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The Influence of Small-Sided Football Games with Numerical Variability in External Training Load

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Abstract: Small-sided games (SSGs) are a motivational strategy and effective training method to develop skills and physical fitness at optimal intensity. This study investigates the influence of variability in the number of players on the physiological response using SSGs. The sample was composed of 10 field players with an average age of 15.9 ± 0.50 years old. Three sessions were held on 3 different days to collect information. The 10 min SSG exercise with temporal numerical variability was repeated twice on each day. The numerical ratio of players involved changed every 2 min without disrupting the practice. In a game space with 35 × 25 m, the exercise always started in a situation of 3 vs. 3. External training load metrics (i.e., physical activity counts, activity intensity, and energy expenditure) were assessed using Actigraph WGT3X accelerometers. The 3 vs. 3 format game had higher physical activity counts (i.e., higher vector magnitude) and requested more time spent in very vigorous physical activity intensity. Consequently, the 3 vs. 3 format in young football players had higher energy expenditure (i.e., a higher METs) than that in the other studied game formats. This study confirms the influence of SSGs with numerical variability in external training load.

Keywords: physiological response; external load; small-sided games; numerical variability

1. Introduction

Small-sided games (SSGs), also referred to as skill-based conditioned games [1], game-based training [2], or reduced and conditioned games [3], are game situations that generate practice conditions to induce specific game behaviours. SSGs are a sustainable training method to develop skills and physical fitness at optimal intensity.

These training methods are based on the variation of practice conditions (depending on training objective), namely, variability in the number of players and game space, and the adaptation or conditioning of the game regulation (among others), but maintaining the logic and reality of the basic principles of the game [4–6].

One of the foci of most significant interest in the use of SSGs in the training process is based on their use to develop the physical dimension of the practitioner's abilities, particularly in situations of pressure and fatigue [7,8]. SSGs are capable of generating high-intensity activities (short sprint, constant tackles, greater proximity to the opponent, and consequently an increase in the number of duels), involving various types of movements, similar to those that exist in the real competitive context [9].

Although the investigation of SSGs arose in the last decade, this training method has been used since the 1970s. However, in the last decade, interest in this type of situation has grown again, intending to increase the participation of players in training, and consequently the physical and physiological load [10–15].

The growing popularity of the SSGs comes from a set of benefits that can be used in football at all ages and levels, which replicate the required movements, physiological intensity, and technical resources of a competitive game [9,10,16,17] while triggering decision making about pressure and fatigue in players [7].

It is possible to measure exercise intensity in SSGs through player movement, and the physiological responses and perception of effort [18]. The coach controls a set of variables that influence exercise intensity in SSGs [19], such as field area, the number of players, coach feedback, training planning (continuous or interval and rest-time manipulation), modification of the rules, and the use of goals and goalkeepers (GK) [9,20–22].

Although there are studies that address the issue of numerical variability in SSGs, they were mostly conducted through the use of jokers [10,23,24], which is momentary variability. The joker is often used by teachers or coaches to manipulate the SGG in terms of numerical relationship, which can be defined as supporting both teams in the offensive or defensive process of the game [24,25]. The dynamics that a joker provides to training situations never happen in a real game context, as this element always plays in the team that has the ball, and there is no reversibility of functions, which is precisely the opposite of what the game is and what this study intends to present.

Physiological analysis of SSGs in football training has been around for over 30 years [26]. More recently, with technological advances and greater access to a wide range of instruments (accelerometers, GPS, heart-rate monitoring), it has led to load assessment and monitoring being more accessible, reliable, and accurate [7,27–30].

Some studies indicate that SSG formats with different numbers of players induce different physiological and perceptual characteristics [31–33]. However, these studies only verified the influence of the numerical change in team players while always maintaining numerical equality between teams. Given that football is currently played in the search (attack) and impediment (defence) of constant numerical imbalances, further research is needed to clarify the impact of team responses on numerical imbalances using SSGs [34,35]. To the best of our knowledge, few studies considered unbalanced formats or a changeable numerical ratio of players in the SSGs on the external load of practitioners [23,34,36,37]. Therefore, this study investigates the influence of variability in the number of players using reduced game formats on the physiological response. We identify if there is a change in the physiological response of players in five different SSG formats with numerical variability (3 vs. 3, 4 vs. 3, 5 vs. 3, 3 vs. 4, and 3 vs. 5).

