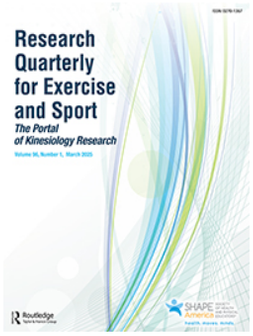

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Exploring the Effects of Instruction and Game Design on Youth Soccer Players' Skill Involvement and Cooperative Team Behaviour

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ABSTRACT

Objectives: The relationship between task constraints and player behaviors is of interest to coaches tasked with designing practice to optimize learning. This study aims to compare the skill involvements and cooperative team behavior of teams of youth soccer players engaged in a goal exaggeration and/or a prescriptive coach instruction condition compared to a free-play control condition. **Methods**: Twenty male soccer players aged 12–15 participated in small-sided games under four conditions: free-play, goal exaggeration, prescriptive coach instruction, and combination over four weeks. Using video footage, teams' collective skill involvements (shot, pass, dribble) and passing network characteristics (closeness, density, and betweenness) were measured for each game. **Results**: A Friedmans rank test identified that playing conditions resulted in significant differences in attempted dribbles ($p < .001$), goals scored ($p < .001$), network density ($p = .001$), closeness ($p < .001$) and betweenness ($p = .002$). Teams attempted to dribble the most in the free-play and goal-exaggeration conditions, and the most goals were scored in the goal-exaggeration and combination conditions. Additionally, teams exhibited more well-connected passing networks (i.e. higher density, higher closeness, and lower betweenness values) in the combination condition and higher network density in the explicit instruction condition. **Conclusions**: The results of this study indicate that coach instruction may be more associated with cooperative team behavior, whereas free-play or manipulating task constraints in the absence of instruction may be associated with players attempting more individual actions.

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KEYWORDS
Constraints; dynamical systems; small-sided games; sports performance

Practice designers, particularly coaches, strive to create effective learning environments that expose players to diverse game-like situations (O'Connor et al., 2017). Recent theoretical perspectives in invasion games, such as soccer, highlight the importance of activities that closely resemble the actual performance environment. These representative training approaches have demonstrated a greater potential to develop decision-making skills and tactical awareness that can readily transfer to competitive contexts, in contrast to traditional coaching methods that primarily emphasize isolated technical skill practice (Pinder et al., 2011; Serra-Olivares et al., 2015). Moreover, these training activities actively engage players in the learning process by encouraging experimentation and discovery (Azzarito & Ennis, 2003). As a result, small-sided games (SSG) with modified rules or equipment (e.g. smaller player numbers, larger field, multiple goals, two-touch etc.) are a popular training tool for coaches. In addition, manipulating key task constraints can be helpful for coaches who use the pedagogical principles outlined in the constraints-led approach to elicit specific behaviors during practice and transfer these to game environments for improved performance and long-term skill development (Côté & Gilbert, 2009; Davids et al., 2013).

Historically, notational analysis techniques such as skill involvements were widely utilized to understand team performance in training and competitive environments. However, recent developments in performance analysis advocate for a shift in approach, aligning with principles from dynamical systems theory and complexity sciences (Ribeiro et al., 2017; Vilar et al., 2012). One approach involves creating cooperative passing networks based on the origin and destination of passes, to understand interpersonal interactions and collective performance Gonçalves et al. (2017). Previous research suggests that well-connected passing networks could be associated with a team's ability to maintain ball flow and depend less on certain players (Travassos et al., 2014), which are often associated with positive match outcomes (Clemente et al., 2015). For example, Gonçalves et al. (2017) discovered that youth soccer teams with lower betweenness (a skewed passing contribution where a few players are more frequently involved in passing interactions) and higher closeness (each player can be easily reached through passes) scores in their passing networks demonstrated greater efficacy, meaning they scored more goals relative to shots at goal. This suggests that teams relying less on a single player's passing contribution and fostering mutual passing interactions among all players were more likely to score frequently during goal attempts.

