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Internal and external load of youth soccer players during small-sided games

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Abstract
Introduction. **A majority of soccer players are engaged in recreational sport and particularly in developmental soccer: it seems necessary to assess the internal and external load of small--sided games (SSGs) of this specific group in view of the scarce scientific data on the subject.** Aim of Study. **The aim of the study was to investigate the internal and external load of youth soccer players during SSGs with different numbers of players and field dimensions.** Material and Methods. **The total sample consisted of 16 youth recreational under-15 soccer players. The participants performed SSGs (1v1, 2v2, 3v3, 4v4 with goalkeepers) at an individual playing area of 1:150 m², 1:100 m², and 1:75 m² in random order. They wore portable GPS (Polar Team Pro) tracking sensors in order to record internal and external loads during the whole training session. All participants were asked to rate the RPE at the end of SSGs. The significance level was set at $p < 0.05$.** Results. **The results showed that SSGs with a smaller number of players and a larger individual playing area led to an increasing internal load. The external load analysis in the present study showed that SSGs with a higher number of players and a larger individual playing area had a more significant impact on the external load.** Conclusions. **In conclusion, the number of players and field dimensions should be taken into account by coaches during SSGs so as to achieve the ideal training organization and as an implementation of the training sessions, competitive microcycle, and yearly planning.**

KEYWORDS: heart rate, youth soccer, small-sided games, internal and external load.

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Introduction

Small-sided games (SSGs) lead to an improvement of physical fitness and increase the levels of enjoyment and competence, factors that constitute goals of recreational sport. In the last decade researchers have tried to quantify the resulting training load. The advancement of technology has contributed to this progress to a great extent. Training load evaluation methods are divided into these that monitor internal load and those that monitor external load [7].

The predominant method that is used for measuring external load is the Global Positioning System (GPS). GPS detects players' position by receiving data from satellites. This particular monitoring system is used for measuring total distance, distance in different speed zones, accelerations and decelerations during official matches and training sessions [10].

On the other hand, internal load refers to the athletes' physiological response to training load. It is apparent that the internal load determines players' adaptations [21]. The most common quantification method of internal load is through monitoring heart rate (HR), the measurement of lactate concentration and the use of rate of perceived exertion (RPE, CR-10, 6-20) [7, 8].

SSGs are becoming an increasingly popular training tool for soccer. SSGs are not only used for adults, but also for youth players starting from an early age. SSGs are smaller adapted versions of the official game, which aim to simulate dynamic game conditions [19, 22]. These games are widespread globally as they ensure the existence of a physiological stimulus combined with technical and tactical characteristics [5]. Concerning youth players, it was apparent that fitness coaches preferred SSGs because they improved technical and tactical behavior concurrently due to high cardiorespiratory intensity. Fitness has also improved [20]. Moreover, this training type was more pleasant for the players [20].

Over the recent years, the number of studies concerning SSGs has increased and researchers' interest focuses on the differentiation of their structure (field dimensions, number of players, game duration, coach encouragement, technical limitations) causing different physiological loads [6].

Furthermore, studies which were carried out with youth players presented conflicting results. In particular, Köklü and Alemdaroğlu (2016) [17] observed higher values of % HRmax during 3v3 and 4v4 formats in comparison with 2v2. However, in a previous study Köklü (2012) [15] found higher HR values during 3v3 compared with 2v2 and 4v4. Nevertheless, a majority of studies showed a reversed relationship between the number of players and internal load [9].

There are several studies concerning the influence of field dimensions on external load. Specifically, a study implemented on collegiate students at the two larger relative field sizes (120 m^2/player, 200 m^2/player) resulted in greater covered distance and also a higher number of decelerations and accelerations compared with smaller relative field sizes [13]. Furthermore, the results were similar in a study which was carried out in youth U-17 soccer players, as the researchers observed significantly higher values of total distance and high intensity running with a relative field size of 175 and 273 m^2/player [2].

Taking into account the fact that a majority of soccer players are engaged in recreational sport and particularly with developmental soccer, it seems necessary to assess the above variables of this specific group in view of scarce scientific data on the subject. This will clarify which factors should change in order to accomplish specific responses to physical abilities. Thus, coaches will obtain a useful tool for an ideal training organization. The present study aims to investigate the internal and external load during SSGs in youth soccer players. The purpose of this study was to investigate internal and external load of youth soccer players during small-sided games with a different number of players (4v4, 3v3, 2v2, 1v1) and field dimensions (150 m^2/player, 100 m^2/player, 75 m^2/player).

Material and Methods

Experimental design

The study was conducted during the second half of the competitive season. Participants abstained from any training stimulus 48 hours before initial measurements. The examinees did not participate in any other physical activity during the research period. For the next three weeks the soccer players performed SSGs (4v4, 3v3, 2v2, 1v1 with goalkeepers) with a relative field size of 150 m^2/player, 100 m^2/player and 75 m^2/player in random order. Participants wore portable GPS (Polar Team Pro) tracking sensors in order to record internal and external loads during SSGs. Examinees were asked to rate the RPE (CR-10) at the end of each SSG format. SSGs were performed after 20′ standardized warm up, consisting of slow jogging, strolling locomotion, active stretching, progressive sprints and accelerations. SSGs were followed by 5′ of recovery. Training sessions were performed at the same time in order to avoid the possible effects of circadian rhythm on the variables.