2. Materials and Methods

2.1. Participants

The sample was composed of 10 male field players with an average age of 15.9 $\pm$ 0.50 years old. Ten field players were twice examined on 3 different assessment days. In total, 24 observations were considered in the analyses. All participants were affiliated with the local football association in the last 5 seasons and belonged to the same team. They had a regular weekly program of 3 training sessions of 75 min each and the competitive moment at the end of the week (regional or local championship that qualifies a team for the final national championship phase). The study sample size was determined following a priori power analysis, which indicated that, to detect a large effect size of r = 0.40 with an alpha probability of 0.05, a power of 0.85, and a total of 5 measurements, the sample size would need to comprise 10 participants. GPower, (Heinrich Heine University, Düsseldorf, Germany; 3.1.9.7 software) was used in the calculations [38]

All players were informed about the research objectives, its requirements, and the potential benefits and risks. Participation was voluntary. Parents or legal guardians signed informed consent, and players gave their verbal assent. All procedures followed the guidelines stated in the Declaration of Helsinki [39] and had been approved by the ethics commission: Ethical Committee of the Faculty of Human Kinetics, University of Lisbon, approval code: CEIFMH No: 35/2021; approval date: 6 July 2021.

2.2. Study Design and Procedures

Three sessions were held for the data collection on three different days, starting at the same time and following a 24 h interval between each of the collection sessions. The presented SSG format was variable, with a total duration of 10 min and changing the numerical ratio of players in the game every 2 min without interrupting the practice. The exercise always started as a 3 vs. 3 + GK game format (0 to 2 min), then 4 vs. 3 + GK (2 to 4 min), 5 vs. 3 + GK (4 to 6 min), 3 vs. 4 + GK (6 to 8 min), and 3 vs. 5 + GK (8 to 10 min).

The order in which these changes took place was randomised differently for the three days of the study (except for the initial 3 vs. 3 + GK format). The purpose was to keep uncertainty about the sequence of the situations to ensure that there were no strategic behaviours on the part of the participants who played the format. Every 2 min, the team structure was reconfigured, entering players in a delimited zone (in the middle of the game space) or leaving the nearest line where they were. However, the original three elements of each team that started the 3 vs. 3 + GK remained throughout the exercise. The new elements that entered always played at the same time each day. The entire 10 min exercise were repeated twice. Teams remained the same throughout the study, and the prior knowledge of the coach was used for the composition and structuring of the teams on the basis of the capacities and usually performed positions or functions for an equitable distribution of individual value, adopting similar strategies and following the recommendations [40].

The sessions started with a 20 min warm-up, with a general mobilisation of all body segments for a musculoskeletal activation, followed by an exercise to maintain ball possession without goals but using GKs as external supports to the game space. These two exercises were later complemented with dynamic stretching and speed exercises. After the warm-up, the used SSG formats lasted 10 min, followed by 5 min of passive rest to perform a second series of 10 min. The sessions ended with a 10 min cooldown using a series of static stretches.

The dimensions of the game space were 35 × 25 m using smaller football goals that were 6 m wide and 2 m high. The only changes to regulation were removing the offside rule and replacing the ball when it left the end line, always starting by being carried out by the GK of the team to which the ball belonged, regardless of whether it was a corner. In these replacements, the GKs had the freedom to use hands or feet. To keep play intensity high and increase the effective playing time, several balls were placed around the field, and several collaborators in the study were strategically positioned to collect and give the ball whenever it left the game space. The teachers or coaches and those responsible for the study were only authorised to provide verbal encouragement feedback. They were expressly prohibited from giving any information or indications on strategic issues or tactical-technical behaviour.