Coaches commonly use small-sided games to exaggerate formats of competitive contexts and help to strengthen specific individual technical and collective tactical behaviors, providing opportunities to experience the physical, physiological, and technical demands of competition (Hill-Haas et al., 2009;

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Ometto et al., 2018; Travassos et al., 2014). Multiple studies have examined the influence of these task constraints, finding that coaches can increase the distances between players of the same team by increasing the field size (Clemente et al., 2020) and creating numerical superiority (Canton et al., 2019). Additional studies have noticed an increase in the technical-tactical actions performed when reducing the number of players (Batista et al., 2019) and the field size (Katis & Kellis, 2009) in SSG. Similarly, manipulating scoring targets is a common practice in training sessions to impose constraints on SSG, consequently affecting the physical and technical demands of the game (Duarte et al., 2010; Hill-Haas et al., 2011). By altering the location or number of scoring targets, the information available to players changes, which in turn impacts their exploration of possible actions during the game (Davids et al., 2013). Specifically, increasing the number of scoring targets in small-sided games heightens the information that attackers must consider when aiming for the goal, as it introduces a greater number of shooting lines that constantly emerge and disappear.

Some studies have analyzed the effect of instruction as a task constraint in the learning process of sports participants and physical education students [14–16]. For example, Cordovil et al. (2009) showed that manipulating initial instructions in basketball (neutral, risk or conservative) changed interpersonal relationships among players and affected how players explored space during 1 × 1basketball tasks. Further research has revealed that providing athletes with tactical instructions before completing a simulated soccer decision-making task impaired player response accuracy, particularly when instructions were incongruent with the task (Beavan & Fransen, 2021). However, instructions were associated with faster response times regardless of the congruency. While there are quite are a number of studies examining the influence of instructions in practice environments, no studies have looked at how this impacts a teams passing network.

Two main pedagogical methods are those relying heavily on prescriptive instruction and those using practice design methods based on constraints (Cushion et al., 2012). Despite some coaches utilizing a combination of these two pedagogies, the literature does not reflect the commonplace nature of these methods in a practical setting. Therefore, this study aims to compare task constraint manipulation and explicit instructions (in isolation and combination) with a free-play control condition regarding the skill involvement and the cooperative team behavior of youth soccer players. Given this study's exploratory nature, the aim is to understand better the relationship between SSG design and collective and cooperative behaviors in youth football teams without providing conclusive results.

Methodology

Participants

A convenience sample of twenty male soccer players (12-15y) who compete at the highest-level state league (National Premier League) in Australia in the U13 and U15 competitions volunteered to participate in the study. Participants engaged in at least four hours of coach-led training per week (i.e. 2 × 2-hour sessions). All participants were free from injuries, which would have prevented maximal efforts at the time of assessment. The participants were divided into four evenly skilled teams of five players within their respective age groups as determined by their coach's perception of skill (i.e. athleticism and technical/tactical proficiency). Participants in each team all has experience training and playing together. All participants and their parents/guardians were informed of the testing procedure. They completed written consent before participating in this study. The study received approval from the Human Research Ethics Committee of the University of Newcastle (reference number: H-2017–0245).

