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The effects of individual and collective variability on youth players' movement behaviours during football small-sided games

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ABSTRACT
This study aimed to identify the effects of playing with additional individual (IND), collective (COL) or individual-collective (MIX) variability on youth football players' performance during small-sided games. Twelve youth football players (U17, age = 16.1 ± 0.9 years) played a goalkeeper (Gk) + 6 outfield players a-side (Gk+6vs6+Gk) under four conditions: (i) playing in the 1:2:3:1 formation without any other rule (control condition, CTR); (ii) 1:2:3:1 formation with additional body restrictions changing each minute (individual condition, IND); (iii) using different tactical formations modified each minute (collective condition, COL; (iv) using different tactical formations and body restrictions varied each minute (individual-collective condition, MIX). Generally, there were similar behaviours across conditions, especially for the CTR and the MIX. Nevertheless, the CTR condition presented moderate higher values in the lateral direction ($p \leq .05$), while also higher longitudinal synchronization compared to the IND ($p \leq .05$). The COL condition presented higher spatial exploration ($p \leq .05$), which may justify the higher values for distance covered while running and sprinting ($p \leq .05$). Overall, coaches may use the IND condition to refine players' technical actions, while the COL condition to develop players' ability to perform in different playing positions and team structures.

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Positioning variables; technical performance; team sports; movement variability; adaptability

Introduction

In recent years, there has been an increasing body of research that suggests that football players may benefit from performing tasks with additional variability (Coutinho et al., 2019a, 2018; Santos et al., 2018a). Under this domain, differential

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learning (DL) emerges as one of the few theoretically consistent and empirically substantiated motor learning approaches that assist coaches in optimizing movement variability (Henz & Schollhorn, 2016; Schöllhorn, 2000; Schöllhorn et al., 2012, 2006). Differential learning fosters adaptive mechanisms in the perception-action system of the players by increasing fluctuations in their movement patterns throughout neither movement repetition nor corrective feedback after the task executions (Frank et al., 2008; Santos et al., 2018a). In this approach, for example, players are encouraged to shoot at a target with unusual movements and/or postures in each execution (e.g. right arm circles, both hands on the chest, upper body leaning forwards, left knee stiff), which improves players' movement adaptability as a result of the imposed body conditions. Accordingly, DL consists of exposing players to a broader range of individual conditions that destabilize the existing movement patterns and initiates the exploration of new possibilities of individual and tactical coordination (self-organization). In consequence, DL leads to the development of more functional and adaptive movement patterns (Santos et al., 2018a; Schöllhorn et al., 2006).

Taking into consideration these assumptions, various training programmes have been developed to understand how tasks embodied in variability impact the players' movement behaviour. For example, one study analysed an intervention of a 5 month period, consisting of 3 training sessions per week with a duration of 30-min, in which the players (under-13 and under-15) had to perform small-sided games (SSG) with additional variability (e.g. using different types of balls, playing with hands tied or with using a patch in one eye; Santos et al., 2018a). For this purpose, the players performed a Goalkeeper + 4 outfield players (Gk+4vs4+ Gk) small-sided game in which their spatial movements were tracked with global positioning system (GPS) and recorded the game with a digital video camera. From the GPS data, it was possible to compute spatial relations between teams, such as the distance to the team centroid or to both targets. The video analysis allowed to be captured the players' passing, dribbling and shooting actions, as well as the creative components of attempts, fluency, versatility and originality (Santos et al., 2018a). The training intervention improved the players' technical actions and creative predisposition, suggesting that the variability guided the players to search for adaptive movement behaviours (Santos et al., 2018a). The benefits of adding variability in certain playing positions were also addressed in another study, where the results showed improvement in players' technical, creative and positional behaviour (Coutinho et al., 2018). Experimental groups (age: U15 and U17) were exposed to a two-month intervention supported mainly by variability during SSG, while the control group performed more traditional and normal SSG. The players were tested using the previously reported methodological procedures (GPS and video analysis). Compared to the control group, players' passing, dribbling, and shooting skills improved (especially in the U15), as did their fluency and versatility (i.e. creative components). Their behaviour also led to more unpredictable movements on the field (Coutinho et al., 2018). Similarly, in basketball, continuous variation in the number of players during SSGs, without any explicit instructions on their behaviour, led the team to self-organize their behaviour to resemble that of expert players without explicit instructional support (Poureghbali et al., 2020). Overall, these studies have provided evidence for improvement in players' and teams' performance as a result of interventions sustained by variability (Coutinho et al., 2018; Poureghbali et al., 2020; Santos et al., 2018b).

