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SPORTS PERFORMANCE

Designing a small-sided game to elicit attacking tactical behaviour in professional rugby union forwards

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ABSTRACT

This study aimed to investigate the consistency of attacking tactical and technical behaviour, and physical characteristics, over multiple bouts, and variability across days, of a specific rugby union forwards small-sided game (SSG). Data was collected from 21 professional rugby union forwards during four training sessions. The SSG, consisting of five bouts of work (150-s) interspersed by passive recovery (75-s), aimed to elicit specific attacking tactical behaviour. Tactical behaviour (i.e., regularity of attacking shape [entropy]), and technical (e.g., passes) and physical (e.g., total distance) characteristics were quantified. Results showed that technical characteristics remained consistent, whereas the regularity of width of the attacking shape and two physical characteristics (i.e., total distance, training impulse) varied across bouts. However, these effects had limited practical significance. Technical characteristics were consistent across days, but minimal variability was observed for tactical behaviour and physical characteristics, as shown by their small random effects with 95% profile likelihood confidence intervals (PLCI) including zero (e.g., SD [95%PLCI] = 0.03[0.00, 0.06]). Consequently, consistency of stimulus over bouts and days is achievable for the majority of the variables investigated, thus supporting the use of SSG to elicit consistent attacking behaviour, but also technical and physical characteristics in rugby union forwards.

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Coaching; training design; tactics; small-sided game

Introduction

Small-sided games (SSG) have been defined as "*constrained game-based drills that change the structural dynamic of the formal match*" (CLEMENTE et al., 2021, p. 1), and is a training method commonly used to develop tactical understanding, technical skills, and physical qualities, concurrently in team-sport athletes (BUJALANCE-MORENO et al., 2019; DAVIDS et al., 2013; RENSHAW et al., 2019). Small-sided games have been classified as `open` training drills as they allow the integration of an action within its performance context, thus leading to the emergence of behaviours directed to achieve specific objectives (e.g., scoring a try in rugby union; DAVIDS et al., 2013). The inclusion of two teams competing against each other exposes players to multiple sources of information from the environment, such as their positioning on the pitch and the positioning of their teammates and opposition (DAVIDS et al., 2013; RENSHAW et al., 2019). This information is constantly changing due to players' movements, thus offering opportunities for action (i.e., affordances), which may or may not be exploited (ARAÚJO & DAVIDS, 2016; DAVIDS et al., 2013). Successful performance in sport has been defined as the appropriate use of information to select an action that can achieve a certain goal (ARAÚJO & DAVIDS, 2016). Consequently, SSGs can be utilised to foster players' ability to detect significant information from the environment, and to develop flexible and adaptable movement strategies to achieve a specific objective (DAVIDS et al., 2013; RENSHAW et al., 2019). Based on the tactical preference of the coaching staff, a SSG can be designed to provide repeated exposure to specific competition scenarios, thus allowing the desired tactical behaviours to emerge (DAVIDS et al., 2013).

The application of SSG in rugby union has been given limited attention in the literature, with the majority of published studies focusing on the physical characteristics (i.e., external, internal loads), limited research investigating technical skills, and no study assessing tactical behaviours during SSGs (ZANIN et al., 2021). However, SSG may have utility for developing tactical behaviours in rugby union, alongside technical and physical characteristics. During rugby union matches, the longest ball-in-play periods ranged between 152 and 161 seconds for both backs and forwards (REARDON et al., 2017). Throughout these periods, sequences of play unfold through the tactical behaviour of sub-units of players that tend to operate together as complex dynamical systems, coordinating tactical decisions and actions based on the team strategy, established before the game, and the constantly changing information that players can detect throughout the game (BISCOMBE & DREWETT, 2009; GREENWOOD, 2003; PASSOS et al., 2008b, 2011). A common attacking tactical behaviour exhibited in rugby union is the formation of a micro-unit of three players with "*one ball receiver at the center and two support players, one at the left side and other at the right side, forming a pointing arrow shape*" (PASSOS et al., 2008b, p. 134). This shape allows players to apply two important attacking

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principles of rugby union: (1) to move forward towards the try line, and (2) to support the ball carrier to provide continuity to the game (PASSOS et al., 2011). Following the formation of a ruck, or from a shortened lineout, forwards commonly adopt this attacking shape in preparation of receiving the ball from the scrum half, with the aim of advancing the ball up the field (GREENWOOD, 2003). After the first pass, open play occurs, and the ball carrier may decide whether to get into a collision with a defender, whether to pass the ball to a supporting player in the arrow shape, or whether a line break is possible based on the available information (e.g., interpersonal distance between ball carrier and defender; PASSOS et al., 2008a). If the ball carrier can successfully pass the ball to a teammate, the same options are offered to the new ball carrier, who may act based on the perceived information. Given SSG can be designed to provide repeated exposure to specific match situations (DAVIDS et al., 2013), this mode of training may be useful for developing such attacking tactical behaviour.

Additionally, a SSG may allow players to consistently practice technical skills, thus supporting their development, alongside experiencing high internal and external loads, which may elicit chronic physiological adaptations over time (BUCHHEIT & LAURSEN, 2013; FISK & LLOYD, 1988). A consistent stimulus has shown to substantially improve the performance of a task, in terms of accuracy and speed (FISK & LLOYD, 1988). As SSGs are often implemented with an intermittent format (i.e., multiple activity bouts interspersed by recovery) and repeated over time, consistency may be desirable not only among SSG bouts (SSGB), but also among training days (BUJALANCE-MORENO et al., 2019). However, contrasting findings can be found in the SSG literature. Across SSGBs, technical (i.e., number of successful passes) and physical (e.g., total distance) characteristics progressively decreased in soccer (DELLAL et al., 2011) whereas physical characteristics (i.e., total distance, heart rate) were consistent in rugby league (SAMPSON et al., 2015). Across training days, soccer SSGs produced similar physical characteristics (i.e., external, internal loads) and rugby league SSGs resulted in similar internal loads (BREDT et al., 2016; CUSTODIO et al., 2021; FOSTER et al., 2010). Conversely, tactical behaviours showed a high variability between days in soccer SSG (BREDT et al., 2016). However, no research has been conducted in rugby union SSG and findings from other field-based team sports may not be directly applicable due to the peculiar nature of the sport. Rugby union requires the ball to only be passed backwards using hands, and rucks (i.e. `*when at least one player from each team is in contact, on their feet and over the ball, which is on the ground*` (HENDRICKS et al., 2020, p. 4)) can be formed in open play to contest for ball possession, in contrast with rugby league where the ball is momentarily out of play after a tackle (van ROOYEN et al., 2010). These characteristics should be taken into account when designing a SSG, in order to provide a learning environment that is ecologically valid (RENSHAW et al., 2010). Ecological validity refers to the similarity between information available during official matches and during training (RENSHAW et al., 2010). It is this similarity that would allow players to become attuned to match information, and ultimately improve sport performance (ARAÚJO & DAVIDS, 2016).

