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Manipulating field dimensions during small-sided games impacts the technical and physical profiles of Australian footballers

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Manipulating field dimensions during small-sided games impacts the technical and physical profiles of Australian footballers

ABSTRACT

This study investigated the effect of manipulating field dimensions on the technical and physical profiles of Australian football (AF) players during small-sided games (SSGs). A total of 40 male players (23.9 ± 3.5 y) participated in three, five-a-side SSGs; defined as 'small' (20m x 30m; 600m^2), 'medium' (30m x 40m; 1200m^2), and 'large' (40m x 50m; 2000m^2). Notational analyses enabled the quantification of technical skill indicators, while physical activity profiles were measured using microtechnology, resulting in 18 criterion variables. A multivariate analysis of variance modelled the main effect of field dimension on the criterion variables. A significant main effect was observed ($V = 1.032$; $F_{38, 102} = 2.863$; $P < 0.05$), with the 'small' and 'medium' SSGs generating more turnovers and ineffective handballs relative to the 'large' SSG. Further, the 'small' SSG generated more tackles and fewer bounces compared to the 'large' SSG. The 'large' SSG generated a greater absolute distance, relative distance, maximum velocity, PlayerLoad® and distance >4.16 m.s^{-1} compared to the 'small' and 'medium' SSGs. These results provide AF coaches with insights into how task constraint manipulation impacts the technical and physical profiles of players during small-sided game-play. Thus, coaches and physical performance specialists could use this information to assist with the tactical periodisation of technical complexity and physical load at different phases of the AF season.

Key words: Notational analysis, team sport, constraints-led approach, skill acquisition, global positioning system

INTRODUCTION

The multi-component, non-linear, and dynamic nature of team invasion sports often generates challenges for practitioners when designing representative learning environments [1, 2]. A popular strategy to account for this dynamic interaction between technical, physical, and perceptual-cognitive requirements has been to utilise small-sided games (SSGs) [3-5]. Amongst other means, coaches typically construct SSGs by manipulating the field dimensions and/or playing numbers [5, 6], with this manipulation thought to shape the activity profiles of players. For example, Klusemann et al. [7] demonstrated that increasing the number of players within a small-sided basketball game led to an increased number of successful passes and a decreased number of dribbles. Timmerman et al. [5] manipulated both pitch dimensions and player numbers within hockey games, noting the constrained environments that forced greater player density saw the emergence of fewer successful passes, skilled actions and a change in the physical activity profiles of players. Accordingly, manipulating features of a performance environment could afford coaches with the capability to increase or decrease the complexities associated with SSGs, information which would be of value for the periodization of skill development in high performance sport [8].

A theoretical underpinning to assist coaches with the effective manipulation of SSGs may be the constraints-led approach [9]. This theoretical approach considers organismic, environmental and task constraints, and the role each play within skill acquisition [9, 10]. As each constraint class can be viewed independently of one another, this approach offers coaches the relative flexibility in the manipulation and control of certain constraints. Briefly, organismic constraints are defined by anthropometric (e.g. limb length), physiological (e.g. $V0_{2max}$) or psychological (e.g. resilience) capabilities, and are categorised as either structural or functional [11]. Environmental constraints are those viewed external to the human movement system, with examples including ambient temperature, light and altitude [11]. Task constraints are those which are specific to the task needing to be performed, and relate to its outcome and/or rules [11]. Central to the present study, task constraint manipulation is likely to be of most use to coaches given the relative control they are likely to possess over this constraint class during SSGs [12].

The informed and strategic manipulation of the aforementioned constraint classes during SSGs is likely to alter the perceptual information available to participants, potentially impacting upon the emergence of idiosyncratic movement solutions [13]. For example, manipulating task constraints during SSGs, such as the field dimensions, could influence the spatial and temporal pressures imposed upon participants through an increased or decreased player density. The relative spatial and/or temporal complexity generated by a reduction in playing space may result in the emergence of adaptive behaviour [14], increase the difficulty of performing technical skills such as passing [5], and/or alter the physical loads placed on the human movement system [6]. It is likely that field dimension manipulation would also implicate the physical activity profiles of players during SSGs. When afforded with greater field dimensions, it is likely that players will be afforded with a greater opportunity to reach higher running velocities relative to SSGs played within smaller field dimensions [15]. Thus, this task manipulation is likely to be important for coupling skill acquisition and physical conditioning in team sports, as it could attune participants to pertinent environmental information to guide movement responses, while affording them with opportunities to engage in differing physical activities.