Soccer players seem to benefit from mid- to long-term interventions sustained on variability (Coutinho et al., 2018; Santos et al., 2018b). That is, soccer players seem to improve performance when exposed to training interventions of at least 2 months embedded by added variability. However, in these interventions (Coutinho et al., 2018; Santos et al., 2018b), the players' performance was assessed in tasks without any additional variability (e.g. Gk+5vs5+ Gk under normal circumstances). In this respect, different results would likely emerge if players' performance were measured in an acute perspective, in which their behaviour is analysed when playing under variability (e.g. playing with the hands tied). Based on these considerations, a narrow body of research started to explore how players dynamically adjust their behaviour because of the continuous manipulations of the boundary conditions promoted by the coach. For example, one study explored how varying the pitch boundaries in a dynamic way (that is, varying the pitch size/shape every 1 min for a total of 6-min) affected the players' performance in under-13 and under-15 players (Coutinho et al., 2019a). To attain such aims, players' positional variables were explored, such as the teams' lateral and longitudinal synchronization, which are metrics that measure the percentage of time that the players spent synchronized in the longitudinal and lateral directions (Folgado et al., 2014, 2018). In addition, the effect of additional variability on the distance travelled by players at different intensities (low, moderate, and high intensity) was also investigated. Results revealed decreased movement synchronization (i.e. ability to move collectively in the same direction; from a practical perspective, being synchronized in the longitudinal direction would mean that both central defenders would decrease their distance to their own goal while defending and in the same time-period) and physical performance parameters decreased when playing in the pitch whose space and shape dynamically varied compared to a control condition (i.e. the task performed without this additional variability; Coutinho et al., 2019a). Santos et al. (2020) recently explored how players adjust their movement patterns during a 4-a-side and 6-a-side SSG while varying the type of ball: a) football ball (control condition); b) handball ball; c) rugby ball; and d) a mixed condition, which the ball of the match was replaced by one of the three balls used every 2 min for a total of 6 min. By means of GPS and video recordings the same parameters related to performance, technique and creative aspects as in previous studies were assessed. When comparing the control with the mixed condition (with additional variability), the latter decreased the players' technical performance and distance covered and promoted lower team dispersion (i.e. ability to use the pitch width and length, as this variable is processed as result of the maximum distance between players from the same team in either the longitudinal and lateral direction; Santos et al., 2020).

Interestingly, the type of variations applied seems to elicit different responses by each player. That is, the impact of the variability on the players' performance seems to result from the type and magnitude of the manipulation. For example, when manipulating task-related boundary conditions (e.g. pitch size/shape), players seem to be more affected from their collective perspective (i.e. team coordination that represents the team ability to either move in the longitudinal or lateral direction collectively, such as while attempting to pressure the opponent in a wider channel), as reflected by the movement synchronization parameters (Coutinho et al., 2019a). In contrast, when manipulating individual-related boundary conditions (e.g. playing with different types of balls), variability seems to predominantly affect individual responses, such as passing, dribbling and shooting actions (Santos et al., 2020). In addition, different brain areas are activated depending on the type and magnitude of variability induced (Henz et al., 2018), which seem to reinforce that the structure and amount of variability influence how and which players adapt their behaviour. On this basis, it is possible that promoting manipulations that are more individual-based, such as adding interference in the form of physical constraints (e.g. playing with hands tied), or that are more team-based, such as dynamically changing the team game structure (e.g. starting with 2-3-1 and changing to 2-2-2 after 1 min), may result in different tactical, technical, and physical behaviours. Nevertheless, further research is required to find corroborative evidence for these hypotheses. Therefore, this study aimed to identify the effects of playing with the additional individual (IND), collective (COL) or individual-collective (MIX) variability in youth football players' positional, physical and technical performance during small-sided games.

Methods

Participants

Twelve youth football players (age = 16.1 ± 0.9 years; height = 172.1 ± 12.2 cm; weight = 65.6 ± 6.2 kg; football experience = 7.5 ± 3.4 years) from a Portuguese club competing at the regional level volunteered in this study. All players were engaged in four training sessions per week (90 to 105 min per session) and had an official eleven-a-side match during the weekend. Two goalkeepers participated in the study. However, their data were excluded from data analysis as their role is quite specific and different from those of the outfield players. An informed and written consent was provided to the coaches, players, and their parents, as well as by the club, before the beginning of the study. All participants were notified that they could withdraw from the study at any time. The study protocol followed the guidelines and was approved by the local Ethics Committee and conformed to the recommendations of the Declaration of Helsinki.

Study design

The study design consisted of a repeated measures approach, by playing one goalkeeper (Gk) + 6 outfield players a-side (Gk+6vs6+ Gk) game-based format under four experimental conditions for both teams: (i) control situation (CTR condition), an SSG using the 1:2:3:1 (1 goalkeeper, 2 defenders, 3 midfielders, 1 striker) formation without any additional instruction; (ii) experimental situation by instructing the players to use a 1:2:3:1 formation and with additionally instructed variants (see, Table 1) that were modified each minute to increase the fluctuations in their individual movement behaviour (IND condition); (iii) experimental situation by instructing the players to perform according to specific playing formations (see, Table 1 and Figure 1) that were modified each minute to affect their collective movement behaviour (COL condition); and (iv) experimental situation by instructing the players to concomitantly perform according to specific movement patterns and playing formations (see, Table 1) that were modified at each minute to affect their individual and collective movement behaviours (MIX condition). On each testing day (n = 3) and between days, the order of each condition was randomly set.