The aim of the current study was to assess the consistency of attacking tactical behaviour (i.e., formation of arrow shape [AS] after open play) and of technical, and physical characteristics across multiple bouts of a specific forwards rugby union SSG. A secondary aim was to investigate the variability of these characteristics over multiple days. Due to the contrasting findings from previous literature (CLEMENTE et al., 2019; SAMPSON et al., 2015), a specific hypothesis on the effect of SSGB could not be formulated. Based on previous research (BREDT et al., 2016; CUSTODIO et al., 2021; FOSTER et al., 2010), it was hypothesised that similar physical characteristics would be observed among days of data collection.

Methods

Subjects

Twenty-one professional rugby union forwards (mean [SD]: stature = 187.00 [7.70] cm, body mass = 116.00 [5.60] kg, age = 24.60 [3.80] years, maximal heart rate: 193.00 [11.40] bpm, maximal speed: 8.10 [0.30] $m\cdot s^{-1}$) from one professional rugby union club competing in the English Gallagher Premiership were included in this study. In addition, two elite professional rugby union coaches working at the same club (RFU level 3 coaching qualification, 6 years coaching professionally) were involved in the design and delivery of a specific rugby union forwards SSG. Informed and written consent was received by both coaches and players before the start of the study. The protocol of this study followed the guidelines of the Declaration of Helsinki and received ethical approval from Leeds Beckett University Ethics Committee (ethics ID: 74,815).

Procedures

A forwards specific SSG to elicit attacking tactical behaviour (i.e., formation of AS) was designed in collaboration between elite rugby union coaches and sport scientists using the constraints-led approach as the selected pedagogical approach (DAVIDS et al., 2013; RENSHAW et al., 2019). Following the constraints-led approach, practice design should be based on the achievement of specific objectives (e.g., tactical objective). Once the objective is established, constraints – defined as the `*information to shape or guide the (re)organisation of a complex adaptive system*` (RENSHAW et al., 2019, p. 14) and divided into individual (e.g., fitness level), environmental (e.g., weather), and task (e.g., pitch dimensions) constraints – can be manipulated to achieve the objective.

In the current study, a strategy for the attacking players was established before the game, similar to the preparation for official competitions. Strategy has been defined as *"the intensions of players and the boundaries that define the defensive and offensive actions of players"* (BUEKERS et al., 2020, p. 3). The attacking strategy was represented by the formation of the AS (Figure 1) for the first three players next to a ruck – specifically forwards – as this would offer more opportunities to break the defensive line and gain metres towards the try line whilst offering support to the ball carrier. Strategy generally aims to support players in finding balance between stable and variable movement patterns to achieve a certain goal (DAVIDS et al., 2013). As per the goals of competition, the goal of attacking players was to score a try, whereas the goal of the defenders

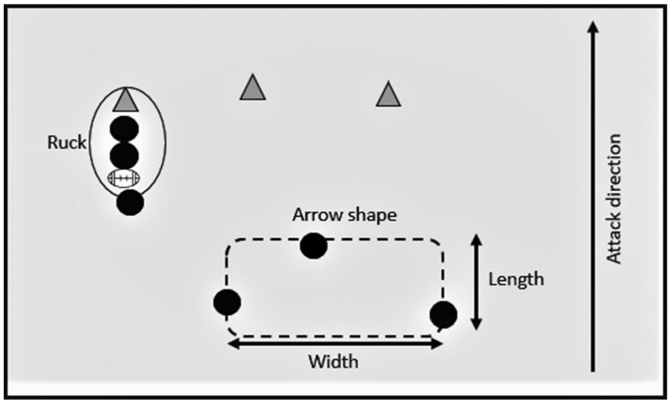

Figure 1. Arrow shape (AS) in relation to ruck, defenders, and attack direction. Black dots: attacking players, grey triangles: defending players.

was to stop the attacking players from scoring a try. Ultimately, the key objectives of the rugby union SSG were: (1) the reinforcement of specific principles and shapes of attack, and (2) the development of consistency of skill habits under fatigue. The work interval duration of each SSGB was based on the longest ball-in-play periods recorded during official rugby union competitions (REARDON et al., 2017). The rest interval duration was manipulated to create a 2:1 work-to-rest ratio, thus maximising time at maximal oxygen uptake and enhancing activity of aerobic enzymes, capillarisation, and myocardial adaptations (BUCHHEIT & LAURSEN, 2013; MIDGLEY et al., 2006). The number of players was manipulated to offer more frequent opportunities of 3v2 interactions between attackers and defenders, thus reproducing subphases of official games (DAVIDS et al., 2013; HILL-HAAS et al., 2011). Each SSG was supervised and refereed by a rugby coach who decided if a turnover should occur in accordance with the constraints of the SSG. A description of the task and environmental constraints applied to the SSG is reported in Table 1. A spatial-temporal representation of the SSG is included as supplementary material.