Procedures

The study was conducted during four regular training sessions over a four-week period during the competitive season. One session each week was dedicated to study and the other to regular soccer training. Participants played three eight-minute games in each session, separated by five minutes of passive recovery. SSGs were prescribed as 5 vs. 5 without goalkeepers on a 44 m long by 35 m wide pitch (relative space per player = 154 m^2). Small, modified goals (4 ft round pop up goal [Pro Football Group, Australia]) were utilized in each of the games and multiple balls (>5) surrounded the field to maintain the speed of play across the total game duration (i.e. the players could continue to play immediately if the ball left the field of play). If the ball went out of the field of play, a kick-in restart was taken. In all playing weeks, players received standardized instructions about the purpose of the game and were instructed to play as if it is a normal competitive match with regulation playing rules. In each of the four sessions, teams were assessed under one of four conditions in the following order: (1) "Free-play" - players were instructed to play the SSG as if it were a standard training game and were provided with no further rules or conditions. One small, modified goal was set up in the middle of each end of the field (Figure 1a). (2) "Goal exaggeration" - each team attacked and defended three goals, with the two outside goals worth triple points (Figure 1b). (3) "Explicit instruction" – attacking players were instructed to use the width of the pitch as much as possible, and the coach provided verbal cues of this concept throughout the games (e.g. directing players to move to and pass to team members in the lateral corridors of the pitch). Field layout is identical to the Free-play condition. (4) "Combination"– a combination of the goal exaggeration and explicit instruction conditions. The methodological design of the SSG protocol was developed with the input of experienced youth coaches who use variants of these SSGs to encourage cooperation by spreading out the team to create space for the team in possession of the ball. This is a common principle of play amongst all types of invasion games. Under the Explicit Instruction and Combination conditions, participants were provided with instructions from their coach before the game, with verbal cues aligning only to the tactical principal allowed throughout the games. All games were filmed from a height of approximately three meters from the corner of the field to ensure the entirety of the game could be seen in one frame

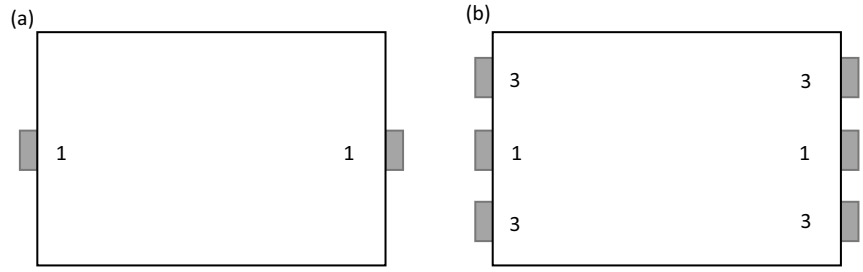

Figure 1. Field formats utilized. Standard scoring conditions (a) is used in the Free Play and Explicit Instructions conditions. Alternative scoring format (b) is used in the Goal Exaggeration and Combination conditions. Numbers represents points allocated to each goal.

using a 4K video camera (GoPro, San Mateo, California). In addition, a secondary camera was placed in the opposite corner of the field at approximately 1.5 m high to ensure all aspects of play could be viewed and analyzed.

Data collection

Individual skills

Video files of the SSG were analyzed using Dartfish video analysis software and a customized macro-based Microsoft Excel spreadsheet. Attempted and completed offensive individual skill involvements (dribble, pass, and shots) were noted for each team during all small-sided games, as per the definitions listed in Bennett et al. (2018) and O'Brien-Smith et al. (2022). To assess intra-rater reliability, the primary researcher coded two SSG twice over a two-week period under the same conditions. Cohens Kappa revealed a near perfect agreement (K = .85) between the retest trials for all variables.

Cooperative passing networks

Notational analysis of distributors and receivers of effective passes from the video analysis aided the creation of a 5×5 directed adjacency matrix for each team, for each game. The adjacency matrix presents the number of successful passes between players within teams and can be used to create cooperative passing networks, which are visualizations of the passing interactions between players within the same team (Sheehan et al., 2022). The characteristics that define these cooperative networks can then be studied by calculating derivative metrics: in this case, density, closeness and betweenness at the level of the whole team. The density of a passing network refers to the number of potential connections in a network that are actual connections. For example, in a team of five players, the number of possible connections in a directed network is 20 (each player connects bi-directionally with each other player). A density of 0.5 would indicate that half of the possible edges ($n = 20 \times 0.5 = 10$) are actual observed interactions between players in a game. The more the density of a network approximates 1, the more "complete" the passing network. Betweenness is a measure of the centrality of a passing network that can be used to understand which players are influential in circulating ball possession throughout the team. It is calculated based on how often a player lies on the shortest passing path between two other players within their team. Lower values relate to a well-balanced passing strategy that is not reliant on the passing performed by a specific set of players. Finally, closeness centrality refers to how many passing interactions connect a single player to all other players within a team and represents how reachable a single player is by all other players within their team. Higher values assume a player requires fewer passes to connect with other players (O'Brien-Smith et al., 2022). The network measures for each team were calculated based on the adjacency matrix using Social Network Visualizer (SocNetV 3.0.4)

Given the nature of this study (the observation of cooperative behaviors and team-aggregated skill involvements), the sample size for this study is logically small (i.e. the unit of analysis is the team, even though it consists of multiple players. As a result, the sample size used in this study is based on feasibility and likely limits statistical power.

