream approaches to training practice are still heavily influenced by movement repetition and task reductionism (Pizarro et al., 2016; Ribeiro et al., 2019). This type of practice reduces the probability of athletes experiencing tasks oriented towards the perception-action dyad (Moy et al., 2020). Likewise, practice based on repetition,

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characterized by dividing the concept that needs to be taught, is also decontextualized from the nature of the game, and the technique is taught in isolation. Afterwards, in the last stage of this method, the tactic is incorporated in the sport tasks (Pizarro et al., 2016; Hooper, 2002).

Given this state of affairs, the objectives of this investigation are twofold. First, to assess the efficacy of an intervention program aimed at the learning of a new basketball offensive sub-phase, by comparing a traditional technique approach with an ecological dynamics approach guiding a nonlinear pedagogy that is focused on the manipulation of task constraints. Secondly, to provide a tentative practice session design.

Empirical research on sports training and coaching (Renshaw et al., 2016; Chow et al., 2019a), can further clarify the influence of nonlinear pedagogy and the manipulation of task constraints in enhancing players' adaptive behavior (Roberts et al., 2020). By introducing variability in tasks, particularly in opening diverse solutions for each task, players expand their own repertoire of motor behaviors. Consequently, processes of self-organization are stimulated, leading to enhanced autonomy and creativity in the choice (Colella and D'Arando, 2021). Based on the above, this context provides a greater attunement to the most relevant informational constraints and a more effective exploration of action opportunities that feature typical game environments (Chow et al., 2009b). As an example, Mateus et al. (2019) showed that the use of additional baskets (i.e., 4 baskets) modulated players' behavior by increasing physical demands and players' dispersion. Beyond the manipulation of task equipment, the feet positioning of the direct opponent showed to be highly influential on the direction of the drive of the attacker, within a specific range of interpersonal distance (Esteves et al., 2011). Importantly, the importance of constraints in shaping players' behavior has also been verified at the perceptual level. In basketball shooting, a larger number of visual fixations on the body of the defender has been reported as the interpersonal distance between attacker and defender decreased (Esteves et al., 2021).

Thus, the design of a task must incorporate components reflective of competitive environments. Put differently, the practice environment type will either provide or lack an experience akin to competition (Smith et al., 2020). The emerging perspective disavows exhaustive repetition-based practice (Hernández et al., 2023). In sports such as basketball, athletes must attend not only to their adversaries but also to their teammates and other opponents in order to make decisions (Hernández-Peña et al., 2024). Therefore, practice environment must have elements based on the demands of the game (Jeličić et al., 2023).

This is important, mainly because when one works with complex systems such as those found in sports, their qualities do not need to be separated (Hernández, 2021). Moreover, following the concepts of nonlinear pedagogy, the activities have to provide a situation of interaction and inferferences between players. In this way, the sport task offers multiple scenarios to create an answer (Serra-Olivares and García-Rubio, 2007).

Training practices guided by nonlinear pedagogy have shown the potential to enhance exploratory behaviors and to expand movement solutions, much needed in dynamic sport environments (Lee et al., 2014). Similarly, it has been observed that manipulating task conditions can improve players' adaptability within the game (Oppici et al., 2018). In this regard, team sports demand the tactical understanding of the game, anticipation and reading capacity, interpretation of contextual cues, emotional regulation, and rapid decision-making. Therefore, all of these facets necessitate manipulation within a training task (da Silva et al., 2023). Despite the growing interest in ecological dynamics and nonlinear pedagogy concepts (Chow et al., 2019a; Correia et al., 2019), traditional methods overly relying on direct instruction and skill repetition are still the generalized approach for coaching in team sports (Pizarro et al., 2016).

Aligned with the ecological dynamics approach to skilled behavior, the goal of this study was to compare the efficacy of two learning methods of a basketball offensive sub-phase, as the task-vehicle. By drawing upon ideas from the ecological dynamics approach and complexity thinking, we proposed a novel framework to enlighten the design of basketball training tasks. We expected that the group trained using the complex method would present a better performance in learning the aforementioned basketball offensive sub-phase.

Material & methods

Design and participants

A descriptive, cross-sectional study was conducted using a non-probabilistic convenience sampling method. The study participants consisted of sixteen Under-11 years old (U11) basketball players from the Snaiperis Club in Kaunas, Lithuania. Detailed information about the sample characteristics can be found in Table 1.

To ensure randomization, the subjects were assigned to two groups using specialized software (http://www.randomizer.org). The groups were identified as the traditional method (TR) group and the complex method (CM) group, with 8 athletes assigned to each group.

The research was conducted in compliance with the guidelines set forth in the Declaration of Helsinki. The participants and their parents were fully informed about the study details, and the parents provided informed consent on behalf of the participants, who were under 18 years old. The research project received approval from the Ethics Research Committee of the National School of Sport Trainers (Mexico) with identification number DI-F1-RP-15.