Data for the SSG were collected across four different days separated by a minimum of 48 hours of recovery during a ten-day period within preseason 2019/2020 Gallagher Premiership campaign. To ensure reproducibility of performance, one familiarisation session was performed before the start of the data collection period. On each day, players were divided into four teams and two SSGs were performed concurrently with one rugby coach randomly assigned to each game (Figure 2). Of the eight SSGs, only six were used for analysis, due to global navigation satellite system (GNSS) failures.

Each SSG was preceded by a standardised warm-up consisting of light aerobic exercise, dynamic stretching, and sprint efforts including change of direction. Throughout the 3-week period before the start of the study, individuals' maximal speeds

Table 1. Task and environmental constraints applied to the SSG.

Constraints	Specifics	Description
Task constraints	Playing rules	- \`on-side\` rule: players can pass the ball exclusively backwards to players in an \`on-side\` position, behind an imaginary line passing through the ball and parallel to the try line. - When the *ball carrier* was touched by a *defender*, a ruck was created. The *ball carrier* had to fall to the ground with a focus on a long presentation of the ball to his teammates. One *attacking player* had to join the ruck in a low and strong position on top of the tackled player (i.e., *ball carrier*), and a *defender* had to test the *attacking player* by pushing and pulling him, thus mimicking an opponent's action of contesting for ball possession. -. A turnover should occur after a try was scored, when the *attacking player* was not low and strong under the pushing/pulling action of a *defender*, when there was a poor ball delivery or when the ball was dropped.
	Encouragement	Encouragement was provided by coaches during the games, and feedback during the rest periods.
	N° of players	6v3, exclusively forward players
	Pitch dimensions	17.5x15 m (length x width) Relative Playing area: 29.2 $m^2 \cdot player^{-1}$
	N° of W and R intervals	W: 150 sec R: 75 sec N° of W intervals: 5
	W:R ratio	2:1
Environmental constraints	Playing conditions	Time: 1.30pm-3.00pm, natural grass, outdoor, temperature: 17–20°C, partially sunny, July 2019.

Notes: AS: arrow shape, N°: number; m: metres, W: work; R: rest; sec: seconds.

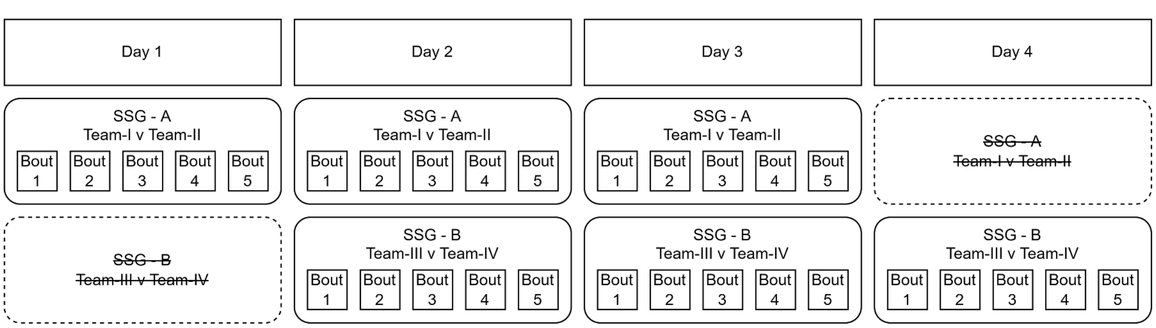

Figure 2. Representation of the data collection process across four days. Players were divided into four teams (i.e., Team-I, Team-II, Team-III, Team-IV), and two SSGs (i.e., SSG-A, SSG-B) occurred concurrently on each day. Due to GNSS devices failure, SSG-B with Team-III and Team-IV on day one and SSG-A with Team-I and Team-II on day four were not used for analysis. SSG: small-sided game, GNSS: global navigation satellite system.

were collected using a 40 m straight line sprint (ROE et al., 2017) while maximal heart rate was collected as the highest 5-second average heart rate achieved during either a 30–15 Intermittent Fitness Test, running conditioning sessions, or team rugby training sessions (PÓVOAS et al., 2019). Tactical behaviour, and technical and physical characteristics of the SSG represented the dependent variables, whilst SSGB number (i.e., 1, 2, 3, 4, 5) represented the independent variable. Additionally, in order to control for the potential effect of coach, the two coaches (CO) involved (i.e., 0, 1) were also included as independent variables, thus allowing for more accurate estimates for the effect of SSGB.

Computational tools

Data pre-processing and statistical analysis were conducted using R v4.0.3 (R CORE TEAM, 2021) in RStudio (RStudio Team, 2018, v1.2.1335) with complementary packages downloaded from the Comprehensive R Archive Network (CRAN).

Data collection

Tactical behaviour (Table 2) was quantified using video camera recoding at 25 Hz (Sony NXCAM Avchd MPEG2 SD, Sony, Tokyo, Japan) and GNSS devices recording at 10 Hz (Vector S7, Catapult Sports, Melbourne, Australia; Figure 3). Videos of the SSGs were initially imported into Vision Catapult (Catapult Sports, Melbourne, Australia) whereby the AS (Figure 1) were visually identified. Annotations were successively imported into OpenField Catapult (Catapult Sports, Catapult Innovations, Melbourne, Australia) whereby GNSS data and annotations were synched based on the moment when the head rugby coach blew his whistle to start the first bout of SSG. Data were then exported, and an R script was specifically developed to convert the longitude latitude into *x y* coordinates and to filter the data exclusively of players involved in the AS. Normalised approximate entropy (NApEn; FONSECA et al., 2012) was used to assess the regularity of the multiple AS across bouts. Normalised approximate entropy allows a comparison of time series of multiple lengths by normalising the original values of approximate entropy with respect to a maximum value for the time series of that specific length (FONSECA et al., 2012). Values of NapEn can range between zero and two, with lower values indicating more regularity and predictability while higher values would indicate more randomness and unpredictability (DELGADO-BONAL & MARSHAK, 2019). Specifically, approximate entropy was calculated using $m = 2$ and $r = 0.2$ as suggested in previous research (DELGADO-BONAL & MARSHAK, 2019; FONSECA et al., 2012). Normalised approximate entropy was calculated for *length, width*, and *length width ratio* for each SSGB using the ApEn() function from the *TSEntropies* package. Intra-rater reliability for *length* NapEn (ICC[95%CI] = 0.76[0.54–0.87]) and *width* NapEn (ICC[95%] = 0.76[0.55–0.88]) was "excellent" and *length width ratio* NapEn was "good" (ICC[95%] = 0.73[0.51–0.86]). Intraclass correlation was calculated as a two-way, agreement, mixed effects model using icc() function from *irr* package and interpreted following PORTNEY and WATKINS (2009).