Table 1. Characteristics of experimental and control groups.

	Control condition	Individual variability	Collective variability	Mixed variability
Minute	CTR	IND	COL	MIX
0–1′	without specific instruction (1:2:3:1 playing formation)	arms crossed	1:2:1:3	1:2:1:3 + arms crossed
1–2′		hands on the back	1:3:2:1	1:3:2:1 + hands in the back
2–3′		arms down (holding the shorts)	1:2:2:2	1:2:2:2 + arms down (holding the shorts)
3–4′		arms elevated	1:1:3:2	1:1:3:2 + arms elevated
4–5′		left hand touching the head	1:1:4:1	1:1:4:1 + left hand touching the head
5–6′		right hand touching the head	1:3:1:2	1:3:1:2 + right hand touching the head

Procedures

The players were tested in three sessions on non-consecutive days (i.e. across 3 weeks in the Wednesday session) during the competitive period (mid-season). Considering that the players were familiar with comparable conditions under analysis, no familiarization session was necessary. That is, players were exposed to similar conditions as for example, playing with body restrictions such as playing with the hands tied; playing in different playing systems during a Gk+9vs9+ Gk; or even combined different types of variability such as playing with one eye patch and under different number of players. On all days, the sessions began with a standardized 15-min warm-up based on running and a ball possession game (6-a-side without goals). For the SSGs, the head coach selected the 12 best players from the team according to his subjective evaluation of their technical, tactical and physical skills. Considering that balanced teams contribute to better performances (Lemes et al., 2020), participants were divided into two balanced teams based on their playing positions during competitive games (see, Figure 1a, 1:2:3:1 formation). The teams were kept the same across the data collection. Each team performed a total of four Gk+6v6+ Gk SSGs using official 7-a-side goals on an official 62x43m (length × width; individual interaction space = ~225 m^2) artificial turf pitch (Castillo et al., 2020).

Each SSG condition lasted for 6-min with 3-min passive recovery between bouts (see, Figure 2). A considerable number of official size footballs were distributed around the pitch to ensure its replacement as fast as possible, decreasing the time that the ball was out of play. The offside rule was applied and controlled by two assistant coaches that acted as referees close to the sideline. No coach feedback or encouragement was allowed during the SSG conditions (Nunes et al., 2020), apart from the researcher instruction about the technical and tactical specific conditions. That is, in order to ensure that the players followed the conditions imposed, the researcher monitored the game and at every 20 s repeated (sound stimulus) the rules in practice (e.g. from 0 to 1 min, the players had to play with arms crossed, so the game started with this rule, which was again mentioned by the researcher at the 20 s and 40 s, while during the 60 s the information provided was “now play with both hands on the back”).

Players were encouraged to drink water before SSG and between bouts. All sessions started at the same time of the day and were completed within the same duration (60 min; Clemente et al., 2014).