Table 1. *Descriptive data collected through the GPAI prior to the application of the training program*

	Pre (n=16)									
	TM (n=8)		CM (n=8)		p		TM (c=8)		CM (n=8)	
	M±	SD	M±	SD			M±	SD	M±	SD
DM	2.25±	1.27	1.95±	0.97	0.46	Age (years)	10.61±	0.18	10.46±	0.20
SE	1.92±	1.12	1.89±	0.96	0.49	Height(cm)	150.30±	6.49	149.15±	4.44
S	2.84±	1.19	2.81±	1.36	0.98	Weight (kg)	37.35±	4.49	38.41±	7.08
B	1.68±	1.10	0.90±	0.46	0.11	BMI	16.52±	1.35	19.32±	4.77

Note: TM=Traditional method; CM=Complex method; n=number; DM= decision making; SE=skill execution; S=support; B=base; BMI= body mass index p= level of significance; GPAI= Game Performance Assessment Instrument.

Sample size

Sample size calculations were performed with G*Power 3.1.9.4 software. The significance level was set at α=0.05. Consequently, the sample size (power analysis) revealed that 12 participants would provide a power or 95% (Faul et al., 2007; Power et al., 2012). To avoid possible dropouts or the elimination of recorded data due to the detection of an anomalous response or dropout, the decision was made to recruit a larger number of participants.

Measurements and equipment

The Game Performance Assessment Instrument (GPAI) was modified and adapted to specifically evaluate the players' ability to utilize our offensive system in various aspects, including skill execution, support, base, and decision making (Memmert and Harvey, 2008). Table 2 provides detailed information on the parameters and measurements for each variable assessed using the GPAI.

Table 2. *Game components and index measured with GPAI*

Game component	Criteria	Index calculation
Skill execution	Efficient performance of selected skills	SE= number of appropriate skill executions/number of inappropriate skill executions
Base	Appropriate return of a performer to a position between skill attempts	B=number of appropriate returns/number of inappropriate returns
Decision making	Making appropriate choices about what to do with the ball: a) After receiving a ball in the perimeter, the player makes a triple threat position if he has a defense in front. b) After receiving a ball inside the perimeter, the player dribbles to find a better offensive option. c) The player makes a jump shot if his defense performs sagging (floating). d) The player makes a drive if his defense does a press. e) The player passes the ball if a teammate makes a cut without defense. f) The player passes the ball if a teammate supports him on the perimeter.	DM=number of appropriate choices/number of inappropriate choices
Support	Off-the-ball movement to open position to receive a pass	S=number of appropriate movements to receive the ball/number of inappropriate movements to receive the ball

To record and measure the variables of interest, an 1080p HD 2.1 megapixel video camera, integrated into an iPad running iPadOS 13, was utilized. The recordings captured during the assessment were later analyzed to evaluate the players' performance based on the designated variables.

Process

After the initial evaluation session, sixteen U11 players were randomly assigned to two groups. The groups then participated in two recorded 10-minute games on separate days. Two basketball coaches evaluated the players' performances using the adapted GPAI during these games, focusing specifically on control offenses and excluding fast breaks, set plays in baseline, and sideline set plays. This evaluation process was conducted at the beginning and end of the intervention period.

To assess the relative reliability between the different measurements, the intraclass correlation coefficient (ICC) was utilized, resulting in values above ICC=0.70 (ranging from 0.34 to 0.88). Furthermore, an analysis of variance indicated the absence of bias, as the measurements did not demonstrate significant differences across any of the dimensions within the GPAI questionnaire ($p>0.5$) (Fleiss and Cohen, 1973; Weir, 2005).

Both groups participated in ten sessions, each lasting forty minutes, conducted twice a week during their regular practice periods. Each group practiced using one of the methods to learn the "Five Out Motion" offensive system.

Intervention group:

Following complex systems ideas, three stages guided the design of the complex training approach to basketball (Sotolongo, 2007) such that the scale of interaction between the athlete and game environment was intentionally preserved:

Stage 1. Facilitated opposition

The goal of this stage is to present situations that facilitate the visual exploration of the task, helping players make decisions. One of the most important issues regarding the application of a nonlinear pedagogy approach pertains to its progression (Orth et al., 2009; Renshaw et al., 2016; Chow et al., 2006). Typically, it is argued that for a low expertise level, coaches could simplify training tasks by removing the so-called "complex" information, related with the opponents, teammates, scoring target, and by creating a stable and predictable environment, in order to favor task accomplishment. In contrast, ecological dynamics stand for the manipulation of evolving constraints to simplify learning environments, such as opposition, as a means to facilitate the detection of target information and to enable learning and achievement at early stages of learning. In this first stage, facilitation of players' resolution of the task can be done by providing players with a limited range of action possibilities, while the opposition consistently overexposes their intentions. These conditions can provide relevant information about basic game actions such as passing, dribbling, shooting, and marking (Araujo et al., 2009). The opposition employ low-intensity movements that facilitate anticipation by providing prospective information of upcoming actions. Furthermore, the coach can provide relevant verbal expressions to support exploratory behaviours and enhance decision-making (Araujo et al., 2009; Davids et al., 2013).

Stage 2. Active opposition

The aim of this stage is to familiarize players with making decisions through visual exploration at a rhythm similar to that of a game. Intensity plays a crucial role in this context. The player is required to explore a wider range of movement solutions while facing opposition of higher intensity and less predictability. Accordingly, the coach may resort to the manipulation of task constraints by progressively including more teammates, opponents, and scoring target(s). The task can be designed with multiple players engaging at a pace close to or equivalent to the official game. This practice environment affords the detection of a wider spectrum of informational sources within a shorter timeframe, given that the game flows at a faster pace (Chow et al., 2006).