Technical characteristics of the SSG (Table 2) were quantified using video camera recoding at 25 Hz (Sony NXCAM Avchd MPEG2 SD, Sony, Tokyo, Japan; Figure 3). Videos were imported into Vision Catapult (Catapult Sports, Catapult Innovations, Melbourne, Australia) where notational analysis was used to identify the technical actions of interest for each SSGB. The validity of the metrics utilised (Table 2) is supported by their previous extensive use in rugby league and rugby union SSG research (MORLEY et al., 2016; VAZ et al., 2012). Intra-rater reliability for this process – carried out by the first author (MZ) – resulted to be "excellent" (ICC[95%CI]: successful passes = 0.98[0.97–0.99], unsuccessful passes = 0.95[0.90, 0.98], line breaks = 0.94[0.89, 0.97], rucks = 0.98[0.96, 0.99], tries = 0.95[0.90, 0.97]). Intraclass correlation was calculated as a two-way, agreement, mixed effects model using icc() function from *irr* package and interpreted following PORTNEY and WATKINS (2009).

External load characteristics (Table 2) were quantified using 10 Hz GNSS (Vector S7, Catapult Sports, Catapult Innovations, Melbourne, Australia; Figure 3). The validity and reliability of these devices is supported by extensive research (SCOTT et al., 2016; VARLEY et al., 2012). Devices were turned on outside 15 minutes before the start of the session to optimise GNSS signal. On players' arrival to the pitch, GNSS units were placed in a vest produced by the GNSS manufacturer and each player was assigned a unique GNSS unit throughout the study. The mean and standard deviation (SD) of the number of satellites and horizontal dilution of precision throughout the data collection process were mean = 12.00, SD = 0.39 and mean = 0.67, SD = 0.33, respectively.

Internal load characteristics (Table 2) were quantified using chest strap heart rate monitors (Polar H1, Polar, Kempele, Finland; Figure 3). Heart rate data have been commonly used as an objective measure to monitor the internal load experienced by field-based team sports athletes (IMPELLIZZERI et al., 2005), with chest strap monitors showing the highest accuracy when compared against electrocardiogram in comparison with wrist and arm monitors (at rest, on treadmill and bike: r = 0.99; GILLINOV et al., 2017).

Statistical analysis

This study utilised the likelihood-based approach for statistical analysis and inference (SEVERINI, 2001). The sample of the study was based on the availability of players, specifically forwards, at the professional rugby union club throughout preseason, hence it was derived from convenience sampling (BORNSTEIN et al., 2013). A priori sample size calculations are not required using the likelihood-based approach; and a posteriori, likelihood quantities are exclusively based on the data, thus ignoring the sampling scheme (SEVERINI, 2001). The effects of SSGB and CO were investigated using general and generalised linear (mixed-effect) models with the packages *stats* and *lme4* (BATES et al., 2014; HOFFMAN, 2015). Small-sided game bout and CO were initially included as fixed effects whilst the intercept was included as a random effect which could vary based on the date of data collection and the subjects within each date. This represented the starting model for the model building process. Model building was based on the initial hypotheses, simplicity of the model, Akaike Information Criteria, likelihood ratio test, and visual assessment of the regularity of the log-likelihood function (SEVERINI, 2001).

Table 2. Outcome measures for technical, tactical, and physical characteristics.

Outcome measures		
Performance component	Outcome (dependent variables)	Description
Technical	Successful passes (#)	`*passes in which the attacker passed the ball and the receiver caught the ball*` (CORREIA et al., 2011, p. 987) – at SSGB level. <discrete random variable>
	Unsuccessful passes (#)	Passes in which the attacker passed the ball, but the receiver did not catch it, dropped it, or the ball gets intercepted by a defender – at SSGB level. <discrete random variable>
	Line break (#)	When `*an attacking player with the ball breaks through the defensive line*` (BENNETT et al., 2016, p. 534), thus advancing the ball in respect to the try line – at SSGB level. <discrete random variable>
	Ruck (#)	`*when at least one player from each team is in contact, on their feet and over the ball, which is on the ground*` (HENDRICKS et al., 2020, p. 4) – at SSGB level. <discrete random variable>
	Try (#)	The action of grounding the ball in the opponent's in goal area (World Rugby, 2022) – at SSGB level. <discrete random variable>
Tactical		The AS (Figure 1) was defined as the timeframe starting in the moment when three forwards players were trying to organise themselves into the predetermined attacking shape and at least two out of three players showed the intent to move forwards towards the defensive line. The end of the AS was marked by a defender touching the ball carrier with two hands, by a line break – as this would represent an individual action (i.e., a single player involved rather than a group of players) – or by a dropped ball. Due to the triangular shape of the AS, length, width, and length width ratio (Figure 1) were selected as appropriate metrics to investigate regularity of the triangle.
	Width NApEn (AU)	Normalised approximate entropy for the lateral distance in metres between the two widest players in the AS (Figure 1; FONSECA et al., 2012) – at SSGB level. <continuous random variable>
	Length NApEn (AU)	Normalised approximate entropy for the longitudinal distance in metres between the most and least advanced players in the AS (Figure 1; FONSECA et al., 2012) – at SSGB level. <continuous random variable>
	Length width ratio NApEn (AU)	Normalised approximate entropy for the ratio between length and width of the AS (Figure 1; FONSECA et al., 2012) – at SSGB level. <continuous random variable>
Physical – external load	Total distance (m)	Total distance covered in metres – at player level. <continuous random variable>
	HSR (>61%) distance (m)	High speed running distance covered in metres above 61% of each player's individual maximal speed (REARDON et al., 2015) – at player level <continuous random variable>
	Avg accel decel ($m \cdot s^{-2}$)	Average acceleration deceleration in $m \cdot s^{-2}$ of the absolute of each acceleration deceleration over a period of time (DELANEY et al., 2018) – at player level. <continuous random variable>
	Max speed ($m \cdot s^{-1}$)	Maximal speed in $m \cdot s^{-1}$ achieved during each small-sided game bout – at player level. <continuous random variable>
Physical – internal load	Stagno's TRIMP (AU)	Training impulse (TRIMP) in AU derived from the exponentially increasing arbitrary weighting factors multiplied by the time spent in pre-determined heart rate zones based on an individual's maximal heart rate (STAGNO et al., 2007) – at player level. <continuous random variable>