Statistical analyses

Given the small sample size, we opted to use a series of Friedman tests which are a non-parametric alternative to one-way Analysis of Variance (ANOVA) with repeated measures. Friedman tests are used to evaluate the mean ranks of related groups to indicate how they differ from one another. We used skill involvements (goals, passes and dribbles) and cooperative passing network characteristics (density, closeness and betweenness measures) as dependent variables while SSG design condition (free play, goal exaggeration, explicit instruction and combination) was used as a within-subjects factor. Given that we ran multiple tests (nine outcome measures were tested against one independent variable), we applied the Bonferroni Correction for multiple testing (significance value cutoff is set at $p < .05/6 = 0.006$. Values for Kendall's W effect sizes (ŴKendall) were calculated, and the following thresholds used for interpretation: 0.1 - < 0.3 (small), 0.3 - < 0.5 (moderate) and ≥ 0.5 (large). Statistical analyses were performed using R (R Core Team, 2021).

Results

The median and interquartile range (IQR) were calculated for all variables and are presented in Figures 2–4. The Friedman rank test indicated that there was a statistically significant difference in the number of dribbles attempted, goals scored, network density, closeness, and betweenness (Table 1) between the different SSG design conditions. Post-hoc Durbin-Conover pairwise comparisons were conducted with a Bonferroni correction applied. Teams attempted to dribble the most in the Free-Play and Goal Exaggeration conditions

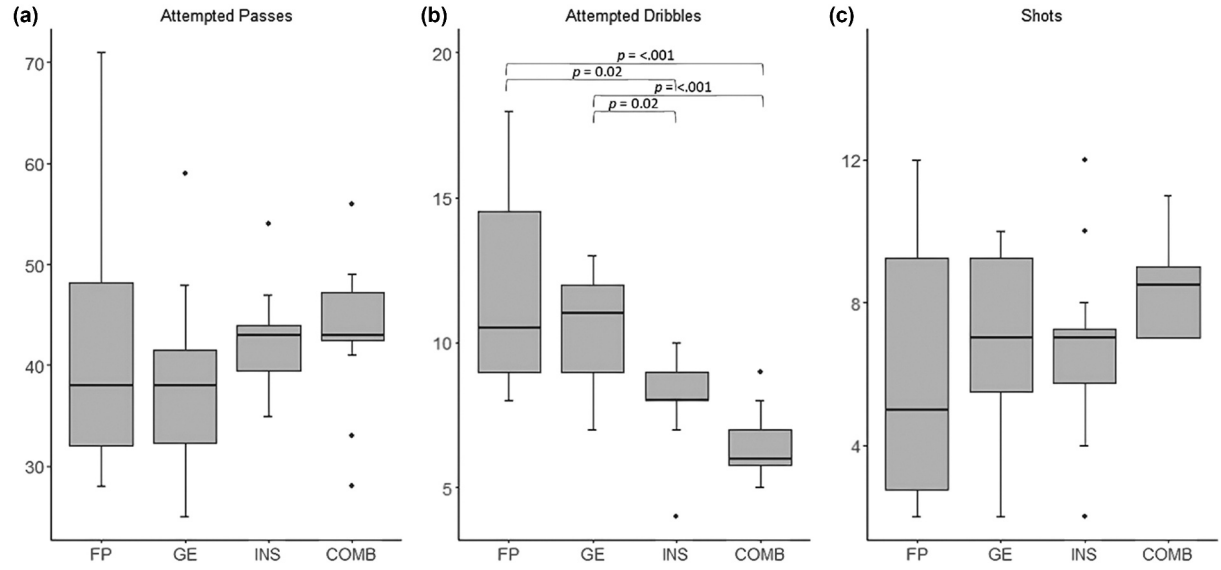

Figure 2. A comparison of attempted passes (a), dribbles (b) and shots (c) in the Free-play (FP), Goal Exaggerations (GE), Coach Instruction (INS) and Combination (COMB) conditions. Bars indicate significant pairwise comparisons under a Bonferroni correction.