Stage 3. Competitive opposition

The aim in this stage is to challenge players' exploratory behaviors and decisions through the manipulation of the opposition level. The intensity of the tasks surpasses that of a match, which means amplifying the demands that players must cope with. For instance, by introducing double or triple opposition against a single player or by severely reducing decision-making time, or incorporating any element that intensifies players' interactions.

The three levels of complexity must be integrated into the learning process, although the duration of each stage depends on the players' skill level. Novice players typically require more practice in the first two stages. However, it is important to incorporate competitive opposition at times. This suggests the importance for coaches to properly implement a diagnostic and intervention procedure in order to design the most effective tasks according to the stage in which the players are found, in a given moment in time (Metz, 1978).

In order to make clear the rationale for implementing the three stages proposed within the complex method, the subsequent list presents the guiding principles that inspired the design of the intervention program:

Principles underlying the complex method

1. The design of the tasks intended to recreate the conditions that players experience in the context of a game, although by simplifying the level of complexity.
2. For each session, tasks with different opposition levels were mixed.
3. All three stages of the complex method offered different levels of visual constraints (e.g., overly showing a defensive position, or denying a target area).
4. Before each task, the coach suggested possible visual areas to explore to the players.
5. All three stages of the complex method were used in the same session as a means to work on a given training topic.
6. The complexity of the tasks in each session increased progressively.
7. In the low-interference tasks, the goal of the opponent was to facilitate the discovery of a solution to the task by the players with the ball (e.g., by providing relevant anticipatory cues on movement intention)

8. In active opposition tasks, the goal of the opponent was to act with an intensity similar to that in a real game, although the coach could prescribe specific rules in order to encourage players to perceive and act on relevant information sources, such as spaces to explore, etc
9. In competitive opposition tasks, players faced a more demanding environment, when compared to competitive game, in order to expose players to an extreme level of adaptation. For example, they could face double or triple opposition, together with a contrived time period to make a decision. All the aforementioned options could be used in conjunction or separately.

Traditional (control) group

The group exposed to a traditional method trained according to the skill repetition and traditional principles. Under this approach, players acquired a desired level of understanding of the new offensive system by experiencing training tasks with limited or no opposition. Ultimately, the opposition level progressively increased over time.

The next list shows the principles followed in each session.

Principles underlying the traditional technique method

1. Players started to practice without opposition and in a low intensity practice environment.
2. The training contents were fractioned in short, independent bouts, in order to be developed in isolation (i.e., with a low degree of game representativeness).
3. Players repeated movement solutions (i.e., game skills), prescribed by the coach, without the need to make decisions.
4. In the beginning of the intervention session, direct instructions about the desired movement patterns were provided by the coach. In addition, the coach corrected each mistake and specified the details about how to perform the activity correctly.
5. In the intermediate phase of the intervention, game skills were coupled to tactical behaviour (i.e., learned in a global context).
6. At this phase, opponents were introduced to the training tasks and the coach provided specific corrections when needed in order to show the players the desired behaviors.
7. At the end of the intervention phase, players faced opponents playing with an intensity equivalent to a competitive game.

For a better understanding, Table 3 illustrates the key distinctions between the complex method and the traditional technique method in terms of training session preparation.

Table 3. *Differences between the complex method and the traditional technique method in training session*

Method	Task design	Instruction	Feedback
Complex method	Constraint-based manipulation	Suggestion of potential of interest to be visually explored and acted upon	Internal (self-organization) External (game, and questions and comments by coach)
Traditional technique method	From skill-based development to tactical behaviour	Direct instructions	Corrections by the coach

Once the main characteristics used throughout the complex method and the traditional technique method in our intervention have been explained, Figure 1 provides a comprehensive visualization of the step-by-step process followed in this study.