Notes: AS: arrow shape; NApEn: normalised approximate entropy; HSR: high-speed running; AU: arbitrary units; Avg: average; accel: acceleration; decel: deceleration; TRIMP: training impulse; #: number of; SSGB: small-sided game bout.

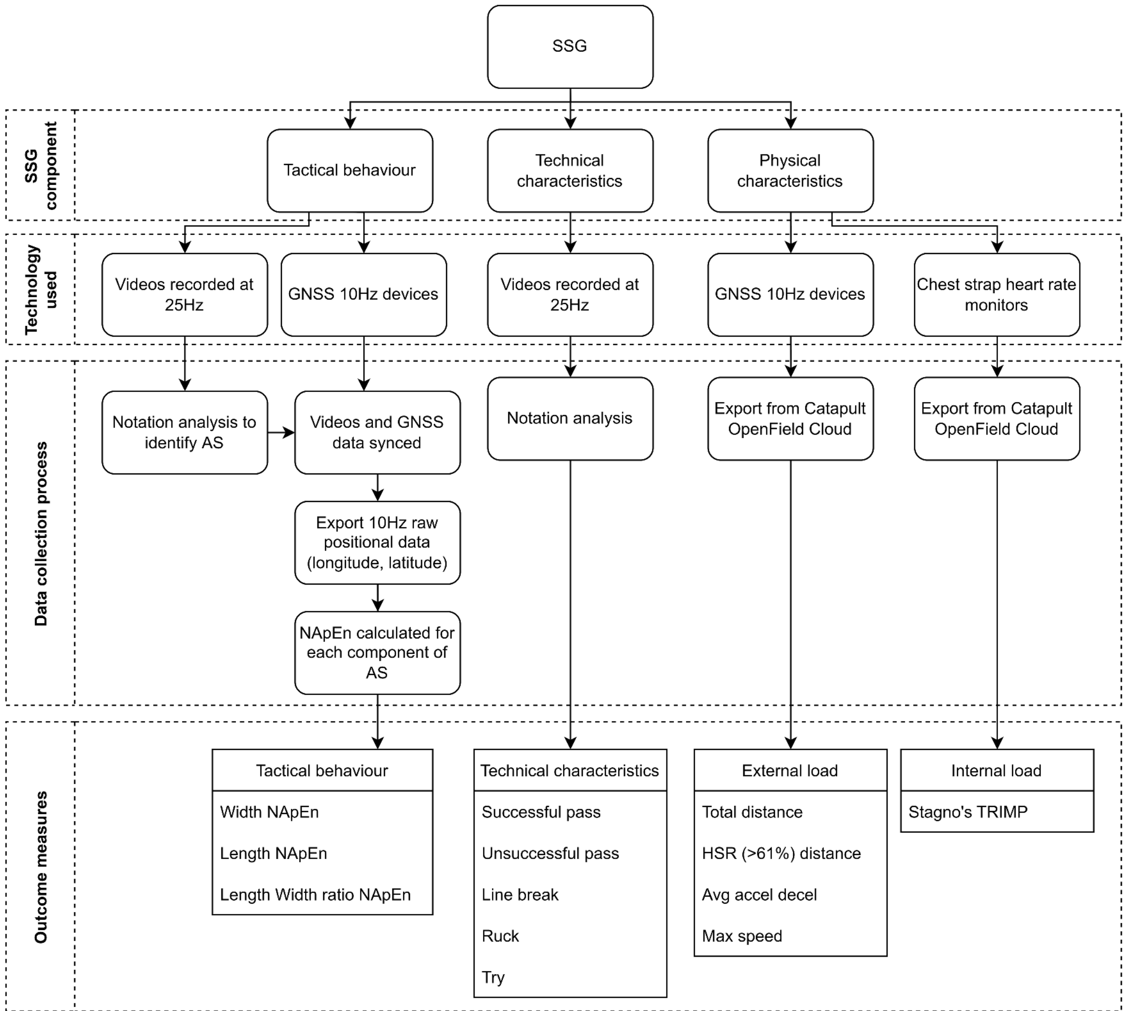

Figure 3. An overview of the quantification of tactical behaviour, technical and physical characteristics of the SSG. The process is divided into the specific components (i.e., tactical, technical, physical), the technology used, the process used to collect the data, and the outcome variables. HSR: high speed running, TRIMP: training impulse, NApEn: normalised approximate entropy, AS: arrow shape, GNSS: global navigation satellite system, SSG: small-sided game.

The likelihood-based approach for statistical inference involved the estimation of the maximum likelihood estimate (MLE) for the parameters of the models and their respective standard errors (SE; SEVERINI, 2001, Section 3.7). Wald statistics (i.e., z and t values) were calculated to test the null hypotheses that model coefficients were equal to zero (SEVERINI, 2001, Section 4.4). A Wald statistic close to zero suggests that the data is consistent with the null hypothesis, whereas more extreme values suggest evidence against the null hypothesis (COX, 1982). In addition, profile likelihood confidence intervals were calculated at the 95% level (95%PLCI) to identify a range of parameter values (e.g., MLE) compatible with the data under the specified model (SEVERINI, 2001, Section 4.5). The lack of effect of a model parameter was identified by a Wald statistic close to zero and a 95%PLCI including zero.