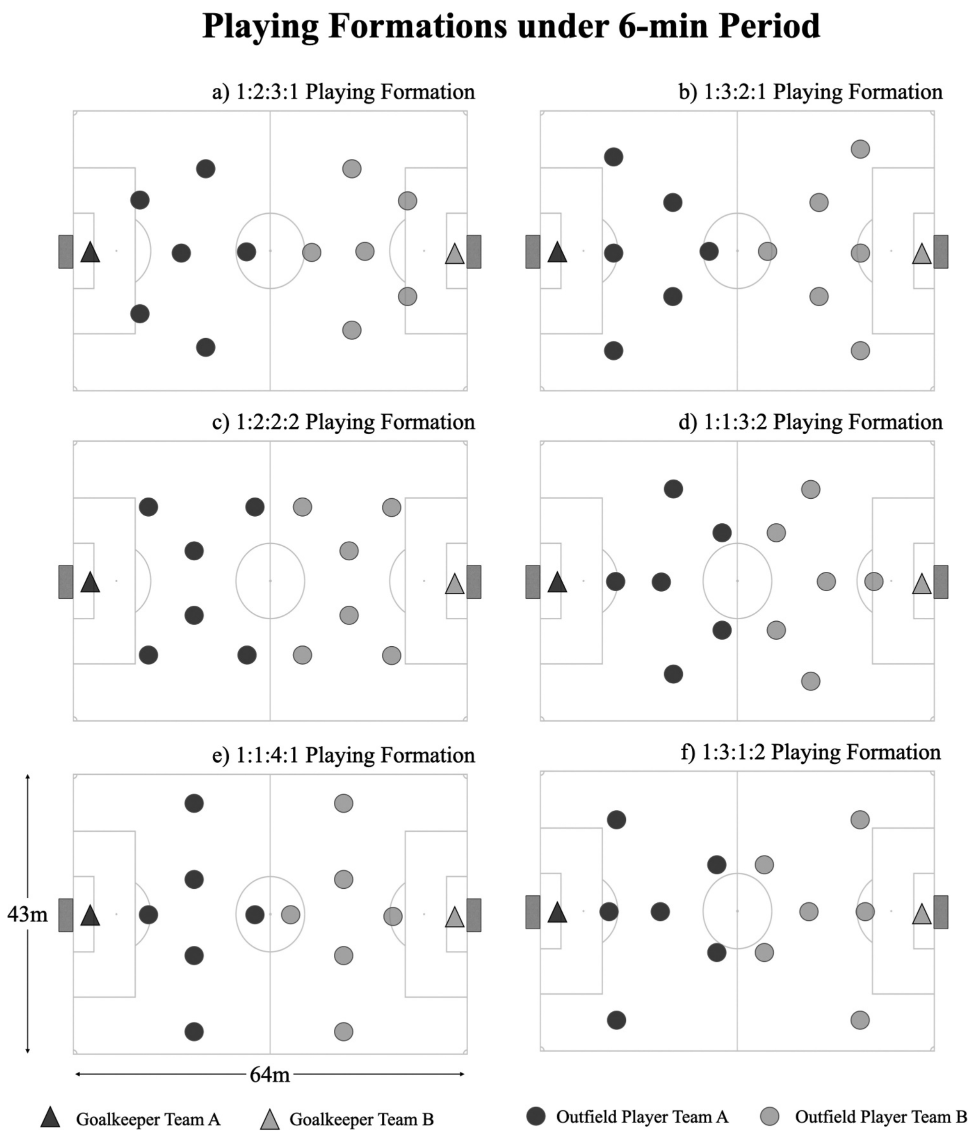

Figure 1. Representation of SSG pitch dimensions and playing formation.

Data collection

Physical and positional data

Positional data and the distance covered during the SSG were collected using 5 Hz global positioning system (GPS) units (SPI-PRO, GPSports, Canberra, ACT, Australia). These devices were worn on the upper back of each player with an appropriate harness. To decrease measurement error and increase the validity and reliability of the system, the players used the same unit for all the game scenarios. The players' latitude and longitude coordinates obtained through games were exported and computed using appropriate

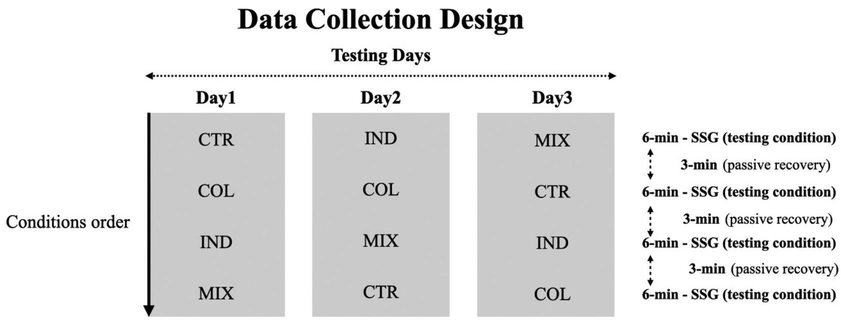

Figure 2. Schematic representation of the data collection design.

routines in Matlab® (MathWorks, Inc., Massachusetts, USA). Additionally, missed data were re-sampled and filtered using a 3 Hz Butterworth low pass filter (see, Folgado et al. (2014) for data correction guidelines).

The positional data of the players were used to determine the spatial exploration index, which represents an average distance in metres from each player means position to his pitch positioning during all the time-series (Gonçalves et al., 2017). The time-position data of the players were also used to calculate the (i) distance from each player to the nearest opponent expressed by the absolute values (m), ii) variability in the distance from each player to the nearest opponent, expressed by the coefficient of variation (CV) and (iii) the regularity in the distance from each player to the nearest opponent, expressed by the approximate entropy (ApEn). The ApEn values range from 0 to 2, in which lower values correspond to a more predictable series. The imputed values used to compute were 2 to vector length (m) and 0.2*std to the tolerance I (Yentes et al., 2013). In addition, the intra-team coordination tendencies were assessed based on the time that players' dyads spent synchronized in both longitudinal and lateral directions through the use of relative phase and the Hilbert transform (Folgado et al., 2015). The movement synchronization of each dyad was quantified by the percentage of time spent between −30° to 30° bin (near-in-phase mode of coordination; Folgado et al., 2014, 2018).

For each player, the total distance covered and the distance covered at different speed levels were calculated (Gonçalves et al., 2016). The following speed categories were considered for analysis: walking (0.0–3.5 km/h); jogging (3.6–14.3 km/h), running (14.4–19.8 km/h) and sprinting (≥ 19.9 km/h; Gonçalves et al., 2016).

Technical performance data

The SSGs were recorded using a digital video camera, Sony NV-GS230, fixed at a 2-m height and aligned with the half-way line of the pitch, to allow the videographer to properly track the ball movement. Then, the video files were downloaded to a computer, and a notational analysis was performed using the LongoMatch software (Longomatch, version 1.3.7, Fluendo; Coutinho et al., 2018). The following technical performance variables were collected: number of touches per possession, successful passes and unsuccessful passes, shots on target and shots out of the target (Liu et al., 2016). The videos were analysed by an experienced performance analyst, and the data reliability was inspected by retesting randomly 20% of the sample. The intra-class correlation was deemed as high (overall values >0.89; touches per possession = 0.86; successful passes = 0.96; unsuccessful passes = 0.90; shots-on-target = 0.84; shots out of target = 0.90; O'Donoghue, 2010).