Participants

The sample consisted of 16 habitually physically active students (age: 14.75 ± 0.45 yrs, Under 15, U15). Anthropometric and physical fitness characteristics of the participants are presented in Table 1. The inclusion criteria were: a) training age ≥4 years, b) absence of musculoskeletal injuries over the last 6 months, c) abstention from any ergogenic supplement or medication ≥6 months, d) ≥90% training and match compliance, e) participation during all SSGs, f) players voluntarily participated in the study, g) informed consent from

Table 1. Anthropometric and performance characteristics

Variable	Mean (±SD)
Age (yrs)	14.75 ± 0.45
Height (cm)	171.75 ± 5.07
Weight (kg)	65.61 ± 8.88
Body fat (%)	17.43 ± 3.64
Sprint 10 m (s)	1.85 ± 0.09
Sprint 40 m (s)	5.77 ± 0.32
VO_2max (ml·kg^{-1}·min^{-1})	45.92 ± 3.25
Playing experience (yrs)	7.19 ± 1.17

their parents was obtained after verbal and written explanation of the experimental design and potential risks of the study. The participants were aware that they could withdraw from the study at any time. The study was conducted in accordance with the guidelines of the Ethical Committee of the Aristotle University of Thessaloniki and the revised Declaration of Helsinki.

Procedure

During the first visit, anthropometric measurements were taken. Then, the participants performed 15′ of warm-up followed by a Maximal Sprint Test 40 m in order to determine speed zones. Afterwards, they performed a Yo-Yo intermittent recovery test level 1 to assess VO2max. All measurements were carried out on artificial grass and at least 48 hours after a match. From the following training session players' movements during all sessions were measured using portable GPS units. According to this study design SSGs were performed at 48-hour intervals. Familiarization with the equipment was performed two weeks prior to the initial measurements.

Anthropometric measurements

An electronic digital weight scale and a height scale (Seca 220e, Seca, Hamburg, Germany) were used to measure the body mass and height of the players. These two measurements were accurate to 0.1 kg and 0.1 cm in the respective evaluations. During the measurements the participants were barefoot and wore only underwear. To assess body fat a Lafayette skinfold caliber (Lafayette Instrument, Indiana, USA) was used to measure the thickness of the soccer players' hypodermic fat in four of their skinfolds (biceps, triceps, suprailiac, subscapular). All skinfold measurements were taken on the right side of the body and body fat percentage was calculated with the use of the equation proposed by Siri [31].

Yo-Yo Intermitted Recovery Test Level 1

The YYIR1 consisted of 2 × 20 m intervals of running interspersed with regular short rest periods (10 s). Furthermore, signals were given by a CD-ROM to control the speed. The player ran 20 m forward and he adjusted his speed, so as to reach the 20 m marker exactly at the time of the signal. Additionally, a turn was made at the 20 m marker and the player ran back to the starting marker, which was to be reached at the time of the next signal. Then the player had a 10 s break to run slowly around the third marker, which was placed 5 m behind him. He had to wait at the marker until the next signal. The course was repeated until the player failed to complete the shuttle run two times in a row. The first time, when the start marker was not reached a warning was given ("yellow card"), at the second one the test was terminated ("red card"). The last running interval that a player had completed before being excluded from the test was noted and the test result was expressed as the total running distance covered in the test. The YYIR1 also started at a speed of 10 km/h. Furthermore, in the next two speed levels the speed was increased by 2 and 1 km/h, respectively. Thereafter, the speed was increased by 0.5 km/h at every speed level. The YYIR1 was sustained during the last completed 40 m. Players' VO_2max was predicted from their distance covered in the YYIR1 using the next equation:

VO_2max prediction (ml/kg/min) = YYIR1 distance (m) × × 0.0084 + 36.4

Speed evaluation

The sprint test performed with the use of three pairs of photocells (Witty, Microgate, Bolzano, Italy), which were placed at three different points; at the starting point, at 10 m and at the finishing line (at 0 m, 10 m and 40 m). Each pair of photocells constituted a gate, through which soccer players ran. Soccer players were starting their attempt from a standing position, 0.3 m behind the first gate. The photocells were placed around the height of the hip joint so as to catch the movement of the torso instead of a fake signal due to the movement of the upper limbs. The two attempts were separated by >3 min recovery, as they were performed in a circular format. The coefficient of variation for the measurement–re-measurement tests was 3.6%.

Internal load

The Borg Rating Perceived Exertion Scale (RPE, CR-10) was used to record internal load. At the end of each SSG players were asked to rate RPE. Examinees were familiarized with the use of RPE in the preceding weeks. Furthermore, HR was recorded in real time with the use of a Polar Team Pro (Kempele, Finland) during SSGs. The variable recorded during SSGs was the % HRmax.

External load

The Global Positioning System (GPS, 10 Hz Polar Team Pro, Kempele, Finland) was used to record external load. The variables recorded were total distance (TD), distance/min (m/min), number of sprints (>19.0 km/h), distance covered in five speed zones (Distance Speed: z1: 0.10-6.99 km/h; z2: 7.00-10.99 km/h; z3: 11.00--14.99 km/h; z4: 15.00-18.99 km/h; z5: >19.00 km/h), the total number of decelerations (NoDec –5.00-3.00,

–2.99-–2.00, –1.99-–1.00 m/s²) and also the total number of accelerations (NoAcc 1.00-1.99, 2.00-2.99, 3.00-5.00 m/s²).