Results

The process of data collection led to 270 observations for each physical outcome measure (i.e., 9 players × 5 SSGB × 6 SSG) as data were collected at a player level, and to 30 observations for each technical and tactical outcome measure (i.e., 5 SSGB x 6 SSG) as data were collected at a SSGB level. Descriptive statistics (mean[SD]) for each SSGB are presented in Table 3. After data collection, HSR (>61%) distance represented a zero-inflated continuous variable, with 169 zeros out of 270 observations (i.e., 63%) (mean[SD] = 1.62[3.22]m). The CRAN was extensively searched for packages to model this data structure, yet no package was appropriate for the needs of this study. Consequently, HSR (>61%) distance was not modelled.

Considering tactical characteristics, these showed some variability across days of data collection (SD = 0.03–0.08; Table 4). *Length* and *length width ratio* NApEn were not affected by SSGB, thus remaining relatively stable across bouts (Table 4). Conversely, *width* NApEn showed to be affected by both linear and quadratic components of SSGB (Table 4). The positive quadratic effect of SSGB (i.e., 0.03) made the linear negative effect of SSGB (i.e., –0.17) less negative by 0.06 (i.e., twice the coefficient of $SSGB^2$) per unit increase in SSGB (Table 4). When controlling for coach involved, technical characteristics were not influenced by SSGB and did not show variability across the four days of data collection (Table 4).

Physical characteristics showed minimal variability across days of data collection (Table 4). *Total distance covered* was affected by SSGB, thus increasing by 2.08 m for each SSGB. Similarly, Stagno's *training impulse* (*TRIMP)* appeared to be influenced by both linear and quadratic components of SSGB (Table 4). The positive quadratic effect of SSGB (i.e., 7.82) made the negative linear effect of SSGB (i.e., −43.75) less negative by 15.64 AU (i.e., twice the coefficient of SSGB^2) per unit increase in SSGB. *Average acceleration deceleration* and *maximal speed* were not influenced by SSGB, thus suggesting that they remained relatively consistent across bouts (Table 4).

Discussion

Findings from this study showed that tactical behaviour, and technical and physical characteristics were consistent across multiple SSGB, when controlling for the coach involved, for the majority of the variables investigated. Small-sided game bout did not affect technical characteristics. Only the regularity of the width of the AS (i.e., *width* NApEn) and two physical characteristics (i.e., *total distance* and Stagno's *TRIMP)* were affected by SSGB. In addition, across days of data collection, technical characteristics were consistent, whereas tactical behaviour and physical characteristics showed minimal variability.

Tactical behaviour

The AS investigated in this study represents a common attacking strategy implemented during official rugby union games (PASSOS et al., 2008b). The constraints were modified to offer increased frequency of 3v2 scenarios to attackers and defenders, and the constantly changing nature of the SSG allowed the attacking players to implement different AS based on the position of the ruck on the pitch and the positioning of the defenders, in order to break the defensive line and score a try (DAVIDS et al., 2013). Findings showed that the length and length width ratio of the AS were not affected by SSGB, thus showing that the SSG elicited a consistent AS in terms of its length and length width ratio across bouts. Only the regularity of the width of the AS (Figure 1) was influenced by SSGB. Specifically, when controlling for coach involved, *width* NApEn decreased first, reached a minimum, and then increased, thus showing a quadratic (curved) pattern of change across SSGB (Table 4). This suggests that the SSG progressively increased the regularity of the width of the AS, but after reaching a maximum, regularity started to decrease, thus becoming more irregular in the last bouts of the SSG. The progressive increase in regularity may show how players can adapt to the constraints by experimenting more consistent movement patterns (HOSSNER et al., 2016). However, the following increase in irregularity may indicate how the acquisition of a skill fluctuates over time and how players may explore various solutions to accomplish the task of scoring a try, or may relate to increased fatigue, thus showing a quadratic pattern of change (HOSSNER et al., 2016). As this represents the first study to investigate the regularity of the AS in rugby union SSG and rugby union official competitions using NApEn, it is hard to compare these findings with other studies. However, as only one variable was affected by SSGB, the specific SSG elicited consistent attacking tactical behaviours in forwards for the majority of the variables investigated.

Tactical behaviour showed some variability across days of data collection as shown by the presence of the random effect of date in the models (Table 4). Nonetheless, the SD of the random effect of date of data collection can be considered small in comparison with the respective intercept (e.g., *length* NApEn: fixed intercept = 0.31, random date = 0.03) and the 95%

Table 3. Descriptive statistics (mean[standard deviation]) for each SSGB.

		Descriptive statistics for each SSGB				
Characteristics	Outcome	SSGB 1	SSGB 2	SSGB 3	SSGB 4	SSGB 5
Tactical	Width NApEn (AU)	0.48 [0.10]	0.40 [0.07]	0.37 [0.08]	0.38 [0.06]	0.46 [0.07]
	Length NApEn (AU)	0.36 [0.07]	0.31 [0.07]	0.33 [0.06]	0.35 [0.05]	0.36 [0.05]
	Length width ratio NApEn (AU)	0.28 [0.11]	0.21 [0.10]	0.28 [0.08]	0.27 [0.09]	0.20 [0.13]
Technical	Successful pass (n)	29.83 [2.79]	30.83 [3.43]	28.33 [6.19]	29.33 [4.93]	30.50 [3.33]
	Unsuccessful pass (n)	1.00 [1.26]	2.33 [1.21]	2.50 [1.97]	2.17 [0.98]	2.00 [1.26]
	Ruck (n)	23.17 [3.49]	23.17 [2.86]	21.83 [1.60]	23.33 [1.50]	23.83 [3.6]
	Try (n)	1.83 [0.75]	3.50 [1.22]	3.17 [0.98]	2.50 [1.05]	2.50 [1.05]
	Line break (n)	0.33 [0.82]	0.83 [1.17]	1.17 [0.98]	1.00 [1.26]	1.00 [0.63]
Physical	Total distance (m)	238.12 [22.88]	245.99 [22.76]	249.19 [21.54]	243.47 [19.15]	249.77 [23.34]
	HSR (>61%) distance (m)	1.41 [2.60]	1.77 [3.96]	1.74 [2.87]	1.00 [2.36]	2.17 [3.95]
	Avg accel decel ($m{\cdot}s^{-2}$)	0.68 [0.06]	0.69 [0.06]	0.69 [0.07]	0.68 [0.06]	0.69 [0.06]
	Maximal speed ($m{\cdot}s^{-1}$)	4.63 [0.62]	4.66 [0.57]	4.68 [0.55]	4.47 [0.52]	4.61 [0.70]
	Stagno's TRIMP (AU)	579.17 [116.59]	556.83 [99.92]	553.17 [132.73]	566.24 [109.61]	590.26 [134.27]