Statistical analysis

All data were assessed for outliers and assumptions of normality using the Shapiro–Wilk Test. Based on the data normality, two types of tests were used: repeated measures analysis of variance (ANOVA) with a mean (M) and standard deviations (SD) as descriptive results, while the non-parametric Friedman ANOVA with median and interquartile ranges (IQR) as descriptive results was used for the variables that did not reveal a normal distribution. Pairwise differences were assessed with the Bonferroni *post hoc* test, while non-parametric analysis used the Durbin–Conover test. Statistical significance was set at $p < .05$, and calculations were carried out using SPSS software V24.0 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.). Complementary, differences in means with 90 (raw; ±90% CL) of confidence and the Cohen's d as effect size was applied to the pairwise comparison. Thresholds for effect size statistics were: 0–0 – 0.19, trivial; 0.–0 – 0.49, small; 0–6 – 1.19, moderate; 1–2 – 1.9, large; and >2.0, very large (Cumming, 2012).

Results

Effects of playing with additional variability on positional variables

The results from the positional variables when comparing the different scenarios (CTR, control; IND, individual; COL, collective; MIX, individual and collective) are presented in Table 2 and Figure 3. When comparing the condition without variability (CTR) with the conditions with additional variability (IND, COL, MIX), statistically significant differences were found in the SEI ($X^2 = 8.0$, $p \leq .05$), the longitudinal ($X^2 = 28.4$, $p < .001$) and in the lateral synchronization ($F = 17.3$, $p < .001$). Post-hoc analysis revealed that there were higher SEI values in the COL condition compared to the CTR condition (1.24 more, $p \leq .05$, small effect). When motion synchronization was considered, higher values were found in longitudinal synchronization (~7.9 more, $p < .001$, moderate effects) when comparing CTR to IND, and higher values were found in lateral synchronization when comparing to IND (~9.5 more, $p < .001$, moderate effects), COL (~8.3 more, $p < .001$, moderate effects), and MIX (~7.6 more, $p < .001$, moderate effects).

When accounting for the analyses between the conditions with additional variability (IND vs COL; IND vs MIX; and COL vs MIX) it was also identified statistically significant differences in the distance to the nearest opponent ($F = 3.1$, $p \leq .05$) and in the percentage of time spent synchronized in the longitudinal direction ($X^2 = 28.4$, $p < .001$). Under this perspective, the IND showed a higher value in the distance to the nearest opponent compared to the MIX condition (~0.5 more, $p < .001$, small effects). From the longitudinal perspective, it was found lower values in the IND compared to the COL (~0.5 more, $p = .008$, small effects) and MIX (~0.5 more, $p < .001$, moderate effects) conditions. Also, higher values for this variable were identified (~3.4 more, $p \leq .05$, small effects) during the COL compared with the MIX scenario.

Table 2. Descriptive analysis (mean ± SD) for the positional and physical variables, and median and interquartile ranges for the technical variables and uncertainty in the true difference comparisons among the considered SSGs scenarios.