2.3. External Training Load Metrics

External training loads were assessed using the ActiGraph wGT3X-BT accelerometer (ActiGraph, LLC, Pensacola, FL, USA). Participants wore the accelerometer over the right anterior superior iliac spine. The accelerometer was initialised to store activity counts at the beginning of each 10 min exercise. The captured raw acceleration data were converted into various objective activities using ActLife Monitoring System software. ActiLife5's cut point data scoring option allows for users to break out the proportion of time that each dataset encompasses into different categories of activity. Data were processed using a 10 s epoch. Activity counts were analysed by the vector magnitude counts and determined physical activity intensity in the following categories: (1) light physical activity intensity (760–1952 counts), (2) moderate physical activity intensity (1953–5724 counts), (3) vigorous physical activity intensity (5725–9498 counts), and (4) very vigorous physical activity intensity (9499 and higher counts). Energy expenditure was also analysed using MET rates.

2.4. Statistical Analyses

First, the Friedman test was used to investigate the change in young football players' internal and external training load across five different small-sided game formats with numerical variability (i.e., 3 vs. 3, 4 vs. 3, 5 vs. 3, 3 vs. 4, and 3 vs. 5). Second, to investigate the change in internal and external training load between each game format (i.e., 3 vs. 3 vs. 4 vs. 3, 3 vs. 3 vs. 5 vs. 3, 3 vs. 3 vs. 3 vs. 4, 3 vs. 3 vs. 3 vs. 5, 4 vs. 3 vs. 5 vs. 3, 4 vs. 3 vs. 3 vs. 4, 4 vs. 3 vs. 3 vs. 5, 5 vs. 3 vs. 3 vs. 4, 5 vs. 3 vs. 3 vs. 5, 3 vs. 4 vs. 3 vs. 5) we used the Wilcoxon signed-rank test. Data analysis assumptions were verified. The level of confidence was set at 95%. Data were analysed using IBM SPSS statistics 26.

3. Results

Participants' characteristics are summarised in Table 1.

Table 1. Participants' characteristics.

Physical Tests	Mean	Std. Deviation	95% Confidence Interval for Mean
Age (years)	15.9	0.50	15.6–16.3
Weight (kg)	60.5	7.60	55.7–65.3
Height (cm)	171.5	6.57	167.3–175.7
BMI (kg/m^2)	20.5	2.12	19.2–21.9
Bar suspension (s)	32.8	11.64	25.4–40.2
Sit-ups (n)	26.7	1.72	25.6–27.8
Sit and Reach Bilateral (cm)	33.1	7.59	28.3–37.9
Dynamometry Right hand (kg)	35.6	4.12	33.0–3.2
Flamingo Balance (n)	11.9	4.06	9.3–14.5
Sprint 5 m (s)	1.0	0.06	0.97–1.0
Sprint 10 m (s)	1.7	0.06	1.7–1.8
Sprint 35 m (s)	5.0	0.16	4.9–5.1
YYIR1 (s)	1151.7	462.21	858.0–1445.3
T Test (s)	9.9	0.52	9.6–10.2
Counter Movement Jump (cm)	28.6	2.8	26.8–30.4
Squat Jump (cm)	28.9	2.5	27.3–30.5

Table 2 depicts the results of the Friedman test, indicating that, in the external training load metrics, there was a statistically significant difference in the vector magnitude counts, (χ^2 (4, n = 72) = 79.12, $p < 0.001$), steps counts (χ^2 (4, n = 72) = 10.88, $p < 0.001$), light physical activity intensity counts (χ^2 (4, n = 72) = 20.26, $p < 0.001$), moderate physical activity intensity counts (χ^2 (4, n = 72) = 69.79, $p < 0.001$), vigorous physical activity intensity counts (χ^2 (4, n = 72) = 9.88, $p = 0.043$), very vigorous physical activity intensity counts (χ^2 (4, n = 72) = 72.44, $p < 0.001$), and METs (χ^2 (4, n = 72 = 109.86, $p < 0.001$), across the different studied game formats.

Table 2. External training load metrics.