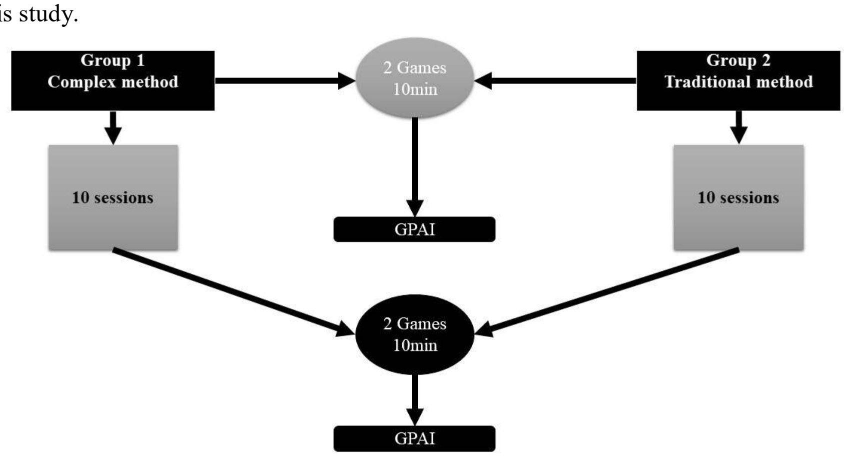

Figure 1. Evaluation and process of the intervention

Statistical analysis

The descriptive data of the sample are presented. The parameters of normality and homogeneity of the sample were tested with Shapiro-Wilk and Levene tests, respectively. A two-way repeated measures analysis of variance (ANOVA) with time (before and after the application of the intervention program) and the type of intervention program (Traditional (TR) vs Complex (CM)) was then applied to analyze the scores obtained in each of the dimensions included in the GPAI questionnaire. Within this statistical test, when necessary, the Bonferroni post-hoc test was applied to explore the possible differences between each of the two conditions. On the other hand, the Mauchly correction was used to verify the assumption of sphericity. The effect size (ES) was estimated by calculating the partial eta-squared (ŋP2) [<0.01 (small); >0.06 (medium) and >0.14 (large) effect]. In addition, a t-test for independent samples was applied to assess prior differences in the descriptive scores of the sample according to whether the subjects were grouped into TR or CM.

Finally, an analysis of ROC (Receiver Operating Characteristic) curves was performed to determine the cut-off point for the different dimensions of the GPAI questionnaire according to the type of training program applied. The classification accuracy for each set of cut-off points was assessed by calculating weighted statistics, sensitivity, specificity, and the area under the receiver operating characteristic curve (AUC). An area of one represents a perfect classification, while an area of 0.50 represents an absence of classification accuracy. ROC-AUC values of >0.90 are considered excellent, 0.80- 0.89 good, 0.70-0.79 fair and <0.70 poor (Silva et al., 2013). Data analysis was performed using SPSS software (IBM Corp., Armonk, NY, USA) for Windows, version 24.0, as well as MedCalc 14.12.0 (Mariakerke, Belgium). The level of statistical significance was set at p<0.05 for all statistical comparisons.

Results

As can be observed in Table 1, the scores obtained for each of the dimensions that composed the GPAI questionnaire did not show any significant differences prior to the application of the training programs (p>.05).

On the other hand, Table 4 shows the data obtained for the scores achieved in each of the dimensions of the GPAI questionnaire, for the interaction between point in time (pre-test and post-test) and the interaction between groups (TR and CM).

Table 4. *Descriptive data recorded through the GPAI according to the type of training developed in each basketball team*

	TR (n=8)								CM (n=8)								Post Intervention (n=16)			
	Pre		Post		Δ (Pre_Post)		p	ŋP^2	Pre		Post		Δ (Pre_Post)		p	ŋP^2	Δ (TR_CM)		p	ŋP^2
	M±	SD	M±	SD	M±	SD			M±	SD	M±	SD	M±	SD			M±	SD		
DM	2.25±	1.27	3.91±	1.01	-1.67±	0.26	0.01**	0.39	1.95±	0.97	5.20±	0.93	-3.26±	0.04	0.001**	0.71	-1.29±	0.08	0.02*	0.35
SE	1.92±	1.12	3.35±	0.55	-1.44±	0.57	0.002**	0.55	1.89±	0.96	3.90±	0.82	-2.01±	0.13	0.001**	0.76	-0.55±	-0.27	0.07	0.23
S	2.84±	1.19	4.29±	0.94	-1.45±	0.25	0.08	0.22	2.81±	1.36	5.78±	1.47	-2.96±	-0.11	0.004**	0.49	-1.49±	-0.53	0.05*	0.27
B	1.68±	1.10	3.43±	1.75	-1.76±	-0.65	0.006*	0.46	0.90±	0.46	4.62±	1.20	-3.72±	-0.74	0.001**	0.79	-1.19±	0.56	0.08	0.21

Note: TR=traditional method; CM=complex method; n=number; DM= decision making; SE=skill execution; S=support; B=base; Δ=differences between groups; p= level of significance; *=p<0.05; **=p<0.01.

The two-way repeated measures analysis revealed no significant effects of time on the mean values obtained in the GPAI in each one of its dimensions (F3=0.59; p=0.63; ŋP2=0.043). However, the Bonferroni post hoc test revealed a significant interaction between time (pre-test and post-test) and the groups (TR and CM), as illustrated in Table 4. In particular, in the TR training program, the point in time had an effect on the mean scores obtained for the dimensions DM (F1=8.15, p=0.01, ŋP2=0.39), SE (F1=15.83, p=0.002, ŋP2=0.55) and B (F1=11.00, p=0.006, ŋP2=0.46). More specifically, after the application of the TR training program, basketball players obtained higher scores in the three dimensions of the questionnaire, with mean values that were 74.18% higher for the DM dimension, 74.90% higher for the SE dimension, and 104.54% higher for the B dimension.

On the other hand, the CM training showed significant differences in the mean scores of each of the dimensions of the GPAI due to the effect of the point in time. More specifically, for the DM dimension (F1=31.15, p=0.001, ŋP2=0.71), the mean values after the application of the program showed a score that was 167.14% higher than that recorded before the application of the program. A similar trend could be observed in relation to the SE dimension: SE (F1=40.02, p=0.001, ŋP2=0.76), with an increase of 106.27% with respect to the initial values; S (F1=12.52, p=0.004, ŋP2=0.49), with a percentage 105.33% higher when comparing the mean values obtained before and after the CM training program, and B (F1=48. 79, p=0.001 ŋP2=0.79), with an increase of 411.85% with respect to the initial values obtained previously before applying the CM training program.