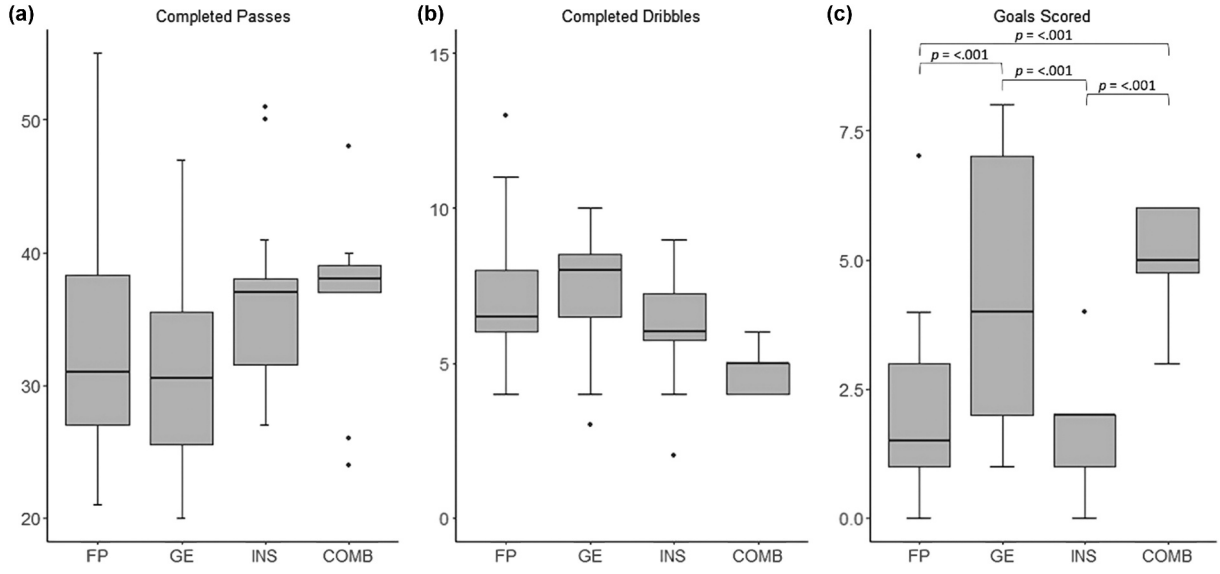

Figure 3. A comparison of completed passes (a), dribbles (b) and goals (c) in the Free-play (FP), Goal Exaggerations (GE), Coach Instruction (INS) and Combination (COMB) conditions. Bars indicate significant pairwise comparisons under a Bonferroni correction.

when compared with the instruction and combination conditions (Figure 2b). Additionally, teams scored more goals in the goal exaggeration and combination conditions than in the free-play and instruction conditions (Figure 3b). Moreover, teams exhibited higher intra-team well-connected passing relations (i.e. higher density, higher closeness, and lower betweenness values) in the combination condition versus all other conditions. Additionally, higher network density was observed in the Explicit Instruction condition when compared with the goal exaggeration condition (Figure 4a).

Discussion

This study explored the relationship between SSG design and cooperative skill behaviors in youth soccer teams. The current study's findings demonstrate that the nature (i.e. task constraints) of a SSG is related to a team's behaviors, such as how many goals are scored, the number of attempted dribbles and the nature of the teams' passing network interactions. More specifically, the combination condition (instructions and additional scoring targets) resulted in the highest number of goals scored, the densest passing network, the highest closeness values, and the lowest betweenness values. Contrarily, attempting to dribble was most frequently observed in free-play and goal-exaggeration conditions.