The structure of SSG
Table 2 presents the number, duration, interval rest periods, relative field size and field dimensions used during SSGs. Throughout SSGs goalkeepers (GK) were used and verbal encouragement was not provided. Moreover, there was an abundance of reserved soccer balls around the field in order to replace the ball, ensuring the required playing time. Soccer players were able to consume water during rest intervals.

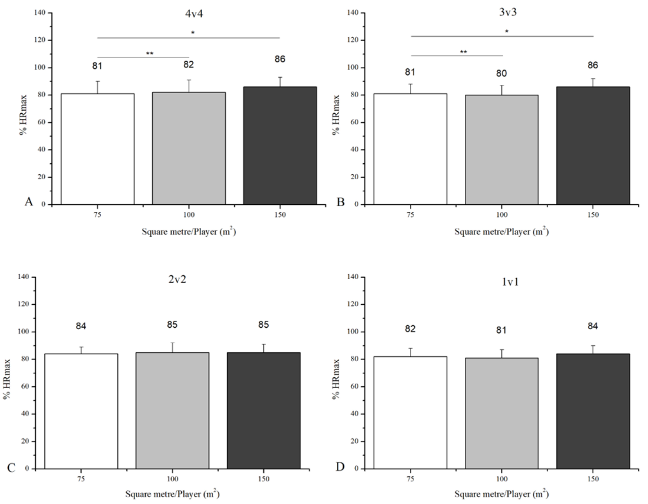
Table 2. Pitch sizes used for small-sided games

SSG	Set × Duration	Rest	Small (S)	Medium (M)	Large (L)
1v1 + GK	4 × 1′	2′	1 : 75 m² 10 × 15m	1 : 100 m² 20 × 10m	1 : 150 m² 20 × 15m
2v2 + GK	4 × 2′	4′	1 : 75 m² 20 × 15m	1 : 100 m² 27 × 15m	1 : 150 m² 30 × 20m
3v3 + GK	4 × 3′	3′	1 : 75 m² 25 × 18m	1: 100 m² 30 × 20m	1 : 150 m² 36 × 25m

Note: GK – goalkeeper

Statistical analysis
The data analysis was carried out using IBM SPSS (Statistics for Windows, version 25.0 Armonk, NY: IBM Corp). Descriptive statistics were used and the data was presented as the mean and standard deviation. The normality of the distributions was assessed using the Shapiro–Wilk test. Repeated measures of variance analysis (GLM Repeated Measures ANOVA) were applied when normality emerged and then the post--hoc Bonferroni test was used when statistically significant difference was found. In the case of non--normal distribution, a non-parametric Friedman test was implemented. Whenever a statistically significant difference was found between the samples, the Wilcoxon signed-rank test was applied. The level of statistical significance was set at $p < 0.05$.

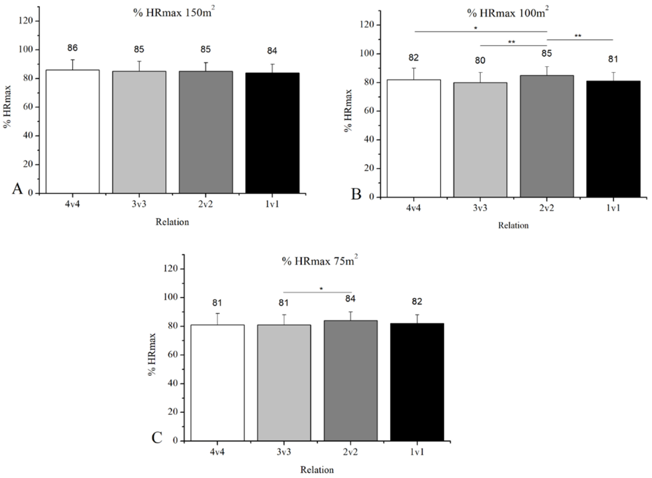
Results
Anthropometric characteristics and the results on fitness tests of the 16 participants are presented in Table 1.
The data analysis of SSGs 4v4 with different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player) revealed the following results, one of them being a difference in % HRmax between the different field dimensions ($F = 6.028$, $p = 0.006$). In particular, there were differences between the 150 m^2/player and 100 m^2/player ($p = 0.006$) and 150 m^2/player and 75 m^2/player field sizes ($p = 0.013$) (Figure 1). Regarding 3v3 there was a difference in % HRmax between the three field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player) ($F = 8.378$, $p = 0.01$). Specifically, differences were found between the 150 m^2/player and 100 m^2/player ($p = 0.003$) and between 150 m^2/player and 75 m^2/player field sizes ($p = 0.01$) (Figure 1). As far as 2v2 and 1v1 formats with different relative field sizes, data analysis revealed no differences in % HRmax between the three field dimensions ($F = 0.404$, $p = 0.671$, $F = 1.459$, $p = 0.250$, accordingly) (Figure 1). After analyzing the data during performing SSGs (4v4, 3v3, 2v2, 1v1) with a relative field size of 150 m^2/player revealed no difference in % HRmax between the different SSGs formats ($F = 0.927$, $p = 0.436$) (Figure 2). Regarding 100 m^2/player the difference in % HRmax was found between the different SSG formats ($F = 5.662$, $p = 0.002$). Particularly, there were differences between the 4v4 and 2v2 formats ($p = 0.04$), 3v3 compared to 2v2 ($p = 0.002$) and between 2v2 and 1v1 ($p < 0.001$) (Figure 2). Concerning 75 m^2/player a difference in % HRmax was found between the SSG formats ($F = 2.754$, $p = 0.049$). In particular, a difference was found between 3v3 and 2v2 ($p = 0.037$) (Figure 2).