External Load Metrics	3 vs. 3 (1) (*n* = 24)		4 vs. 3 (2) (*n* = 24)		5 vs. 3 (3) (*n* = 24)		3 vs. 4 (4) (*n* = 24)		3 vs. 5 (5) (*n* = 24)		† (*p*)	‡
	M ± Std.	**Med.**	**M ± Std.**	**Med.**	**M ± Std.**	**Med.**	**M ± Std.**	**Med.**	**M ± Std.**	**Med.**		
Vector magnitude	18,144.18 ± 3018.63	18,534.60	16,109.92 ± 2259.99	16095.10	16,069.22 ± 2189.49	16,141.55	15,486.84 ± 2887.96	15,109.35	16,658.36 ± 2102.17	16,616.40	<0.001	1 > 2, 3, 4 and 5; 2 < 5; 4 < 5
Steps (counts)	244.00 ± 17.51	244.00	227.31 ± 22.23	230.00	227.04 ± 22.43	229.00	215.04 ± 26.96	220.00	229.14 ± 24.18	233.00	<0.001	1 > 2, 3, 4 and 5; 2 > 4; 3 > 4; 4 < 5
SPA counts	0,00 ± 0,00	0.00	0.005 ± 0.04	0.00	0.00 ± 0.00	0.00	0.01 ± 0.05	0.00	0.002 ± 0.02	0.00	0.046	n.s.
LPA counts	0.00 ± 0.00	0.00	0.02 ± 0.06	0.00	0.00 ± 0.00	0.00	0.02 ± 0.07	0.00	0.002 ± 0.02	0.00	<0.001	1 < 2 and 4; 2 > 3 and 5; 3 < 4; 4 > 5
MPA counts	0.08 ± 0.14	0.00	0.33 ± 0.30	0.33	0.31 ± 0.31	0.17	0.42 ± 0.37	0.34	0.27 ± 0.35	0.17	<0.001	1 < 2, 3, 4 and 5; 3 < 4; 4 > 5
VPA counts	1.14 ± 0.39	1.17	1.18 ± 0.41	1.17	1.29 ± 0.36	1.33	1.14 ± 0.34	1.17	1.27 ± 0.40	1.33	0.043	1 < 3 and 5; 2 < 3; 3 > 4; 4 < 5
VVPA counts	0.79 ± 0.41	0.83	0.45 ± 0.34	0.33	0.39 ± 0.36	0.33	0.43 ± 0.42	0.33	0.44 ± 0.37	0.33	<0.001	1 > 2, 3, 4 and 5
MET rates	7.85 ± 0.72	7.89	6.81 ± 0.94	6.85	6.73 ± 0.87	6.89	6.48 ± 1.09	5.78	7.02 ± 0.92	7.08	<0.001	1 > 2, 3, 4 and 5; 2 > 4; 2 < 5; 3 > 4; 3 < 5; 4 < 5

† *p*-value from the Friedman test to investigate the change in young football players' internal and external training load across five different small-sided game formats; ‡ Wilcoxon signed-rank test indicating the individual differences in internal and external training load between each game format.

3.1. Vector Magnitude Counts

The Wilcoxon signed-rank test revealed statistically significant higher vector magnitude counts in 3 vs. 3 in comparison to those in 4 vs. 3 ($z = -4.99$, $p < 0.001$), 5 vs. 3 ($z = -5.28$, $p < 0.001$), 3 vs. 4 ($z = -5.35$, $p < 0.001$), 3 vs. 5 ($z = -5.14$, $p < 0.001$).

3.2. Light Physical Activity Intensity Counts

There were also statistically significant higher vector magnitude counts in 3 vs. 5 in comparison to those in 4 vs. 3 ($z = -2.30$, $p = 0.021$) and 3 vs. 4 ($z = -3.72$, $p < 0.001$). There were statistically significant lower light physical activity intensity counts in 3 vs. 3 in comparison to those in 4 vs. 3 ($z = -2.53$, $p = 0.011$), and 3 vs. 4 ($z = -2.64$, $p = 0.008$). We also identified statistically significant lower light physical activity intensity counts in 4 vs. 3 in comparison to those in 5 vs. 3 ($z = -2.53$, $p = 0.011$) and 3 vs. 5 ($z = -2.11$, $p = 0.035$). In addition, the 3 vs. 4 format had statistically significant higher light physical activity intensity counts in comparison to those in 5 vs. 3 ($z = -2.12$, $p = 0.034$) and 3 vs. 5 ($z = -3.30$, $p = 0.001$).