Likewise, table 4 shows the results of interaction between groups. In this context, two dimensions exhibited significant differences in the mean values: DM (F1=7.06, p=0.02, ŋP2=0.35) and S (F1=4.85, p=0.04, ŋP2=0.27). When comparing the mean scores of the DM dimension, it was evident that players who underwent CM training achieved scores that were 32.97% higher than those in the TR group. Likewise, in the S dimension, players in the CM group scored an average of 34.69% higher as compared to their TR counterparts.

Finally, through the analysis of ROC curves, the cut-off point for the different dimensions that composed the GPAI questionnaire was determined, according to the type of training to which the players of the different basketball teams were subjected. The details for the AUC, as well as the scores obtained for that classification of basketball players according to the type of training followed by their team, can be observed in Table 5.

Table 5. *Analysis of ROC curves as a function of the type of training applied to basketball players for the different dimensions of the GPAI questionnaire*

	DM (n=16)	SE (n=16)	S (n=16)	B (n=16)
	Post	Post	Post	Post
	TR	TR	TR	TR
AUC	0.81	0.7	0.82	0.72
SE	0.12	0.14	0.12	0.14
95% CI	0.54 to 0.96	0.43 to 0.90	0.55 to 0.93	0.44 to 0.91
P	0.01**	0.14	0.01**	0.11
Youden index	0.63	0.37	0.63	0.38
Cut point	>4	>4	>4.8	>4

Note: TR=traditional method; n=number; DM=decision making; SE=skill execution; S=support; B=base; ES=standard error; CI=confidence index; AUC=area under the curve; p= level of significance; *=p<0.05; **=p<0.01.

The ROC curve analysis showed cut-off points in the scores obtained for the DM and S dimensions after the application of the training program of 4 and 4.8, respectively, in order to discriminate according to the type of training program followed (TR or CM). The ROC curves for these two dimensions that showed differences are shown in Figure 2.

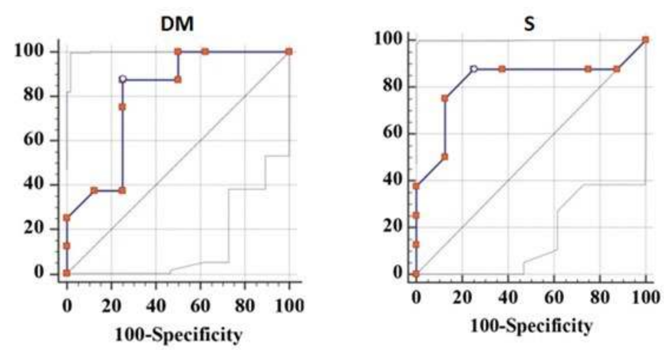

Figure 2. Receiver-operator curves of DM and S dimensions to identify the score as a function of the type of training program applied to basketball players

Discussion

The objective of this study was to assess the effectiveness of the complex method when compared to the traditional technique method in the acquisition of a basketball offensive system. Our results reveal that the Complex Method group exhibited more substantial improvements in the dimensions of decision-making and support when compared with the Traditional Method group, as observed in the analysis of the interaction between groups. Additionally, significant enhancements across all measured variables were observed within the Complex Method group when assessing the interaction between points in time. Conversely, the Traditional Method group displayed meaningful improvements in the dimensions of decision-making, skill execution, and base, when analyzing the interaction between points in time.

According to Araujo et al. (Araujo et al., 2020), ecological dynamics skills emphasize the continuous interaction between the player and the environment, resulting in mutual reorganization. By employing the complex method, players are exposed to a constantly changing environment, characterized by a wide range of constraints. Through these experiences, players have the opportunity to perceive affordances, resulting in a greater variety of action possibilities to be explored, that encompasses multiple decisions. Conversely, when working with the traditional technique method, such circumstances are not present, which impacts the functionality of the perception-action cycle. This means that the limited range of available information in the practice environment may have not prompted the performers to actively search, explore and act, according to each player's own characteristics, to fulfill task goals. Consequently, this is one of the reasons why the group trained with the complex method achieved better results in the decision making dimension.

Similarly, players are constrained to attune themselves to the affordances of the game as they progress over time (Araujo and Davids, 2011). Dynamic instabilities within environmental systems enable players to constantly forge their decisions and actions, stimulating adaptability and flexibility in their responses (Araujo et al., 2020). The three stages of the complex method, each with a different spectrum of constraints, offer dynamic instabilities that may have contributed to the improved results in the decision-making dimension. Such environments promote the player's ability to choose between multiple options (select an affordance), and act upon such possibilities according to each player's state and circumstances (Kaya, 2014; Memmert and Harvey, 2008).

The "support" dimension relates to the players' ability to find and take advantage of free space in order to receive a pass from the ball handler (Memmert and Harvey, 2008). This action requires the player without the ball to monitor the actions of the player with the ball, together with those of the teammates and opponents (Stavropoulos et al., 2021). Therefore, movement regulation with respect to teammates and opponents, both in space and time, is crucial for the functionality of the offense (Lamas et al., 2018). Given these considerations, the dimension of support may have greatly benefitted from the application of the complex method. The complex method incorporates concepts such as nonlinearity, self-organization, and emergence, which align with the demands of the support dimension within the ecological dynamics perspective (Seifert et al., 2018).