* denotes significance at level 0.05; ** denotes significance at level 0.01

Figure 1. Heart rate distribution expressed in percentage of HRmax during SSG with three different relative field sizes of 150 m^2/player, 100 m^2/player and 75 m^2/player. A: 4v4. B: 3v3. C: 2v2. D: 1v1. Data are presented as means ± SD

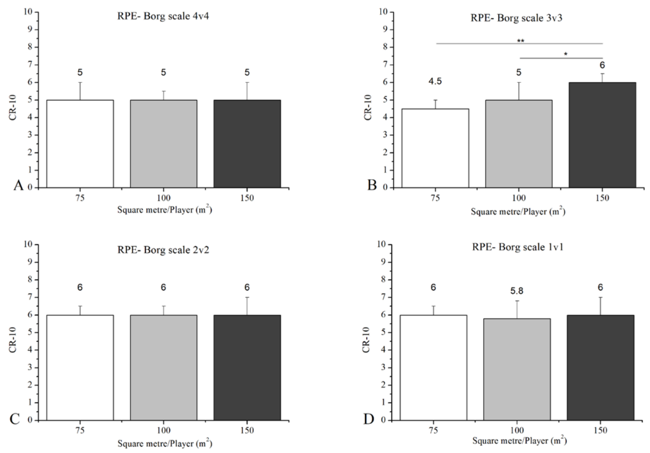
Regarding RPE in the course of the 4v4, 2v2, 1v1 formats with three different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player) there were no differences



* denotes significance at level 0.05; ** denotes significance at level 0.01

Figure 2. Heart rate distribution expressed in percentage of HRmax during SSG with three different relative field sizes of 150 m^2/player, 100 m^2/player and 75 m^2/player. A: 150 m^2/player. B: 100 m^2/player. C: 75 m^2/player. Data are presented as means ± SD

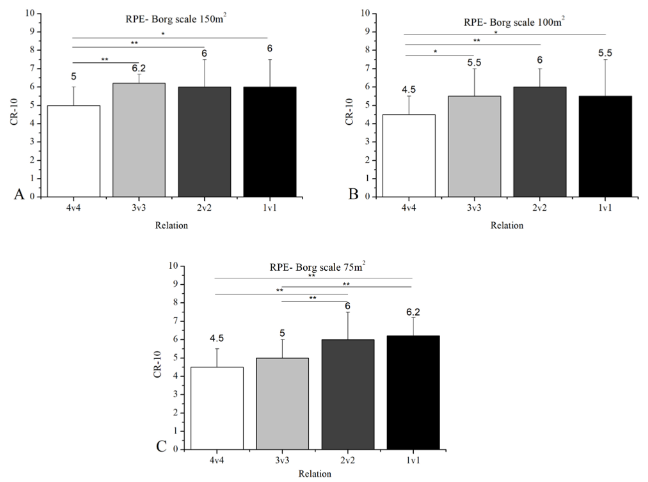
($x^2 = 0.311$, $p = 0.856$, $x^2 = 1.697$, $p = 0.428$, $x^2 = 4.667$, $p = 0.097$, respectively) (Figure 3). However, differences were found during the 3v3 format ($x^2 = 14.941$ $p = 0.001$), between the 150 m^2/player and 100 m^2/player ($Z = –2.072$, $p = 0.038$) and between 150 m^2/player and 75 m^2/player field sizes ($Z = –3.236$, $p = 0.001$) (Figure 3).



* denotes significance at level 0.05; ** denotes significance at level 0.01

Figure 3. RPE scores (Borg Scale CR-10) during SSG (4v4, 3v3, 2v2, 1v1) with three different relative field sizes of 150 m^2/player, 100 m^2/player and 75 m^2/player. A: 4v4. B: 3v3. C: 2v2. D: 1v1. Data are presented as means ± SD

Differences were also found ($x^2 = 15.853$, $p = 0.001$) concerning RPE during the 4v4, 3v3, 2v2, 1v1 formats with the relative field size of 150 m^2/player, in particular, between 4v4 and 3v3 ($Z = –3.228$, $p = 0.001$), 4v4 and 2v2 ($Z = –2.972$, $p = 0.003$) and between 4v4 and 1v1 formats, respectively ($Z = –2.430$, $p = 0.015$) (Figure 4). With the relative field size of 100 m^2/player differences were found ($x^2 = 12.581$, $p = 0.006$), specifically between 4v4 and 3v3 ($Z = –2.124$, $p = 0.034$), 4v4 and 2v2 ($Z = –3.104$, $p = 0.002$) and between 4v4 and 1v1 formats ($Z = –2.240$, $p = 0.025$) (Figure 4). With the relative field size of 75 m^2/player statistical analysis revealed differences for the four different formats ($x^2 = 29.488$, $p < 0.001$). This was in particular between 4v4 and 2v2 ($Z = –3.256$, $p = 0.001$), 4v4 and 1v1 ($Z = –3.134$, $p = 0.002$), 3v3 compared to 2v2 ($Z = –3.213$, $p = 0.001$) and between 3v3 and 1v1 formats ($Z = –3.305$, $p = 0.001$) (Figure 4).