3.3. Moderate Physical Activity Intensity Counts

There were statistically significant lower moderate physical activity intensity counts in 3 vs. 3 in comparison to those in 4 vs. 3 ($z = -5.64$, $p < 0.001$), 5 vs. 3 ($z = -5.49$, $p < 0.001$), 3 vs. 4 ($z = -6.26$, $p < 0.001$), 3 vs. 5 ($z = -4.77$, $p < 0.001$). In the 3 vs. 4 format, there were statistically significant higher moderate physical activity intensity counts in comparison to those in 5 vs. 3 ($z = -2.12$, $p = 0.034$), and 3 vs. 5 ($z = -3.30$, $p < 0.001$).

3.4. Vigorous Physical Activity Intensity Counts

There were statistically significant lower vigorous physical activity intensity counts in 3 vs. 3 in comparison to those in 5 vs. 3 ($z = -2.68$, $p = 0.007$) and 3 vs. 5 ($z = -2.40$, $p = 0.016$). We also identified statistically significant higher vigorous physical activity intensity counts in 5 vs. 3 in comparison to those in 4 vs. 3 ($z = -2.17$, $p = 0.030$) and 3 vs. 4 format ($z = -2.46$, $p = 0.014$). Lastly, the 3 vs. 5 format had statistically significant higher vigorous physical activity intensity counts in comparison to those in the 3 vs. 4 format ($z = -2.55$, $p = 0.011$).

3.5. Very Vigorous Physical Activity Intensity Counts

There were statistically significant higher very vigorous physical activity intensity counts in 3 vs. 3 in comparison to those in 4 vs. 3 ($z = -5.51$, $p < 0.001$), 5 vs. 3 ($z = -6.02$, $p < 0.001$), 3 vs. 4 ($z = -5.99$, $p < 0.001$), 3 vs. 5 ($z = -6.12$, $p < 0.001$).

3.6. METs

There was statistically significant higher energy expenditure (METs) in 3 vs. 3 in comparison to that in 4 vs. 3 ($z = -7.17$, $p < 0.001$), 5 vs. 3 ($z = -7.20$, $p < 0.001$), 3 vs. 4 ($z = -7.23$, $p < 0.001$), 3 vs. 5 ($z = -7.00$, $p < 0.001$). We also identified statistically significant higher METs in 4 vs. 3 in comparison to that in 3 vs. 4 format ($z = -2.58$, $p = 0.010$). In addition, there were statistically significant higher MET counts in 3 vs. 5 in comparison to those in 4 vs. 3 ($z = -2.07$, $p = 0.039$), 5 vs. 3 ($z = -2.43$, $p = 0.015$), and 3 vs. 4 ($z = -4.27$, $p < 0.001$). Lastly, the 5 vs. 3 format had statistically significant higher MET counts in comparison to that in the 3 vs. 4 format ($z = -2.12$, $p = 0.034$).

4. Discussion

This study analysed the effect of different SSG formats with numerical variability on young football players' external training load metrics. In general, the 3 vs. 3 format game had higher physical activity counts (i.e., higher vector magnitude) and requested more time spent in very vigorous physical activity intensity than the 4 vs. 3, 5 vs. 3, 3 vs. 4, and

3 vs. 5 formats did. Consequently, the 3 vs. 3 format in young football players provided higher energy expenditure (i.e., higher METs) than that of other studied game formats.

In the last decade, SSGs have been simultaneously studied as effective training methods with promising results in skills and fitness dimensions. SSGs provide optimal work intensities and appropriate training structures. However, it remains unclear which practice conditions related to the number of players, space, or rules better impact the physiological response.