The dimension "skill execution" directly relates to the effectiveness of a technique (Méndez, 2011). It evaluates the motor capacity to achieve a given goal. With the adoption of complex approach, changes in coordination patterns are expected to occur through time (Moreno and Ordoño, 2014). As observed in other studies (Bañuelos and González, 2004; Reynoso, 2013), performance in motor skills may not improve more than through repetitive practice. One possible explanation for the fact that no positive effects were obtained by the adoption of the complex method approach, is that a greater emphasis is placed on the perception-action functionality, which demands a longer timescale for the stabilization of movement patterns. Therefore, positive results could be observed in the complex method over the traditional method, if future research could consider a retention test (Moreno and Ordoño, 2014).

Regarding the dimension "base", which refers to starting or recovering a position between each offensive attempt (Memmert and Harvey, 2008), no significant differences were found when comparing both groups. The concept of base entails observing whether the players initiate the attack from the designated areas. In other words, it evaluates whether the players start in the correct positions. This phase of the game, known as set offense, is important to study as it requires players to occupy specific zones (Selmanović et al., 2015). However, considering that the complex method intervention was underpinned by the attunement to the evolving informational constraints, (Balague et al., 2015), the base variable may have not been sensitive enough to this specific approach.

On the other hand, when comparing the performance of the traditional method group before and after the intervention program, meaningful results were found in the decision-making (DM), skill execution (SE), and base (B) dimensions. However, the dimension of support (S) did not show significant changes. Improvements with this method may be understood according to the fact that it focuses on technical proficiency by prioritizing the learning of technical skills before introducing rules and game situations (Smith et al., 2014). Furthermore, studies such as the one conducted by McPherson and French (1991) have shown that the instructional model can have positive effects on the improvement of technique skills (Blomqvist et al., 2001).

In the case of the group trained with the complex method, meaningful results were found in all measured dimensions when comparing pre-and post-intervention values within the group. These results can be explained by the use of nonlinear pedagogy, which emphasizes the constant interaction between the player and the environment (Práxedes et al., 2018). It has been demonstrated that manipulating constraints such as the player, environment, or task can improve decision-making and skill execution (Chow et al., 2009a), aspects that were stimulated within the framework of the complex method. Additionally, the training conducted using this strategy focused on promoting self-organization and the capacity to find solutions to emergent situations within the system, concepts supported by the ecological dynamics approach (Raiola et al., 2022). This approach has been mentioned in several studies as an interesting perspective for motor learning (Guignard et al., 2020; Araujo et al., 2020; Strafford et al., 2018; Seifert et al., 2017).

Regarding the evidence shown in the ROC curve analysis, cut-off points were observed in DM and S after the implementation of the intervention of 4 and 4.8, respectively. These findings are relevant, as flexibility and adaptation to situations that arise from player interactions are required in team sports, and both DM and S dimensions capture such data (Seifert et al., 2017; Silva et al., 2020).

Conclusions

The complex method intervention promoted an enhancement of decision-making and support-related dimensions in the process of mastering a basketball offensive system, when compared to the traditional method.

The fact that the complex method intervention was underpinned by an intentional manipulation of evolving constraints across the three stages, to facilitate the detection of purposive information, may have supported these results. Importantly, it seems that this approach may provide a solution to the challenge of enabling learning at early stages, by designing challenging practice environments with useful information, such as opponents, teammates and scoring targets. In sum, the complex method can stand as a useful approach to enhance the learning and development of offensive collective behavior in basketball.

Further evidence is required to acquire a deeper understanding on the effects of adopting a complex method intervention to other phases of the game, such as defense and counter-attacks.

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References:

Araujo, D., & Davids, K. (2011) What exactly is acquired during skills acquisition. *Journal of Consciousness Studies, 18*(3–4), 7–23.

Araujo, D., Davids, K., Chow, J., & Passos, P. (2009). The development of decision making skill in sport: an ecological dynamics perspective. *Perspectives on Cognition and Action in Sport*, 157-169.

Araujo, D., Davids, K., & Renshaw, I. (2020). Cognition, emotion and action in sport: an ecological dynamics perspective. *Handbook of sport psychology*, 535-555.

Balague, N., Torrents, C., Hristovski, R., Davids, K., & Araújo, D. (2013). Overview of complex systems in sport. *Journal of Systems Science and Complexity, 26*, 4-13.

Bañuelos, S., & González R. (2004). The dynamic systems approach in the dribble learning in basketball at school context [in Spanish]. *Revista de Psicología del Deporte, 14*(1), 97-107.

Blomqvist, M., Luhtanen, P., & Laakso, L. (2001). Comparison of Two Types of Instruction in Badminton. *European Journal of Physical Education, 6*(2), 139–155.

Chow, J. Y., Davids, K., Button, C., Shuttleworth, R., Renshaw, I., & Araujo, D. (2006). Nonlinear pedagogy: a constraints-led framework for understanding emergence of game play and movement skills. *Nonlinear Dynamics, Psychology, and Life Sciences, 10*, 741-103.

Chow, J. Y., Davids, K., Button, C., Renshaw, I., Shuttleworth, R., & Uehara, L. (2009b). Nonlinear pedagogy: implications for teaching games for understanding (TGfU). *TGfU: Simply Good Pedagogy: Understanding a Complex Challenge*, 131-143.