* denotes significance at level 0.05; ** denotes significance at level 0.01

Figure 4. RPE scores (Borg Scale CR-10) during SSG (4v4, 3v3, 2v2, 1v1) with three different relative field sizes: A: 150 m^2/player, B: 100 m^2/player, C: 75 m^2/player. Data are presented as means ± SD

The results showed differences for TD in each player relationship (4v4, 3v3, 2v2, 1v1) between three different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player). Also, differences were found between SSG formats in the same field size. These differences are presented in Table 3.

Similarly, regarding distance/min (m/min) differences were found for each format (4v4, 3v3, 2v2, 1v1) between three different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player). These differences and the results for the formats are presented in Table 3.

Table 3. External load during SSG (4v4, 3v3, 2v2, 1v1) with three different relative pitch sizes of 150 m^2/player, 100 m^2/player and 75 m^2/player. Data are presented as means ± SD

Variable	Relation	150 m^2/pl	100 m^2/pl	75 m^2/pl
TD (m)	4v4	$439 \pm 40^{***,\#\#\#,aaa,bb,cc}$	$395 \pm 46^{\#\#,aaa,bbb,ccc}$	$363 \pm 31^{aaa,bbb,ccc}$
	3v3	$311 \pm 35^{*,\#\#\#,bb,cc}$	$288 \pm 28^{\#\#\#,bbb,ccc}$	$262 \pm 22^{bbb,ccc}$
	2v2	$223 \pm 19^{*,\#\#\#,cc}$	$207 \pm 24^{\#\#,ccc}$	182 ± 17^{ccc}
	1v1	$109 \pm 9^{*,\#\#}$	$100 \pm 11^{\#}$	93 ± 10
Dist/min (m/min)	4v4	$106 \pm 10^{**,\#\#\#}$	$98 \pm 12^{\#\#,}$	90 ± 8
	3v3	$104 \pm 11^{*,\#\#\#}$	$96 \pm 9^{\#\#\#}$	87 ± 7
	2v2	$111 \pm 10^{**,\#\#\#}$	$102 \pm 12^{\#\#\#}$	86 ± 9
	1v1	$109 \pm 9^{**,\#\#}$	$98 \pm 10^{\#}$	92 ± 10
Sprint (>19 km/h)	4v4	1 ± 0.6	$1 \pm 0.5^{a,c}$	1 ± 0.5^{c}
	3v3	0.58 ± 0.4	0.61 ± 0.58	0.59 ± 0.5^{c}
	2v2	0.71 ± 0.31	0.78 ± 0.59^{c}	0.48 ± 0.55
	1v1	$0.5 \pm 0.4^{\#}$	0.4 ± 0.3	0.2 ± 0.3
Z1 (m)	4v4	$170 \pm 18^{**,\#\#\#,aaa,bbb,ccc}$	$184 \pm 18^{aaa,bbb,ccc}$	$189 \pm 17^{aaa,bbb,ccc}$
	3v3	$131 \pm 15^{bbb,ccc}$	$130 \pm 12^{\#\#,bbb,ccc}$	$136 \pm 10^{bbb,ccc}$
	2v2	$79 \pm 9^{**,\#\#\#,ccc}$	$88 \pm 8^{\#\#,ccc}$	97 ± 10^{ccc}
	1v1	$38 \pm 4^{***,\#\#}$	43 ± 5	45 ± 5
Z2 (m)	4v4	$132 \pm 24^{**,\#\#\#,aaa,bbb,ccc}$	$112 \pm 25^{\#,aaa,bbb,ccc}$	$98 \pm 25^{aa,bbb,ccc}$
	3v3	$91 \pm 22^{\#\#,bb,ccc}$	$78 \pm 16^{b,ccc}$	$76 \pm 18^{bbb,ccc}$
	2v2	$71 \pm 8^{\#\#\#,ccc}$	$66 \pm 12^{\#\#,ccc}$	52 ± 14^{cc}
	1v1	$43 \pm 4^{**,\#\#}$	36 ± 7	34 ± 8
Z3 (m)	4v4	$89 \pm 25^{**,\#\#\#,aaa,bbb,ccc}$	$68 \pm 27^{a,bbb,ccc}$	$55 \pm 19^{a,bbb,ccc}$
	3v3	$60 \pm 2^{\#\#,bb,ccc}$	$54 \pm 18^{\#\#,b,ccc}$	$38 \pm 11^{bbb,ccc}$
	2v2	$49 \pm 13^{*,\#\#\#,ccc}$	$39 \pm 12^{\#\#\#,ccc}$	23 ± 9^{cc}
	1v1	$22 \pm 6^{*,\#\#}$	$16 \pm 6^{\#}$	12 ± 6
Z4 (m)	4v4	$33 \pm 12^{\#\#\#, a,bb,ccc}$	$27 \pm 15^{bb,ccc}$	$17 \pm 8^{aa,bbb,cc}$
	3v3	$23 \pm 11^{\#\#\#,ccc}$	$20 \pm 9^{\#\#\#,b,ccc}$	10 ± 4^{ccc}
	2v2	$20 \pm 6^{**,\#\#\#,ccc}$	$13 \pm 8^{\#,cc}$	8 ± 6^{cc}
	1v1	6 ± 4	5 ± 4	2 ± 3
Z5 (m)	4v4	$8 \pm 5^{*,\#\#,b,cc}$	$5 \pm 5^{bb,cc}$	$2 \pm 2^{b,cc}$
	3v3	$6 \pm 5^{b,cc}$	$6 \pm 6^{b,cc}$	2 ± 3^{c}
	2v2	3.6 ± 4^{cc}	1.4 ± 1.6	0.8 ± 1.6
	1v1	1 ± 1.4	0.4 ± 0.9	0.2 ± 0.4