Notes: NApEn: normalised approximate entropy; Avg: average; accel: acceleration; decel: deceleration; SD: standard deviation; TRIMP: training impulse; HSR: high speed running; AS: arrow shape; AU: arbitrary units; n: count; m: metres; s: seconds. Data are presented as mean and standard deviation [SD].

Table 4. Summary of the models for technical, tactical, and physical characteristics.

Characteristics	Outcome	Effects	Model parameters			
Technical (Poisson generalised linear models)		**Fixed**	**MLE**	**SE**	**z**	**95%PLCI**
	Successful pass	Intercept	3.39	0.05	71.38	[3.29, 3.48]
		CO	0.01	0.07	0.17	[−0.12, 0.14]
	Unsuccessful pass	Intercept	0.62	0.19	3.30	[0.23, 0.97]
		CO	0.13	0.26	0.52	[−0.37, 0.65]
	Ruck	Intercept	3.09	0.06	56.01	[2.98, 3.19]
		CO	0.10	0.08	0.20	[−0.05, 0.25]
	Try	Intercept	1.05	0.15	6.91	[0.74, 1.38]
		CO	−0.12	0.22	−0.55	[−0.56, 0.31]
	Line break	Intercept	0.29	0.22	1.29	[−0.18, 0.69]
		CO	−1.20	0.46	−2.59	[−2.21, −0.35]
Tactical (General linear mixed-effects models)	**Width NApEn**	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	0.60	0.06	10.01	[0.49, 0.72]
		SSGB	−0.17	0.04	−4.13	[−0.24, −0.09]
		SSGB^2	0.03	0.01	4.02	[0.01, 0.04]
		CO	0.02	0.03	0.83	[−0.03, 0.07]
		Random	**SD**			**95%PLCI**
		Date (int)	0.05			[0.01, 0.12]
		Residuals	0.06			[0.04, 0.08]
	Length NApEn	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	0.31	0.02	15.95	[0.27, 0.34]
		CO	0.06	0.02	2.72	[0.02, 0.10]
		Random	**SD**			**95%PLCI**
		Date (int)	0.03			[0.00, 0.06]
		Residuals	0.05			[0.04, 0.07]
	Length width ratio NApEn	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	0.22	0.04	5.22	[0.13, 0.31]
		CO	0.02	0.04	0.58	[−0.05, 0.09]
		Random	**SD**			**95%PLCI**
		Date (int)	0.08			[0.00, 0.16]
		Residuals	0.09			[0.07, 0.12]
Physical (General linear mixed-effects models)	**Total distance**	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	240.43	5.55	43.35	[228.66, 252.58]
		SSGB	2.08	0.56	3.69	[0.97, 3.18]
		Random	**SD**			**95%PLCI**
		Players (int)	16.35			[13.21, 20.68]
		Date (int)	9.33			[0.00, 22.14]
		Residuals	13.09			[11.91, 14.39]
	Avg accel decel	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	0.69	0.01	66.47	[0.67, 0.71]
		SSGB	0.0001	0.001	0.06	[−0.003, 0.004]
		Random	**SD**			**95%PLCI**
		Players (int)	0.04			[0.03, 0.05]
		Date (int)	0.01			[0.00, 0.03]
		Residuals	0.04			[0.03, 0.05]
	Maximal speed	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	4.69	0.09	49.66	[4.51, 4.89]
		SSGB	−0.02	0.02	−1.07	[−0.07, 0.02]
		Random	**SD**			**95%PLCI**
		Players (int)	0.31			[0.22, 0.41]
		Date (int)	0.08			[0.00, 0.27]
		Residuals	0.51			[0.46, 0.58]
	Stagno's TRIMP	**Fixed**	**MLE**	**SE**	**t**	**95%PLCI**
		Intercept	612.61	28.23	21.70	[555.41, 668.80]
		SSGB	−43.75	13.46	−3.25	[−70.12, −17.38]
		SSGB^2	7.82	2.20	3.55	[3.51, 12.13]
		Random	**SD**			**95%PLCI**
		Players (int)	98.50			[80.60, 123.09]
		Date (int)	34.14			[0.00, 90.77]
		Residuals	60.50			[54.96, 66.38]

Notes: NApEn: normalised approximate entropy; MLE: maximum likelihood estimate, SE: standard error; 95%PLCI: 95% profile likelihood confidence interval; t/z: Wald statistic; SD: standard deviation; CO: coach; SSGB: small-sided game bout; TRIMP: training impulse; (int): variation of Players or Date around the intercept; Avg: average; accel: acceleration; decel: deceleration.

PLCI consistently included zero, thus suggesting that limited variability occurred among days. Consequently, the specific rugby union forwards SSG may elicit consistent AS among SSGB and among multiple days of data collection. Practitioners may implement SSG to promote consistent attacking tactical behaviours in forwards, thus possibly improving their tactical understanding over time (FISK & LLOYD, 1988).