For example, Clemente et al. [4] proposed a set of methodological suggestions and recommendations to insert SSGs into the training process during a sporting season. When changing the number of players, introducing different conditions to the game rules and modifying the dimensions of the game space, different physiological responses occur. In addition, Little [9], in a review of research concerning conditioning with football drills, claimed that SSGs that involve more players result in appropriate intensities for lactate threshold development. On the other hand, the 3 vs. 3 and 4 vs. 4 game formats can be used to develop maximal oxygen consumption. These results suggest that game formats with fewer players may train and develop aerobic endurance that is specific to high-intensity football. Our study partly supports these findings, since we found statistically significant higher very vigorous physical activity intensity counts and energy expenditure in 3 vs. 3 compared to those in other game formats.

To the best of our knowledge, no other study has considered a similar design to investigate the influence of variability in the number of players on the external training load. The work with the most similar results to our study was reported by Praça, Custódio, and Greco [41]. They concluded that the physical demands of players were reduced when adding an element to a team compared to situations in which they played in numerical equality. The same study concluded that if the teacher or coach's goal is to reduce physical demand or energy expenditure (for reasons such as proximity to a competition or even recovery training after a game), numerical superiority situations are helpful in organising consequent reduction in training intensity.

The present study found that the 3 vs. 3 format game provided higher physical activity counts, increased the time spent in very vigorous physical activity intensity, and requested higher energy expenditure than that of other unbalanced game formats (i.e., 4 vs. 3, 5 vs. 3, 3 vs. 4, or 3 vs. 5). Concerning a teaching–learning approach, some important messages to the practice should be considered from our study to sustain the players' performance in the training sessions. First, when there are modifications in the number of players in action, namely, creating an unbalanced game situation, changes are seen in the external training load and the intensity of the activity. Indeed, some studies agreed with the use of SSGs to induce changes in the external load in relatively short periods, suggesting that the ability to develop the players' physical profile while training the tactical–technical elements might make SSGs a very sustainable training method [42]. Second, if teachers or coaches design SSG for conditioning, the 3 vs. 3 format may more significantly impact physiological and physical levels, and request higher energy expenditure. Introducing one or two players into a team, i.e., creating an unbalanced situation, may reduce the intensity levels in both teams. Third, considering that 3 vs. 3 may increase the time spent in very vigorous physical activity intensity, caution about overtraining is needed in implementing this game format to develop skills and physical fitness.

Despite the recognised potential of SSGs, caution is needed in implementing this method in a training periodisation process. Improper programming can hide shortcomings in performance and the development of physical abilities. It is crucial to strictly control the dynamics of SSGs, i.e., the game's duration when designing them, and consequent framing them in the periodisation and management of training.

Some limitations should be acknowledged when interpreting our results. First, even though three sessions were held for data collection on 3 different days to strengthen the reliability of the data collection, the main focus was on the influence of the formats and not on the players' performance, and only one team under 17 was included. Second, the scarce literature on the topic using a similar experimental design limits the discussion of the present results. More longitudinal and experimental studies are needed to better understand how small but significant modifications in the number of players can affect external training load and activity intensity.

This study also has some important strengths that must be underlined. First, there are concrete, practical implications that can help teachers or coaches when designing SSGs for improving players' physical profile while training the tactical–technical elements. Second, the uniqueness of the study design, using a changeable SSG format with a duration of 10 min and changing the numerical ratio of players in the game every 2 min without interrupting the practice, opens new avenues on exploring the potential of the SSGs keeping at the same time the main features of the real game. Lastly, the instrument used to collect the external training load could capture and record continuous accurate information about the quantity and intensity of the physical activity.

5. Conclusions

This study emphasised the influence of SSGs with numerical variability in the external training load in young football players. The 3 vs. 3 format provides higher physical activity, increases the time spent in very vigorous physical activity intensity, and requests higher energy expenditure than that of the other studied unbalanced game formats, namely, the 4 vs. 3, 5 vs. 3, 3 vs. 4, or 3 vs. 5 formats. This study reinforces that unbalanced game formats may require a reduction in training intensity, favouring the development of other components related to individual tactics.

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