Dec (<–3 m/s²)	4v4	$1 \pm 0.8^{a,b,cc}$	$1 \pm 0.5^{a,b,cc}$	$0.5 \pm 0.5^{b,c}$
	3v3	0.6 ± 0.5	0.5 ± 0.4^{c}	0.4 ± 0.4^{c}
	2v2	0.6 ± 0.5	0.5 ± 0.5	0.3 ± 0.3
	1v1	0.3 ± 0.3	0.3 ± 0.2	0.2 ± 0.3
Dec (–2.99 - –2 m/s²)	4v4	$6 \pm 1.7^{*,\#,aa,bb,ccc}$	$4 \pm 2^{a,cc}$	$4 \pm 1.4^{bbb,ccc}$
	3v3	3.6 ± 1.2^{ccc}	3.1 ± 1^{cc}	3.3 ± 0.8^{ccc}
	2v2	0.6 ± 0.5^{cc}	0.5 ± 0.4^{c}	0.3 ± 0.3^{cc}
	1v1	1.9 ± 0.7	1.9 ± 0.7	1.7 ± 0.6
Dec (–1.99 - –1 m/s²)	4v4	$19.5 \pm 2.5^{**,\#,aaa,bbb,ccc}$	$17.5 \pm 2.4^{aaa,bbb,ccc}$	$17.6 \pm 3.5^{aaa,bbb,ccc}$
	3v3	$13.1 \pm 2.4^{bb,ccc}$	12.7 ± 2.9^{ccc}	$13.6 \pm 2.6^{bb,ccc}$
	2v2	11 ± 1.5^{ccc}	11.3 ± 2^{ccc}	10.4 ± 1.9^{ccc}
	1v1	7.1 ± 1.2	6.7 ± 1.5	7.1 ± 1.5
Acc (1 - –1.99 m/s²)	4v4	$20.4 \pm 2.9^{**,\#,aaa,bbb,ccc}$	$17.2 \pm 3.1^{aaa,bbb,ccc}$	$17.8 \pm 3.5^{aa,bbb,ccc}$
	3v3	$13.7 \pm 2.9^{bbb,ccc}$	$13 \pm 2.2^{bb,ccc}$	$13.9 \pm 2.8^{bbb,ccc}$
	2v2	11.5 ± 1.2^{ccc}	10.8 ± 1.7^{ccc}	10.9 ± 2.1^{ccc}
	1v1	7.1 ± 1.2	6.7 ± 1.5	7 ± 1.5
Acc (2 - –2.99 m/s²)	4v4	$5.4 \pm 1.5^{aa,bb,ccc}$	$4.7 \pm 1.4^{aa,b,ccc}$	$5 \pm 1.2^{aa,bbb,ccc}$
	3v3	3.2 ± 1	$3.3 \pm 1.3^{bb,c}$	3.2 ± 0.8^{cc}
	2v2	3.5 ± 1.1^{cc}	3.6 ± 1.1^{cc}	2.9 ± 0.6^{cc}
	1v1	7.1 ± 0.8	7.1 ± 0.8	6.8 ± 1.1
Acc (3 - –5 m/s²)	4v4	0.5 ± 0.3	0.4 ± 0.3	0.4 ± 0.3
	3v3	0.4 ± 0.4	0.3 ± 0.3	0.3 ± 0.3
	2v2	0.4 ± 0.3	0.4 ± 0.4	0.3 ± 0.4
	1v1	0.3 ± 0.2	0.2 ± 0.2	0.2 ± 0.2

Note: M – mean; CI – confidence interval; TD – total distance; z1 – distance with velocity of 0.10-6.99 km/h; z2 – distance with velocity of 7.00-10.99 km/h; z3 – distance with velocity of 11.00-14.99 km/h; z4 – distance with velocity of 15.00-18.99 km/h; z5 – distance with velocity >19.00 km/h; Dec – decelerations; Acc – accelerations

* denotes difference in row with 100 m²/player ($p < 0.05$); ** denotes difference in row with 100 m²/player ($p < 0.01$); *** denotes difference in row with 100 m²/player ($p < 0.001$); $^{\#}$ denotes difference in row with 75 m²/player ($p < 0.05$); $^{\#\#}$ denotes difference in row with 75 m²/player ($p < 0.01$); $^{\#\#\#}$ denotes difference in row with 75 m²/player ($p < 0.001$). ^{a} denotes difference in column with 3v3 ($p < 0.05$); ^{aa} denotes difference in column with 3v3 ($p < 0.01$); ^{aaa} denotes difference in column with 3v3 ($p < 0.001$); ^{b} denotes difference in column with 2v2 ($p < 0.05$); ^{bb} denotes difference in column with 2v2 ($p < 0.01$); ^{bbb} denotes difference in column with 2v2 ($p < 0.001$); ^{c} denotes difference in column with 1v1 ($p < 0.05$); ^{cc} denotes difference in column with 1v1 ($p < 0.01$); ^{ccc} denotes difference in column with 1v1 ($p < 0.001$)

The results showed differences in all the formats (4v4, 3v3, 2v2, 1v1) between the three different relative field sizes (150 m²/player, 100 m²/player, 75 m²/player) in most of the speed zones (z1, z2, z3, z4, z5). The differences are presented in Table 3.
Also, differences existed for decelerations and accelerations between the different field sizes and the results are presented in Table 3.