	SSGs conditions				Difference in means (raw; ±90% CL)					
Variables	CTR	IND	COL	MIX	CTR vs IND	CTR vs COL	CTR vs MIX	IND vs COL	IND vs MIX	COL vs MIX
Positional Variables	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD						
Dist. to Nearest Opp. (m)	5.64 ± 1.32	5.94 ± 1.55	5.63 ± 1.19	5.45 ± 1.17	0.30; ±0.27	−0.01; ±0.49	−0.22; ±0.51	−0.32; ±0.31	−0.49; ±0.27 *	−0.17; ±0.21
Dist. to Nearest Opp. (CV)	53.62 ± 7.26	53.27 ± 9.82	56.53 ± 7.14	54.57 ± 10.25	−0.34; ±3.30	4.20; ±3.88	2.43; ±4.08	3.25; ±3.71	1.30; ±3.57	−1.96; ±3.27
Dist. to Nearest Opp. (ApEn)	0.32 ± 0.07	0.30 ± 0.07	0.30 ± 0.07	0.31 ± 0.07	−0.03; ±0.02	−0.01; ±0.03	0.00; ±0.03	0.01; ±0.02	0.02; ±0.02	0.01; ±0.02
Spatial Exploration Index (m)	10.25 ± 1.71	10.46 ± 1.27	11.13 ± 1.35	10.53 ± 1.65	0.22; ±0.45	1.24; ±0.82 *	0.68; ±0.78	0.67; ±0.37	0.07; ±0.45	−0.60; ±0.45
Longitudinal Sync. (%)	59.65 ± 11.9	51.73 ± 13.7	57.27 ± 11.12	61.11 ± 11.85	−7.91; ±2.50 **	−1.95; ±2.89	3.14; ±3.22	5.54; ±2.76 **	9.38; ±2.80 **	3.84; ±2.92 *
Lateral Sync. (%)	42.23 ± 11.27	32.75 ± 10.62	34.34 ± 11.82	34.79 ± 12.54	−9.48; ±2.21 **	−8.34; ±2.91 *	−7.64; ±2.93 **	1.59; ±2.28	2.04; ±2.59	0.46; ±2.47
Physical Variables										
Total Dist. Covered (m)	639.75 ± 121.61	632.61 ± 93.07	675.74 ± 86.04	628.33 ± 80.56	−7.14; ±31.87	64.82; ±49.39	−0.70; ±4.10	43.13; ±17.05 *	−4.28; ±18.62	−47.41; ±17.11 **
Walking (m)	55.15 ± 24.12	54.34 ± 17.06	49.23 ± 14.31	55.98 ± 14.64	−0.81; ±6.14	−4.88; ±7.89	7.10; ±9.30 *	−5.11; ±3.72 *	1.64; ±3.36	6.75; ±2.94 **
Jogging (m)	490.83 ± 114.89	493.36 ± 84.65	503.41 ± 63.11	487.32 ± 76.35	2.53; ±27.21	33.79; ±40.36	1.20; ±5.20	10.05; ±18.34	−6.03; ±14.04	−16.08; ±16.74
Running (m)	71.55 ± 41.48	65.43 ± 28.09	87.68 ± 42.32	63.41 ± 35.53	−6.12; ±12.68	23.40; ±16.75 *	−2.58; ±15.50	22.25; ±8.72 *	−2.02; ±10.72 **	−24.26; ±10.88 **
Sprinting (m)	22.16 ± 18.66	19.48 ± 18.78	34.34 ± 23.51	21.13 ± 17.17	−2.67; ±6.08	11.34; ±8.19**	−2.10; ±7.51	14.86; ±5.85 **	1.65; ±5.97	−13.20; ±6.71 **
Technical Variables	Median (IQR)	Median (IQR)	Median (IQR)	Median (IQR)						
N. touches per possession (n)	2.57 (1.13)	2.58 (1.34)	2.42 (0.96)	2.55 (1.28)	0.23; ±0.29	−0.05; ±0.29	0.10; ±0.34	−0.37; ±0.28	−0.20; ±0.22	0.17; ±0.27
Successful Passes (n)	4.00 (3.00)	3.00 (5.00)	4.00 (4.75)	4.50 (3.75)	−0.28; ±0.90	0.35; ±0.92	0.50; ±1.06	−0.08; ±0.65	0.00; ±0.81	0.08; ±0.56
Unsuccessful Passes (n)	1.00 (0.55)	1.00 (1.00)	1.00 (1.00)	0.00 (1.00)	0.08; ±0.37	−0.02; ±0.33	0.11; ±0.33	−0.08; ±0.26	0.03; ±0.37	0.11; ±0.33
Shots-on-target (n)	2.00 (0.00)	1.00 (1.00)	1.00 (0.00)	1.00 (0.25)	0.25; ±0.21	0.20; ±0.16	0.26; ±0.22	−0.11; ±0.22	−0.06; ±0.23	0.06; ±0.21
Shots-off-target(n)	1.00 (0.50)	1.00 (0.00)	1.50 (1.00)	1.00 (0.00)	−0.06; ±0.16	0.08; ±0.22	−0.02; ±0.17	0.14; ±0.20	0.06; ±0.13	−0.08; ±0.19

Note: Dist, Distance; Opp, Opponent; Sync, Synchronization; CL, Confidence limits.CTR, control condition; IND, individual condition; COL, collective condition; MIX, mixed condition. * $p \leq .05$;