This study was designed to include different task constraint manipulations to better represent some of the pedogeological principles used in a practice environment (i.e. using both game rule manipulation and the inclusion of explicit instructions). Our study's findings identified that the inclusion of coach instructions was associated with more connected passing networks, even more so when combined with additional scoring

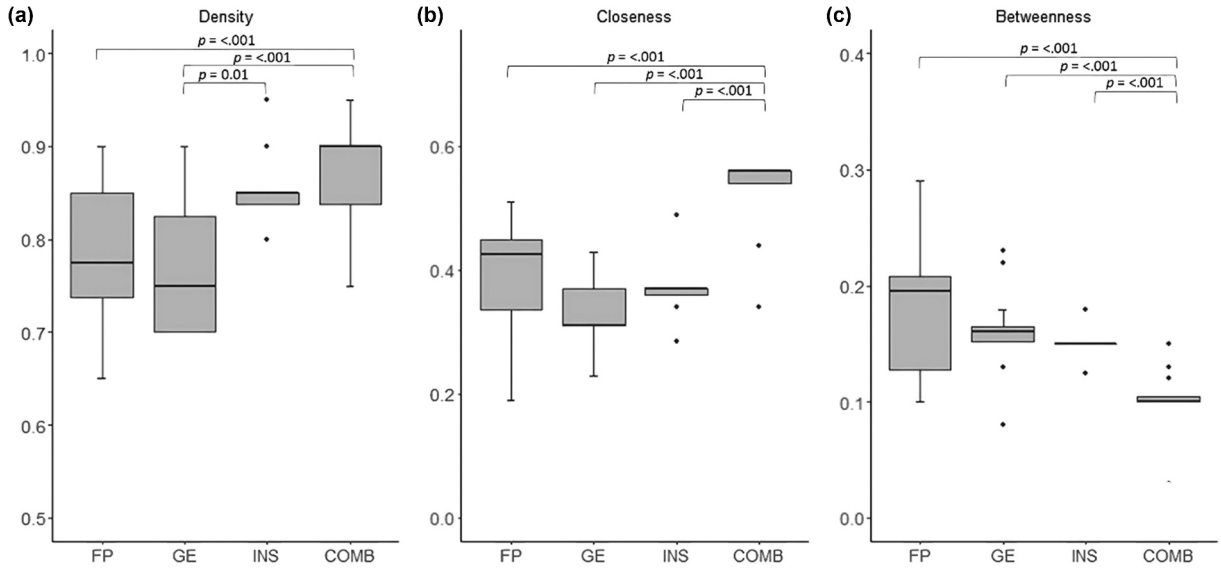

Figure 4. A comparison of network density (a), closeness (b) and betweenness (c) in the Free-play (FP), Goal Exaggerations (GE), Coach Instruction (INS) and Combination (COMB) conditions. Bars indicate significant pairwise comparisons under a Bonferroni correction.

Table 1. Results of Friedman's Rank tests.

Variable	$\chi^2_{Freidman}$ (3)	*p*	$\hat{W}_{Kendall}$		$CI_{95\%}$
Attempted Passes	6.31	.1	0.18	Small	[0.07, 1]
Attempted Dribbles	20.22	<.001*	0.56	Large	[0.32, 1]
Shots	8.42	.04	0.23	Small	[0.08, 1]
Completed Passes	7.56	.06	0.21	Small	[0.05, 1]
Completed Dribbles	12.42	.006	0.35	Moderate	[0.18, 1]
Density	15.72	.001*	0.44	Moderate	[0.30, 1]
Closeness	22.5	<.001*	0.62	Large	[0.44, 1]
Betweeness	14.77	.002*	0.41	Moderate	[0.28, 1]

Note. Friedman's Rank test = χ2Freidman, Kendall's W values as effect sizes = ŴKendall, 95% Confidence intervals of ŴKendall = $CI_{95\%}$, * = significant effects of game condition ($p_{Bonferroni}$ = < 0.006).