The total number of sprints (>19.0 km/h), Dec (–5 to –3 m/s²) and Acc (3 to 5 m/s²) was too small (mean ≤1, presented in Table 3), so no comparison between the field sizes and formats is given here.

Discussion

In the present study we found that SSGs with a smaller number of players and larger individual playing areas led to an increase in the players' internal load. The external load analysis of the present study showed that SSGs with a higher number of players and larger individual playing areas had a greater impact on external load.

After analyzing the internal load data of 4v4 SSGs with different relative field sizes, there was higher % HRmax in the case of the relative field size of 150 m^2/player compared with those of 100 m^2/player and 75 m^2/player. The data in the present study revealed that soccer players with the relative field size of 150 m^2/player remained >85% HRmax, which indicates that anaerobic metabolism is primarily used for energy production. The aforementioned findings are not only confirmed from studies in youth soccer players, but also in adults, making it clear that the increase of field dimensions with a constant number of players can lead to an increase in HR [2, 11, 13, 16, 26]. Furthermore, in a study carried out in amateur players researchers observed higher values of % HRmax during SSGs with larger dimensions [25]. This is probably due to the fact that soccer players are forced to cover longer distances with higher intensity [26]. In particular, players covered a longer distance from defense to offence [27]. The above findings are confirmed by a study of Casamichana and Castellano [2], showing that a reduction of field dimensions causes a decrease in SSG intensity. Therefore, it is evident that during games in fields larger dimensions the anaerobic system is primarily used due to the fact that soccer players have to cover a longer distance with higher intensity.

Regarding % HRmax of SSGs (4v4, 3v3, 2v2, 1v1) with a relative field size of 100 m^2/player higher values were recorded during the 2v2 format compared to the other formats. Additionally, similar results were found for the relative field size of 75 m^2/player, where higher % HRmax values were detected during 2v2 compared to the 3v3 format. The above data were confirmed by previous studies, which reported higher % HRmax values during the 2v2 format [1, 24]. In addition, Owen et al. [24] found greater values of HR during the 2v2 and 1v1 formats. Therefore, it was understood that the increase in the number of players during SSGs provides more recovery time as a consequence of the reduced active participation in the game. It was apparent that during smaller game formats soccer players reached higher HR values [12]. Lastly, it was evident that soccer players used the anaerobic system during the 2v2 format with a relative field size of 100 m^2/player and 75 m^2/player, as indicated by >85% HRmax.

Furthermore, it is obvious that an increase of relative field size has an influence on RPE. Particularly, significant differences were revealed among three different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player) during the 3v3 format. Specifically, higher values of RPE were observed with the relative field size of 150 m^2/player compared to the other field sizes. The above findings were confirmed by Casamichana and Castellano [2], Halouani et al. [11], Köklü et al. [16], Modena et al. [23] as well as Rampinini et al. [26], who found rising RPE values with the increase in relative field size. That being said, the increase of activity profile is probably responsible for the rise of RPE values due to the greater available field. However, contrary results were reported by Kelly and Drust [14] and Tessitore et al. [32], who observed no significant differences with an increase in relative field size.

It is obvious that RPE constitutes a representative index of exercise intensity [32]. The present study revealed lower RPE values with relative field sizes of 150 m^2/player and 100 m^2/player during the 4v4 format compared to the other variants. With the relative field size of 75 m^2/player smaller RPE values were recorded during 4v4 and 3v3 compared to the 2v2 and 1v1 formats. Thus, it is evident that the number of players during SSGs seems to be linked with RPE. The above data are confirmed by previous studies, which found a rise of RPE when the number of players was reduced [26, 29]. These findings are also in line with those presented by Hill-Haas et al. [12], who observed higher RPE values during SSGs with a smaller number of players (2v2 vs 4v4, 6v6). Likewise, Köklü et al. [18] found higher RPE values during 2v2 compared with the 3v3 and 4v4 formats. This was probably due to the fact that during SSGs with a higher number of players participants have lower interaction with the ball and their opponents.

After analyzing the external load data with different relative field sizes between the 4v4, 3v3, 2v2 and 1v1 formats, there were significant differences in TD covered. Particularly, the longest distance covered at the 150 m^2/player field size was compared with those for the other field dimensions. Moreover, a longer TD was recorded in the 100 m^2/player variant in comparison with the 75m^2/player field size. The larger the individual playing area, the longer TD was covered during the 4v4, 3v3, 2v2 and 1v1 formats. Similar results were found in other recent studies [23, 28].

As far as distance/min (m/min) is concerned, there was a rise in the covered distance with an increase in the relative field size during all game formats. This probably was the case due to the fact that soccer players had the opportunity to cover longer distance/min as a result of greater available space [2]. Nevertheless, no significant differences were found in distance/min for any of the four formats with relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player). It is understandable that with a constant relative field size, the pace of the game remains stable regardless of the number of players [4].