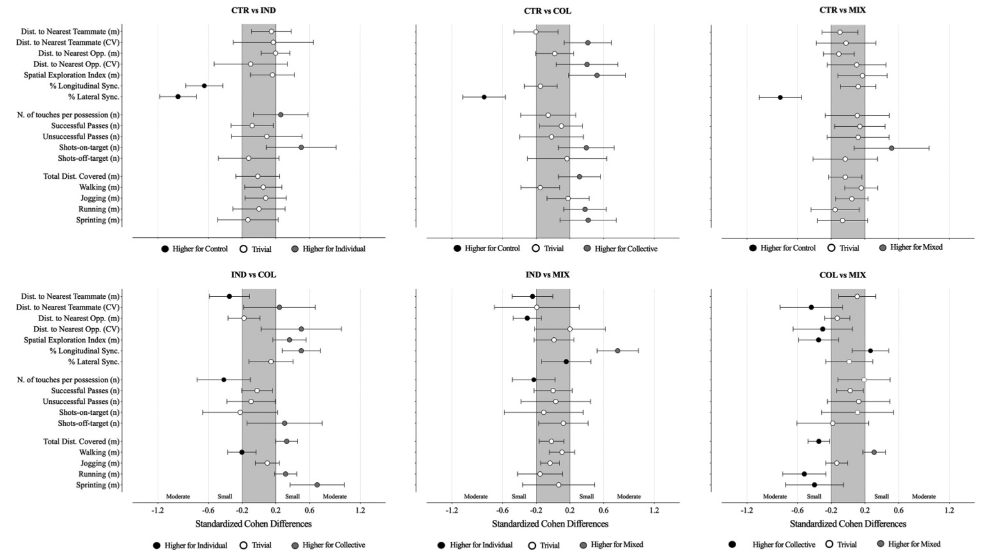

Figure 3. Standardized (Cohen's d) differences in positional, technical and physical variables according to the different SSGs conditions. Error bars indicate uncertainty in the true mean changes with 90% confidence intervals. Dist, Distance; Opp, Opponent; Sync, Synchronization.

Effects of playing with additional variability on the physical variables

The results from the physical variables when comparing the different scenarios are presented in Table 2 and Figure 3. When comparing the condition without variability (CTR) with the conditions with additional variability (IND, COL and MIX), significant differences were only found when compared with the COL in the distance covered while running ($X^2 = 15.4$, $p \leq .05$) and sprinting ($X^2 = 20.0$, $p < .001$). Accordingly, it was found lower values in the distance covered while running (~23.4 less, $p \leq .05$, small effects) and sprinting (~11.3 less, $p < .001$, small effects) during the CTR compared to the COL. When accounting only with the comparisons in the conditions with variability (IND vs COL; IND vs MIX; and COL vs MIX) it was found in general higher values in all intensities (total distance covered, $F = 4.6$, $p \leq .05$; walking distance, $X^2 = 8.9$, $p = .031$; running distance; sprinting distance) apart from the jogging distance that did not reveal statistical differences. Under this perspective, it was found higher values in the total distance covered (~43.2 more, $p \leq .05$, small effects), in distance covered while running (~22.3 more, $p < .001$, small effects), and in the distance covered while sprinting (~14.9 more, $p < .001$, small effects) during the COL compared to the IND. Similarly, it was found higher values during the COL in the total distance covered (~47.4 more, $p \leq .05$, small effects), running distance (~24.3 more, $p < .001$) and in the sprinting distance (~11.2 more, $p < .001$, small effects) compared to the MIX. In contrast, lower values in the walking distance were identified during the COL compared to the IND (~5.1 less, $p \leq .05$, small effects) and COL (~6.8 less, $p \leq .05$, small effects). In addition, no statistically significant differences were found between the IND and the MIX condition.

Effects of playing with additional variability on the technical variables

The results from the technical variables are presented in Table 2 and Figure 3. Overall, no statistically significant effects were identified between conditions. Nevertheless, the results from the effect sizes indicate lower values in the number of touches per possession during the COL compared to the remaining conditions (CTR, 0.2 more, small effects; IND, 0.4 more, small effects; MIX, 0.2 more, small effects).

Discussion

This study aimed to identify the effects of playing with additional individual (IND), collective (COL) or individual-collective (MIX) variability in youth football players' positional, physical, and technical performance during small-sided games. In general, there were limited differences in positional, physical, and technical variables between the four conditions. Particularly, there were very few differences between the CTR and MIX condition in relation to positional, physical, and technical variables. In fact, the comparison between the CTR and the MIX revealed statistical differences only in lateral synchronization. This can be interpreted in line with the theory of the differential learning approach whereby only an optimum amount of variation leads to a resonance with the athlete's performance (Schöllhorn et al., 2009). When the athletes were confronted with too much variability or information per time, their performance may be impaired, as it could be observed while combining rope skipping with high frequency interventions (John & Schöllhorn, 2018). These findings are underpinned by similar observations of brain activation during and after similar tasks (Henz et al., 2018). Therefore, when there is higher stress (like the one resulting from both types of variability), the corresponding brain frequencies may become detrimental to performance from a short-term perspective (John & Schöllhorn, 2018), and may lead the players to explore more familiar pre-structured strategical behaviours such as those found in the control condition. In fact, a previous study found that under highly difficult scenarios their subjects responded with a decrease in the exploration behaviour (Torrents et al., 2016).

Nevertheless, there were some significant and practical differences, mainly between the CTR with the IND and COL conditions. Accordingly, players' positioning emerges from their perception of environmental information (Coutinho et al., 2019a; Gonçalves et al., 2017; Travassos et al., 2012). Therefore, the player's movement on the pitch seems to express their ability to identify and use local information (Low et al., 2020), which is likely to be modified when coaches manipulate training tasks (Coutinho et al., 2019a; Travassos et al., 2012). In this respect, the CTR condition (without variability) revealed higher values in the team lateral synchronization when compared with the conditions with additional variability (IND, COL and MIX). Also higher longitudinal synchronization in relation to the IND scenario. The movement synchronization is a performance indicator that is based on the percentage of time that the players belonging to the same team move in a coordinative fashion to achieve a general aim (i.e. protecting their goal and progress towards opponents' goal to create goal-scoring opportunities; Folgado et al., 2014, 2018). In general, players put more emphasis on coordinating their movement patterns on the longitudinal direction of the pitch because of the goal location