Chow, J. Y., Shuttleworth, R., Davids, K., & Araújo, D. (2009a). Ecological dynamics and transfer from practice to performance in sport. *Skill Acquisition in Sport*, 330-344.

Colella, D., & D'Arando, C. (2021). Teaching styles and outdoor education to promote non-linear learning. *Journal of Physical Education and Sport, 21*(1), 507-513.

Correia, V., Carvalho, J., Araújo, D., Pereira, E., & Davids, K. (2019). Principles of nonlinear pedagogy in sport practice. *Physical Education and Sport Pedagogy, 24*(2), 117-132.

da Silva, W. J. B., Ribas, S., Mizoguchi, M. V., Mazzardo, T., Araujo, N. D., de Oliveira Castro, H., & Aburachid, L. M. C. (2023). Objective and subjective assessment of declarative tactical knowledge among young female basketball athletes throughout a season. *Journal of Physical Education and Sport, 23*(6), 1501-1508.

Davids, K., Araújo, D., Correia, V., & Vilar, L. (2013). How Small-Sided and Conditioned Games Enhance Acquisition of Movement and Decision-Making Skills. *Exercise and Sport Sciences Reviews, 41*(3), 154–161.

Esteves, P., Oliveira, R., & Araújo, D. (2011). Posture-related affordances guide attack in basketball. *Psychology of Sport and Exercise, 12*(6) 639-644.

Esteves, P., Arede, J., Travassos, B., & Dicks, M. (2021). Gaze and shot: Examining the effects of player height and attacker-defender interpersonal distances on gaze behavior and shooting accuracy of elite basketball players. *Journal of Sport Psychology, 30*(3), 1-8.

Faul, F., Erdfelder, E., Lang, A. G., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. *Behavior Research Methods, 39*(2), 175–191

Fleiss, J.L. & Cohen, J. (1973). The equivalence of weighted kappa and the intraclass correlation coefficient as measures of reliability. *Educational and Psychological Measurement, 33*, 613-619.

Guignard, B., Button, C., Davids, K., & Seifert, L. (2020). Education and transfer of water competencies: an ecological dynamics approach. *European Physical Education Review, 26*(4), 938-953.

Hernández, K (2021). *The end of macrocycles* [in Spanish]. MCSports.

Hernández, K., Gea-García, G. M., & Menayo, R (2023). Effect of differential and traditional learning in dribbling ball for beginners basketball players [in Spanish]. *Journal of Sport and Health Research, 15*(1), 167-176.

Hernández-Peña, K., Gea-García, G. M., & Menayo Antúnez, R. (2024). Design and validation by Delphi method of a questionnaire to determine the criteria of a basketball player when he drives [in Spanish]. *Cuadernos de Psicología del Deporte, 24*(1), 275–296.

Hopper, T. (2002). Teaching games for understanding: The importance of student emphasis over content emphasis. *Journal of Physical Education, Recreation & Dance, 73*(7), 44-48.

Jeličić, M., Jelaska, G., Stanković, M., & Čaprić, I. (2023). Exploring interactions between performance and efficiency among junior female basketball players: a canonical analysis approach. *Journal of Physical Education and Sport, 23*(8), 2246-2251.

Kaya, A. (2014). Decision Making by Coaches and Athletes in Sport. *Procedia - Social and Behavioral Sciences, 152*, 333–338

Lamas, L., Drezner, R., Otranto, G., & Barrera, J. (2018). Analytic method for evaluating players' decisions in team sports: Applications to the soccer goalkeeper. *Plos One, 13*(2),1-18.

Lee, M. C. Y., Chow, J. Y., Komar, J., Tan, C. W. K., & Button, C. (2014). Nonlinear pedagogy: an effective approach to cater for individual differences in learning a sports skill. *Plos One, 9*(8), 1-13

Mateus, N., Goncalves, B., Weldon, A., & Sampaio, J. (2019). Effects of using four baskets during simulated youth basketball games. *Plos One, 14*(8), 1-13.

Metz, C., E. (1978). Basic principles of ROC analysis. *Seminars in Nuclear Medicine, 8*(4), 283-98.

Memmert, D., & Harvey, S. (2008). The game performance assessment instrument (GPAI): Some concerns and solutions for further development. *Journal of Teaching in Physical Education, 27*(2), 220-240.

Méndez, A. (2011). Assessment from the understanding perspective. Difficulties and teaching strategies to evaluate the performance of games in modified situations [in Spanish]. *Tándem. Didáctica de la Educación Física, 37*, 42-54.

Moreno, F. J., & Ordoño, E. M. (2014). Variability and practice load in motor learning [in Spanish]. *RICYDE. Revista Internacional de Ciencias del Deporte, 11*(39), 62-78.

Moy, B., Renshaw, I., & Pavey, T. (2020). Impact of the constraints-led approach on students' motor performance. *Journal of Physical Education and Sport, 20*(6), 3345-3353.

Newell, K. M., & Liu, Y. T. (2021). Collective variables and task constraints in movement coordination, control and skill. *Journal of Motor Behavior, 53*(6), 770-796.