Given multi-component nature of game-play, SSGs are a commonly used training modality within Australian football (AF). Davies et al. [6] examined the influence of manipulating field dimension and player numbers on the agility demands in elite senior AF. It was noted that a reduction in space via a smaller field (increased player density) resulted in a small increase in agility manoeuvres, and a large increase in two-dimensional (mediolateral and anterolateral) load [6]. While this information would be of value for the physical conditioning of AF players, it remains unclear how the manipulation of field dimension (task constraint) impacts upon the technical skill demands of SSGs in AF. The aim of this work was to determine the effect of this task manipulation on the technical and physical profiles of AF players. Given work conducted both in AF and other team invasion sports [5, 6], it was hypothesised that this manipulation would alter the players technical and physical activity profiles given the changing spatial and temporal constraints placed on players. Specifically, it was expected that smaller dimensioned SSGs would incur greater erroneous technical activity and reduced total and relative distances in contrast to larger dimensions SSGs.

METHODS

Experimental Approach to the Problem

To test the study hypothesis, an observational cross-sectional research design was used. All participants competed within three different sized SSGs, defined as 'small', 'medium' and 'large' (Table 1). Each SSG was completed on an outdoor regulation AF oval, with the dimensions being strategically manipulated based upon prior work in AF [6]. Each SSG was contested between two teams of five players (five-a-side), with both teams being quasi-randomized to ensure no team had a bias of a certain playing position. Additionally, the players in each team were randomized each week, while a 'small', 'large', and 'medium' design was followed to limit a potential SSG learning effect. To accommodate four simultaneous SSG, field dimensions were set out so that the longest sides (i.e., 30m for the small SSG) were adjacent to the longest side of the oval boundary.

****** INSERT TABLE ONE ABOUT HERE ******

Subjects

Forty male participants competing within a state-based AF competition were recruited (23.9 ± 3.5 *y*; 185.2 ± 4.1 cm; 85 ± 8.4 kg; career games 52 ± 31.7). Participants provided full informed consent and were free of injury at the time of all data collection. Ethics approval was granted by the relevant Human Research Ethics Committee.

Procedures

SSG Rules: Regulation AF rules were imposed for each SSG (including full tackling), with accredited coaches (level two AF coaches) possessing more than 10 years' experience adjudicating each game. As is common practice within AF SSGs and in accordance with prior SSG work in AF [6], disposal mode was constrained, with participants only being eligible to handball. Participants 'scored' by handballing the ball to a coach placed in the 'goal zone', with players being eligible to score at any stage throughout the course of the SSG.

SSG Procedures: Each SSG was competed using an Australian Football League (AFL) match-day adult sized football, with all participants wearing their football boots. Testing took place over the course of a three-week block at the end of the preseason phase of training. Each SSG (small, medium or large) was blocked into weeks one, two or three. Accordingly, week one consisted of two ‘small’ SSGs (performed at the beginning of two training sessions), where game-play was contested over three 60 second playing periods. Between each playing period, a passive recovery interval of 60 seconds was implemented, during which players did not receive any coach driven augmented feedback. This protocol was repeated for weeks two (medium) and three (large).

Technical Involvements: To enable the coding of technical involvements, each SSG was recorded using a Casio Exilim EX-FH100 digital video camera (Casio, Australia), recording at 25 Hz. The cameras were placed to enable a behind-the-goals aerial perspective, with pilot testing showing that this perspective offered comprehensive insight into the participant’s movements. The technical skill notations coded in this study, along with their subsequent description, are presented in Table 2. The notational analysis was performed retrospectively via the use of SportsCode (Sportstec Limited, Sydney, Australia). Given the subjective nature of this coding procedure, the inter-rater reliability of the notational analysis was measured. The lead investigator coded all 11 technical variables for a random 10% of the total number of SSGs. A co-investigator independently coded the same SSGs. Inter-rater reliability was assessed using intra-class correlation coefficient (ICC) statistics using SPSS (version 21, SPSS Inc., USA). ICC range for the coded games was 0.926 – 0.997, showing excellent reliability.