(Folgado et al., 2014). However, to attain high levels of movement synchronization, the players must possess high tactical knowledge (Folgado et al., 2018) and be able to perceive the teammate movements. In this study, there was a decrease in the longitudinal direction during the IND compared with the CTR, suggesting that the players were not capable of coupling their movements with the ones of their teammates. Based on these results, it may be possible that imposing specific body restrictions on the players change their focus of attention towards the ball control and less on the movement of teammates, impairing their movement synchronization. A previous study also observed a decrease in movement synchronization when corridor and sector lines were added to the field, which directed players' attention from teammates to the space (Coutinho et al., 2019b). Most likely, the additional tasks drain too many resources from the players' capacity and distract them from achieving a goal. Interestingly, there was a dominant trend for a higher movement synchronization in the lateral direction during the CTR compared to all other conditions. During the CTR condition, players performed without additional variability, which represents a more common and easier scenario, that is likely to promote more predictable and stable movement behaviours (Torrents et al., 2016), such as protecting the goal by closing the inner spaces near to the target and progressing collectively to the opponents' target. These types of behaviours, which seemed to emerge more predominantly under more familiar scenarios (Coutinho et al., 2019a, 2020), might have forced the players to explore the lateral spaces (increasing the lateral synchronization) during the CTR condition as a result of the possibly higher overload of players in the central zone of the pitch.

Understanding how different playing systems affected the players' positional and physical performance has already been addressed by the available literature (Baptista et al., 2020). In fact, a previous study exploring how different playing structures (4:3:0, 4:1:2, 4:3) found that players occupy different spaces depending on the available team sectors (Baptista et al., 2020). Depending on the number of players per sector, different sizes of space were explored, as well as different movement coordination patterns between teammates and opponents (Baptista et al., 2020). In the present study, the aim was not to compare the different playing systems; however, during the COL condition the players had to employ a different playing structure every minute within the 6-min SSG, which may explain the higher values for the SEI variable. That is, the same player was instructed to perform at least in two of the three sectors (defensive, midfield or forward) and in two of the three corridors (right, central, left), leading to higher space exploration. Therefore, it is not surprising the higher values found in total distance covered and distance covered while running and sprinting during the COL condition in relation to the other three scenarios, as during this condition the players were required to constantly alter the space occupied by them.

This study adds novel information regarding the acute effects of the playing SSG with additional variability; however, some limitations of the study should be acknowledged. For example, all the performance indicators addressed were offensive, and it may be possible that also the defensive behaviours would be affected under such variability. Based on this premise, forthcoming studies should include the defensive analysis when exposing the players under more SSG with variability.

Practical applications

Despite the study limitations, a few suggestions for practice are presented. For instance, similar behaviours were found for the CTR and the MIX scenarios, suggesting that exploratory and adaptive movement behaviour may be refrained when players are confronted with higher levels of variability. In this context, coaches can apply the MIX condition followed by the CTR condition, where the first condition will challenge the players in terms of the available stimuli, while the removal of the stimuli in the subsequent game may change the players' assessment towards an easier game. From the IND perspective, similar technical performance was identified when compared to the CTR, although it led to lower team movement synchronization. In this respect, coaches may take advantage of this condition (IND) to promote technical development and individual movement behaviour adaptability during tasks that require less team organization (e.g. 1vs1, 2vs2 or 3vs3). That is, playing with individual limitations would cause players to internally adjust the way they move and touch the ball, which helps to better accommodate different environmental conditions. Lastly, the COL may be used to emphasize the space exploration with additional external load while also enhancing players' positional adjustments more related to the local interactions than in the team structure (i.e. helping players to adjust their behaviour more related to the space of play in the different playing systems rather than only focused on a pre-defined structure). In this respect, coaches may vary the type of variability imposed to promote behavioural adaptability while adjusting the type of condition (i.e. Individual, Collective or Mixed) to emphasize specific behaviours, such as technical development, space exploration or even to reorganize the players' performance previously to a more regular condition (i.e. without variability).

Conclusions

In general, the results revealed indicators for similarities in terms of adolescent players' positional, physical and technical performance when comparing the different scenarios. This was more evident when comparing the CTR with the MIX condition, which suggested that players adopted more stable movement patterns when facing tasks with high levels of variability. Despite the similarities, some statistically significant findings were identified. Accordingly, players were less synchronized during the IND condition, possibly due to a higher emphasis on the individual motor control than on the environmental information (i.e. teammates movements) that result from the imposed body restrictions (i.e. moving while controlling the ball while having the arms crossed). The COL condition exposed the players to six different playing structures during a 6-min timeframe, which was related to a higher spatial exploration but also more physical demands. Overall, coaches are encouraged to use the IND to refine players' technical actions during game-based situations and the COL to promote the players' ability to play in different playing positions and sustain their actions on the local spatial-temporal information. Following the theory of differential learning, the additional variations should be added mainly in those variables where changes are to be achieved.

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