Orth, D., Van der Kamp, J., & Button, C. (2019). Learning to be adaptive as a distributed process across the coach–athlete system: situating the coach in the constraints-led approach. *Physical Education and Sport Pedagogy, 24*(2), 146-161.

Oppici, L., Panchuk, D., Serpiello, F. R., & Farrow, D. (2018). Futsal task constraints promote transfer of passing skill to soccer task constraints. *European Journal of Sport Science, 18*(7), 947-954.

Pizarro, A. P., García-González, L., Cortés, Á. M., Arroyo, M. P. M., & Domínguez, A. M. (2016). Application of an intervention program to improve tactical understanding in indoor football: a study conducted in an educational context [in Spanish]. *Movimento, 22*(1), 51-62.

Power, G. A., Dalton, B. H., Behm, D. G., Doherty, T. J., Vandervoort, A. A., & Rice, C. L. (2012). Motor unit survival in lifelong runners is muscle dependent. *Medicine & Science in Sports & Exercise, 44*(7), 1235-1242.

Práxedes, A., Del Villar, F., Pizarro, D., & Moreno, A. (2018). The impact of nonlinear pedagogy on decision-making and execution in youth soccer players according to game actions. *Journal of Human Kinetics, 62*(1), 185-198.

Raiola, G., D'Isanto, T., Di Domenico, F., & D'Elia, F. (2022). Effect of Teaching Methods on Motor Efficiency, Perceptions and Awareness in Children. *International Journal of Environmental Research and Public Health, 19*(16), 1-10.

Renshaw, I., Araújo, D., Button, C., Chow, J. Y., Davids, K., & Moy, B. (2016). Why the constraints-led approach is not teaching games for understanding: A clarification. *Physical Education and Sport Pedagogy, 21*(5), 459-480.

Reynoso, S. R., Solana, R. S., Vaíllo, R. R., & Hernández, F. J. M. (2013). Differential Learning Applied to Volleyball Serves in Novice Athletes [in Spanish]. *Apunts. Educación Física y Deporte, 4*(114), 45-52.

Ribeiro, J., Davids, K., Araújo, D., Silva, P., Ramos, J., Lopes, R., & Garganta, J. (2019). The role of hypernetworks as a multilevel methodology for modelling and understanding dynamics of team sports performance. *Sports Medicine, 49*(9), 1337-1344.

Roberts, S. J., Rudd, J. R., & Reeves, M. J. (2020). Efficacy of using non-linear pedagogy to support attacking players' individual learning objectives in elite-youth football: A randomised cross-over trial. *Journal of Sports Sciences, 38*(11-12), 1454-1464.

Selmanović A, Škegro D & Milanović D. (2015). Basic characteristics of offensive modalities in the Euroleague and the NBA. *Acta Kinesiologica, 9*(2), 83-87.

Seifert, L., Orth, D., Button, C., Brymer, E., & Davids, K. (2017). An ecological dynamics framework for the acquisition of perceptual–motor skills in climbing. *Extreme Sports Medicine*, 365-382.

Serra-Olivares, J., & Garcia-Rubio, J. (2017). Tactical problems, key component of the representative design of tasks within the non-linear pedagogy approach applied to sports [in Spanish]. *Retos. Nuevas Tendencias en Educación Física, Deporte y Recreación,* (32), 270-278.

Silva, A. F., Conte, D., & Clemente, F. M. (2020). Decision-making in youth team-sports players: A systematic review. *International Journal of Environmental Research and Public Health, 17*(11), 1-23.

Silva, P., Garganta, J., Araújo, D., Davids, K., & Aguiar, P. (2013). Shared knowledge or shared affordances? Insights from an ecological dynamics approach to team coordination in sports*. Sports Medicine, 43*(9), 765-772.

Smith, S. M., Cotterill, S. T., & Brown, H. (2020). An interpretative phenomenological analysis of performance influencing factors within the practice environment. *Journal of Physical Education and Sport, 20*(4), 1646-1657.

Smith, L., Harvey, S., Savory, L., Fairclough, S., Kozub, S., & Kerr, C. (2014). Physical activity levels and motivational responses of boys and girls. *European Physical Education Review, 21*(1), 93–113

Sotolongo, P. (2007) Complexity, Nonlinearity, and Distributed Networks [in Spanish]. *Revista Sobre Complejidad, Ciencia y Estética, 3*(1), 6-20.

Stavropoulos, N., Papadopoulou, A., & Kolias, P. (2021). Evaluating the Efficiency of Off-Ball Screens in Elite Basketball Teams via Second-Order Markov Modelling. *Mathematics, 9*(16) 1-13.

Strafford, B. W., Van Der Steen, P., Davids, K., & Stone, J. A. (2018). Parkour as a donor sport for athletic development in youth team sports: insights through an ecological dynamics lens*. Sports Medicine-Open, 4*, 1-6.

Torrents, C., Balagué, N., Ric, Á., & Hristovski, R. (2021). The motor creativity paradox: Constraining to release degrees of freedom. *Psychology of Aesthetics, Creativity, and the Arts, 15*(2), 340–351.

Warren, W. (2006). The dynamics of perception and action. *Psychological Review, 133*(2), 358-389.

Weir, J. P. (2005). Quantifying test-retest reliability using the intraclass correlation coefficient and the SEM. *The Journal of Strength & Conditioning Research, 19*(1), 231–240.