The greatest number of sprints (>19.0 km/h) was only found during the 1v1 format with a relative field size of 150 m^2/player in comparison with that of 75 m^2/player. It is obvious that field size was the main factor which probably exerts influence on the number of sprints during 1v1 [30]. Moreover, no differences were found between four different formats with a relative field size of 150 m^2/player. The above data is confirmed by literature [1]. With the relative field size of 100 m^2/player a greater number of sprints was reported during the 4v4 game in comparison with 3v3 and 1v1, and also during 2v2 compared with the 1v1 format. With the relative field size of 75 m^2/player a smaller number of sprints was recorded during 1v1 compared with the 4v4 and 3v3 formats. It may be reliably inferred that during SSGs with a greater number of players the largest available space allows more sprint opportunities [12, 18].

After analyzing the data of five speed zones during the 4v4, 3v3, 2v2 and 1v1 formats with three different relative field sizes, youth players covered a longer distance during the 4v4 and 1v1 formats in speed zone 1 (Distance Speed z1, m, 0.10-6.99 km/h) with relative field sizes of 100 m^2/player and 75 m^2/player. With the decrease in the relative field size the covered distance in speed zone 1 during the 2v2 format increased. As the field dimensions are reduced, the distance in speed zone 1 increased. In speed zone 2 (Distance Speed z2, m, 7.00-10.99 km/h) there was an increase in the covered distance with an increase of relative field size during the 4v4 format. During the 3v3 format players covered a longer distance with a relative field size of 150 m^2/player compared to 75 m^2/player. During the 2v2 format the covered distance was smaller with a relative field size of 75 m^2/player in comparison with the other two field dimensions. During the 1v1 format the covered distance was greater with a relative field size of 150 m^2/player. In speed zone 3 (Distance Speed z3, m, 11.00--14.99 km/h) the covered distance was greater during the 4v4 game with the relative field size of 150 m^2/player compared to the two other field sizes. During the 3v3 format the covered distance was smaller with a relative field size of 75 m^2/player in comparison with the two other field dimensions. There was also an increase in the covered distance with an increase of relative field size during the 2v2 and 1v1 formats. In speed zone 4 (Distance Speed z4, m, 15.00-18.99 km/h) the covered distance was greater with a relative field size of 150 m^2/player compared with that of 75 m^2/player during the 4v4 format. During the 3v3 format the covered distance was smaller with a relative field size of 75 m^2/player compared to the other field dimensions. During the 2v2 format the covered distance was connected to an increase in relative field size. In speed zone 5 (Distance Speed z5, m, >19.00 km/h) the covered distance was greater with the relative field size of 150 m^2/player in comparison with the two other field sizes during the 4v4 format. During the 3v3 format the covered distance was smaller with the relative field size of 75 m^2/player compared with the two other field dimensions. Additionally, during the 2v2 format the covered distance was greater at the relative field size of 150 m^2/player compared with the two other dimensions. It is apparent that the covered distance increased due to the fact that players at an increase in the relative field size were able to move within a larger space. The above findings are confirmed by the available literature [2, 3].

Regarding the total number of decelerations, a smaller number of decelerations (NoDec –2.99-–2.00 m/s^2) was detected during the 4v4 format with a relative field size of 75 m^2/player compared with the two other field sizes. Therefore, it is evident that the number of decelerations is connected to an increase in available space [13]. On the other hand, there were no significant differences for any of the deceleration intensities (NoDec –5.00--–3.00 m/s^2, NoDec –2.99-–2.00 m/s^2, –1.99-–1.00 m/s^2) during the 3v3, 2v2 and 1v1 formats. The aforementioned data is confirmed by previous studies [30].

Concerning the total number of accelerations (NoAcc 1.00-1.99 m/s^2), a greater number of accelerations was found during the 4v4 format with a relative field size of 150 m^2/player compared to the two other field sizes. Lastly, during the 1v1 format more accelerations (NoAcc 2.00-2.99 m/s^2) were found with a relative field size of 150 m^2/player compared with 75 m^2/player. Thus, it is understandable that the total number of accelerations is connected to the increase of the available space [13].

From the present study it was clear that the implementation of SSGs with a different number of players and field dimensions led to a differentiation in the internal and external loads of the recreational youth soccer players. SSGs could be an effective method of physical fitness improvement in youth recreational soccer players. After analyzing the internal load data it was evident that SSGs with fewer players and a larger relative field size led to an increase in the players' internal load. The external load analysis showed that SSGs with a higher number of players and a larger relative field size had a greater impact on external load.

From the present study evidence emerges for the appropriate choice of SSG characteristics depending on the goal of each session. In particular, it is clear that SSGs with fewer players are more suitable for an increase of internal load, while SSGs with a greater number of players can lead to an increase in external load. In addition, if coaches want more sprints, the fields should be large enough, e.g 150 m^2/player.

One specific element of this study is that it was carried out on U15 recreational soccer players. In the literature, most studies on the internal and external load during the SSG concern young soccer players who play in the "academies" of professional soccer teams. As a result, the values of the internal and external loads concern better prepared soccer players and cannot be used as a guide for the load that players of the academies of amateur teams receive. Therefore, the values of the load of this study could be used by the coaches of amateur academies as a guide to the use in the SSG.

Conflict of Interest

The authors declare no conflict of interest.

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