targets. Some previous studies have also examined the effect of instructions on tactical behaviors, such as the amount of space a team occupies (Batista et al., 2019). However, no studies have examined the influence of instructions on team cooperative behaviors in the way of passing networks. The study associating instructions and team-tactical behaviors found that when teams received offensive instructions (i.e. to maintain ball possession), they occupied more space on the pitch than the team who received no instructions (Batista et al., 2019). Previous research has concluded that manipulation of instructions provided by coaches can significantly shape emergent decision-making (Cordovil et al., 2009). Our study adds to this small body of work by suggesting that coach instructions may provide an immediate benefit that supports cooperative behavior at an acute level (i.e. more well-connected passing networks) (Silva et al., 2013). While these effect sizes suggest a moderate to large effect of the playing condition on passing network characteristics, the confidence intervals lack precision (Table 1). Furthermore, the confidence intervals of the effect size indicate that this association observed in our finding can fluctuate in the context of the population from which our sample was sourced. Thus, it is difficult to comment on the true effects of playing condition without research in a larger cohort, which the exploratory findings in this study encourage for future research. With the opportunity to explore this further, we may begin to understand when, where, and why coach instruction is most effective (e.g. performance vs learning).

Although there were no differences in the number of completed skills (aside from a somewhat logical finding that more goals were scored when additional scoring targets were added), there was a significant difference in the number of dribbles attempted between conditions. Players attempted to dribble the ball more in the conditions without instructions (i.e., free-play and goal exaggeration) than in the combination condition. Previous research identifies the importance of dribbling and other creative actions for goal-scoring success and positive match outcomes (Kempe & Memmert, 2018; Wilson et al., 2020). While the addition of instructions may be a more effective way to develop cooperative behaviors and group tactics, their absence may lead to more individualistic behaviors.

In the current investigation, not all methods for assessing skilled behavior produced similar results. For example, the combination of instructions and goal exaggeration was associated with more favorable network characteristics, whereas there was no significant association between the number of attempted or completed passes. This highlights that examining cooperative passing networks provides different results than assessing collective skill involvement alone. Despite some literature highlighting that analyzing team sports in a social

network structure might provide valuable insights about cooperative behaviors in team sport (Passos et al., 2011), relatively few studies have incorporated such a level of analysis alongside more traditional analyses of skill involvements and none have used this tool to examine the influence of task constraints in SSG. Combining cooperative passing networks with measures of notational analysis may provide researchers and practitioners with richer data when describing behavior in team sports.

To our knowledge, this is the first study to examine the influence of task constraints with or without explicit instructions on skill involvements and passing network characteristics using different SSG formats. This study shows that task constraints and instructions are associated with team behaviors. Nonetheless, the findings of this study need to be observed in light of the study's limitations and methodological shortcomings. First, this study only examined a snapshot of player behaviors and may not represent all behaviors exhibited by players during gameplay. While using a(n) (quasi) experimental design was not feasible in this study, future research should use the exploratory findings from this study to argue for an implementation of an experimental trial to examine the causal relationship between task constraint manipulations, coach instructions, and football team behaviors. Furthermore, while this study is a good first step in understanding the interaction of task constraints and instruction on cooperative behavior, the sample size is small. While small sample sizes are common in this field of study (Ometto et al., 2018), it is important to consider that the study itself may have been underpowered and that the results obtained for the specific sample used in this study may not be representative of youth football teams in general.

Conclusion

This study aimed to examine the influence of task constraints with or without explicit instructions on skill involvements and passing networks of youth football teams using different SSG formats. Aside from scoring more goals, no other behaviors were associated with the addition of extra scoring targets. Teams attempted to dribble more in the conditions without instructions (i.e. free-play and goal exaggeration). In contrast, more well-connected passing networks were seen in the conditions with instructions (instructions and combination). These results may indicate that the inclusion of task constraints and instruction may elicit different types of behaviors in youth football teams and that utilizing network science to analyze team behavior may provide valuable insights for coaches and researchers. This study highlights the need for more research to understand the effects of coach and task constraint manipulations on youth football team behaviors. Nevertheless, this study provides some novel insight into the influence of constraints in youth football.

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