****** INSERT TABLE TWO ABOUT HERE ******

Physical Activity Profiles: To ascertain the physical running demands of each SSG, players were fitted with an OptimEye S4 global positioning system (GPS) unit (Catapult Innovations, Scoreby, Australia). Each unit sampled at 10Hz and were positioned between each participant’s scapulae in a custom designed harness provided by the manufacturer. The criterion variables extracted from these devices included: total distance (m), relative distance ($m.min^{-1}$), maximum velocity ($m.s^{-1}$), PlayerLoad® (AU; extracted from the tri-axial accelerometers in each unit), and distances covered while light jogging (0 – 4.13 $m.s^{-1}$), fast jogging (4.16 – 5.54 $m.s^{-1}$) and sprinting (>5.55 $m.s^{-1}$) [16].

Statistical Analysis

Descriptive statistics (mean ± standard deviation) were calculated for each technical and physical performance indicator relative to the SSG field dimensions. All analyses were conducted using SPSS (version 21, SPSS Inc., USA), with the Type-I error rate being set at P <0.05. To establish the inter-rater reliability of the notational analysis, Pearson correlation coefficients were calculated. Following this, a multivariate analysis of variance (MANOVA) modelled the main effect of field dimension (Three levels: small, medium and large) on the technical and physical criterion variables. Further, Cohen's d effect size statistics were calculated according to the main effect, where d <0.10 was considered trivial, d = 0.10 – 0.20 small, d = 0.21 – 0.50 moderate, d = 0.51 – 0.80 large, and d >0.81 very large [17].

RESULTS

The Pearson correlation coefficients for each technical skill indicator ranged between r = 0.84 – 0.96, indicating strong inter-rater reliability for the notational analysis. There was a significant effect of field dimension on the technical and physical skill performance criterions (V = 1.032; $F_{38, 102}$ = 2.863; P <0.05). Thus, for brevity, the subsequent results have been partitioned into technical and physical criterion variables.

Technical Criterion Variables

As displayed in Table 3, the number of turnovers decreased as the field dimensions increased, with the 'small' and 'medium' SSGs generating a significantly greater number of turnovers relative to the 'large' dimension (P <0.05; d = 0.99 and 0.82, respectively). Further, the number of ineffective handballs decreased with the concurrent increase in field dimension (Table 3). The 'large' SSG generated a significantly fewer number of tackles (P <0.05; d = -0.79) and greater number of bounces (P <0.05; d = 0.75) relative to the 'small' SSG. The remaining technical criterion variables did not yield a significant effect.

****** INSERT TABLE THREE ABOUT HERE ******

Physical Criterion Variables

Each physical criterion variable yielded a significant 'large' to 'very large' effect (P <0.05; d >0.51; Table 3). Total distance, relative distance, maximum velocity, PlayerLoad®, fast jogging and sprinting distances all significantly increased from 'small' to 'large' SSGs (Table 3). Conversely, the light jogging distances significantly decreased as the SSG dimensions increased (Table 3).

DISCUSSION

The aim of this study was to determine the effect that field dimension manipulation during SSGs had on the technical and physical profiles of Australian footballers. It was hypothesised that this manipulation would result in observable changes in the participants technical and physical involvements given the expected differing spatial and temporal complexities associated with each SSG. Supportive of this hypothesis, and consistent with others [5,6], results demonstrated that a reduction in playing space (increased player density) led to a greater count of turnovers, ineffective handballs, tackles, a reduction in running bounces, and a considerable change in physical activity profile relative to larger field dimensions (decreased player density). Accordingly, a reduction in field dimension may have limited the participant's capability to develop information-movement responses relative to their functional capabilities (i.e., identify who to pass the ball to and then execute that response) [18]. These results provide AF coaches with insights into how a relatively simple task constraint manipulation within SSGs can alter the technical and physical involvements of players, with this potentially being of use for both skill and conditioning periodization in AF [8].