Technical characteristics

In the present study, technical characteristics remained constant across SSGBs, when controlling for coach involved, as shown by the lack of SSGB as fixed effect in the final models (Table 4). This is in contrast with previous research in soccer SSGs which showed that technical characteristics (e.g., number of successful passes) progressively decreased throughout multiple bouts, possibly due to fatigue (DELLAL et al., 2011, 2012). However, direct comparisons between rugby union and soccer SSGs may not be appropriate due to the specific constraints applied to the current rugby union SSG investigated (i.e., formation of rucks, ball needs to be passed backwards). A possible explanation may be that the players were well accustomed to SSG training with the specific work-to-rest ratio used, and their high experience and technical competencies (professional players) may have also prevented changes in technical characteristics across bouts. In addition, even though technical skills were challenged by the constantly changing information that players could detect, the limited pitch dimensions may have contributed to provide consistency to the frequency of technical skills. For instance, passes were always performed over a short distance, thus limiting their complexity (PASSOS et al., 2008b). Furthermore, in the present study, technical skills were quantified exclusively using their frequency of occurrence without any information about the quality of the skill itself (e.g., body shape at the ruck), which may have shown a possible decrease over SSGB.

Technical characteristics did not show variability across days of data collection, as shown by the lack of a random effect of date in the final models (Table 4). Therefore, the specific rugby union forwards SSG investigated elicited consistent technical skills over bouts and over the 4 days of data collection. Thus, this SSG may serve as a useful game when coaches wish to keep skill execution consistent between games and sessions.

Physical characteristics

In terms of physical characteristics, the SSG investigated in this project produced limited high speed (>61%) running distance covered, which could be expected due to the reduced pitch dimensions and relative playing area used (HODGSON et al., 2014). In addition, when controlling for coach involved, SSGB did not affect *maximal speed* and *average acceleration deceleration*, thus suggesting that the SSG elicited consistent maximal speed and accelerations decelerations over bouts. Similar results have been observed in a hurling SSGs which showed similar maximal speed across six SSGBs (MALONE et al., 2019).

Total distance covered was affected by SSGB, showing a progressive linear increase (Table 4). This is in contrast with previous studies in soccer, which observed a progressive reduction in total distance covered across SSGBs (CLEMENTE et al., 2019; DELLAL et al., 2011, 2012). However, in the current study, the model showed an increase of two metres covered per SSGB, which is unlikely to be of practical significance for practitioners, who may therefore consider total distance to be stable over bouts. Furthermore, this may be the result of a within-session learning effect which would lead to performance improvements within a session (HOSSNER et al., 2016). The average total distance covered during each SSGB (Table 3), lasting 150 seconds, was also similar to the total distance reported for forwards during the longest ball-in-play periods (i.e., tight five: mean[95%CI] = 289[272, 305] m over 161 seconds, back row: mean[95%CI] = 290[270, 309] m over 152 seconds) of official competitions (REARDON et al., 2017), and similar to previously reported values for rugby union SSG played on a small pitch (length × width 32 × 24 m: average speed [SD] = 94[9] $m \cdot min^{-1}$; KENNETT et al., 2012). Therefore, the specific SSG implemented may offer an appropriate external load stimulus to players.

Considering internal load, previous research found both an increase (DELLAL et al., 2011; MALONE et al., 2019), and no change in heart rate (CLEMENTE et al., 2019; DELLAL et al., 2012) across multiple SSGBs. Nonetheless, these findings are in contrast with the present study where internal load (derived from heart rate data) demonstrated a quadratic pattern of change, decreasing first and increasing successively. This may be the result of players adapting to the constraints and optimising their movement solutions, thus increasing efficiency and reducing internal load (MORGAN et al., 1989). However, the process of acquisition and consolidation of a better movement strategy is generally characterised by fluctuations over time, which may be observed in the following increase in internal load (HOSSNER et al., 2016). Comparing this result with previous research may not be appropriate due to the different methods used to quantify internal load, individuals' maximal heart rate, and the fact that a quadratic model was not fitted (PÓVOAS et al., 2019). Nonetheless, based on these findings, practitioners may be confident that implementing SSG with an intermittent format may result in consistent external load, but some fluctuations in internal load may occur.

Similar to tactical behaviour, physical characteristics showed some variability across days of data collection. However, the SD for the random effect of date was consistently small in comparison with its respective fixed intercept and all the 95%PLCI included zero, thus suggesting that little variability across days of data collection may also be consistent with the data. Therefore, the specific SSG investigated may elicit consistent physical characteristics, for the majority of the variables investigated, across SSGB and across multiple days. This may help practitioners to plan training load appropriately when using this SSG.

Limitations

A limitation of the present study is that as a result of minor alterations in the teams between days due to player training load management, teams were not constant across all days of data collection. Although the mixed-effects models used in the study can appropriately handle unbalanced observations, this may result in greater variability in the data (HOFFMAN, 2015). Therefore, definitive conclusions should be made with caution. Furthermore, only a single measure of internal load (i.e., Stagno's *TRIMP*) was implemented, thus offering limited information about the psycho-physiological response over multiple SSGBs. Finally, technical skills were quantified exclusively using their frequency of occurrence without any information about the quality of the skill itself (e.g., body shape at the ruck), which may have shown a possible decrease over time.

Conclusions

The present study represents the first investigation on the consistency of tactical behaviour, and technical and physical characteristics over multiple bouts, and the variability over days, of a specific rugby union forwards SSG. Findings showed that when controlling for coach involved, tactical behaviour was affected by both SSGB (i.e., regularity of *width* of AS) and day of data collection. Technical characteristics were consistent across multiple SSGBs and days. In terms of physical characteristics, exclusively *total distance* and Stagno's *TRIMP* showed changes over SSGB, and little variability among days was observed. However, some of the differences identified may not be of practical significance for practitioners. In summary, these findings indicate that consistency of tactical behaviour, and technical and physical characteristics can be achieved for the majority of the variables investigated over multiple SSGB and days. Future research should investigate different attacking shapes and SSGs characterised by different objectives and involving rugby union backs or the combination of backs and forwards.

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The authors declare that there is no conflict of interest.

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Supplemental online material

The three datasets used for this investigation are provided.

Authors' contributions

All authors contributed equally to this paper.

Data Availability

The data used for this study are publicly available on a GitHub repository, accessible via https://github.com/marcozan93/Research-data/tree/main/study_2

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