It was apparent that the 'small' SSG generated the highest technical difficulty for participants relative to the 'medium' and 'large' dimensions. The greater erroneous activity recorded in the 'small' SSG could have arisen from temporal and spatial constraints generated between the attackers and defenders. For example, the relatively greater count of turnovers and ineffective handballs could have stemmed from the spatial pressure imposed upon the ball carrier from their opponent given the increased player density. This spatial pressure is likely to have temporally constrained the attacker's capability to visually search for, and process, the necessary environmental information needed to inform their motor response [7]. Concurrently, it is possible that the smaller field dimensions enabled greater dyadic interactions between defenders and attackers [14]. Notably, the higher density in the 'small' SSG may have afforded a defender with greater opportunity to impact the attacker. This is likely to place a greater emphasis on the execution of the disposal, as the defender may have been afforded with a greater capability to impact upon the pass, resulting in the higher count of turnovers and tackles recorded in the 'small' SSG. Despite a regulation adult AF game being contested on playing fields with dimensions between 130-150 m by 150-190 m [19], it is common for players to compete for ball possession in high congestion, as they strive to gain a 'clearance' (the act of clearing the ball into space or to a teammate in space). Pertinently, elite senior AF teams who accrue a greater count of clearances are more likely to finish a season higher on the ladder [20]. Accordingly, despite the 'small' SSG incurring greater erroneous passes, the temporal and spatial constraints imposed in this condition may assist AF players to refine the perceptual and technical skills needed to manage congested scenarios experienced during match-play.

As expected, the 'large' SSG resulted in greater total, relative, and high speed running distances as well as PlayerLoad® and maximum velocities when compared to the 'small' and 'medium' SSGs. It is likely that the greater field dimension and reduced player density in the 'large' SSG afforded participants with the capability to utilise the space in an attempt to uncouple the attacker-defender dyad in order to maintain possession. These observations are in general agreement with work conducted in youth hockey [5], and soccer [21]. Casamichana and Castellano [21] found that a relatively larger pitch area resulted in a higher physical and physiological workload in soccer, concluding that coaches could use this information when designing practice conditions at different phases of a competitive season. Further, it was of note that the 'large' SSG afforded participants with a greater capability to engage in running bounces relative to the 'small' SSG. In AF, players must bounce the ball if they maintain possession while running greater than 15 m. Thus, the greater space afforded to the players in the 'large' SSG seemed to result in the emergence of an action (the bounce) that was not utilised by participants within the 'small' or 'medium' SSGs. This observation is important for AF coaches, as it demonstrates that SSG design is likely to shape the types of actions players perform.

In summary, the 'large' SSG generated fewer technical errors, tackles, more bounces, and a greater physical activity profile relative to the 'small' and 'medium' dimensions. These observations were likely driven by the increased spatial and temporal complexities associated with an increased player density incurred by reducing the field dimensions. Despite these promising results, the study is not without limitations that require acknowledgement. Firstly, given data availability, we were unable to quantify the player's acceleration and deceleration profiles, information which is likely to be of use when planning the conditioning of players throughout a football season. Secondly, it is possible that the 60 second duration of the SSGs limited a player's capability to fully engage in game-play, particularly in the large dimension SSGs. Lastly, given the observational design of this work, it is difficult to ascertain the exact causation of the increased erroneous technical activity in the 'small' SSGs (i.e., motor or perceptual). We hypothesise that errors were the resultant of both execution (motor) and perceptual (passing to the 'wrong' player) misjudgements, but it would be an interesting avenue for future research to empirically address given the implications the subsequent findings could yield for skill periodization. Nonetheless, these limitations provide an enticing platform for future work, along with the examination into other task constraint manipulation, such as understanding how player number (in)equalities impact the technical and physical profiles of AF players during SSGs.

PRACTICAL APPLICATIONS

Two main practical applications stem from this work. Firstly, results demonstrate that strategic manipulation of task constraints (field dimension) can result in behavioural changes in Australian footballers. This could afford a coach with the capability to train players to attune their perceptions to pertinent environmental information of use to inform motor responses, particularly in periods of high player density. Secondly, coaches could use these results to assist with the periodization of the technical and physical loads generated in their practice environments [8]. Specifically, in training phases that require higher perceptual and technical complexity (perhaps 'in-season'), coaches may consider the use of 'small' SSGs, while periods of the season requiring greater physical load (perhaps 'pre-season'), coaches may consider the use of 'large' SSGs. Given these results, it would be of interest for future work to ascertain how the manipulation of additional and interacting task constraints, such as player numbers, impacts upon the technical and physical activity profiles of AF players.

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