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CONTENTS

ORIGINAL ARTICLE

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Factors associated with final attempts during counterattacks in Champions League 2018-2019 matches

VASILIS ARMATAS, EMMANOUIL ZACHARAKIS, NIKOLAOS APOSTOLIDIS

Abstract
Introduction. **Although counterattacks are the most effective style of play for scoring goals, they occur less frequently during soccer matches than organized attacks and the research on the subject conducted to date is limited.** Aim of Study. **This study sought to investigate factors associated with final attempts during counterattacks in Champions League 2018-2019 matches.** Material and Methods. **The sample included 1415 ball recoveries corresponding to 16 knock-out matches. Multidimensional qualitative data using 11 ordered categorical variables were obtained to characterize each counterattack. The data were analysed using chi-squared tests and binary logistic regression.** Results. **Bivariate analysis revealed that the performance indicators significantly associated with the final attempt in a counterattack included the defenders' positions, invasive zone, number of passes, counterattack duration and zone of recovery. Spatial analysis revealed that final attempts from counterattacks were most frequently assisted from the central zone outside the box (Zone 7: 23%) and finishing was typically executed from the central zone inside the box (Zone 4: 30.4%). The regression model indicated significant probabilities of a final attempt when the ball was recovered inside the invasive zones, used a high proportion of penetrative passes and involved 4 or more attacking players.** Conclusions. **This study enhances coaches' understanding of the factors that affect counterattack effectiveness and provide practical implications for developing and implementing training sessions for the transition phase.**

KEYWORDS: soccer, transition phase, effectiveness, goal scoring.

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Introduction

Soccer matches have been documented as having four key repeating phases: the attacking phase, defensive transition, defensive phase and attacking transition [21]. These phases have a dialectic relationship between the opposing teams, meaning that when one team is in the attacking phase, the other team is in the defensive phase, etc. Moreover, although the four phases are discrete, each can affect the other phases or elements of play [9]. A team's habitual behaviour in each of these four phases can be described as the team's game style. Hewitt et al. [21] defined game style as "the characteristic playing pattern demonstrated by a team during games. It will be regularly repeated in specific situational contexts such that measurement of variables reflecting game style will be relatively stable". Consequently, when a team recovers the ball, there are two styles of play it may adopt: possession play or counterattack, depending on the team's strategy [8] and the opposition's performance and tactics [25].

Although transition phases and, particularly, counterattacks have been the focus of many influential head coaches, such as Jurgen Klopp and Jose Mourinho, the research concerning these elements is limited. For example, Klopp describes the transition game in a way that characterizes his philosophy: "The best moment to win the ball is immediately after your team just lost it.

The opponent is still looking for orientation where to pass the ball. He will have taken his eyes off the game to make his tackle or interception and he will have expended energy. Both make him vulnerable" [5]. Similarly, Mourinho stated, "Everybody says that set plays win most games, but I think it is more about transitions" [44]. Previous research identified the importance of transition phases; surprisingly, however, more studies have been conducted on defensive transitions [7, 11].

Although counterattacks occur less frequently during soccer matches than organized attacks, they are the most effective style of play for scoring goals, especially against an imbalanced defence [35, 41]. Recently Schulze et al. [36] found similar results and added that counterattacks were characterized by there being fewer defenders behind the ball and were more physically demanding than organized and direct attacks.

Existing research consistently indicates that teams tend to recover the ball closer to their own goal; thus, the most frequent locations of ball recovery are the defence and pre-defence zones in Champions League 2011--2012 [1], Champions League 2014-2015 [22], English Premier League and Spanish La Liga [11] matches. However, when considering effectiveness previous research found a strong relationship between regaining the ball in attacking zones and positive attack outcomes [11, 17, 22].

The conflicting results reported by previous studies on recovery type could arise from methodological differences. In particular, some studies have shown that interception was the most common type of ball recovery [1], while others reported more recoveries through tackles [4, 22].

In a recent study Gonzalez-Rodenas et al. [18] concluded that counterattacks in Major League Soccer (MLS) had a higher frequency of short possession (3 or fewer passes), while attacking sequences involving medium possession (4-6 passes) had greater odds of creating final attempts. Likewise, Turner and Sayers [42] noticed that transition speed was not related to effectiveness, suggesting that offensive transitions need not be fast or concern short sequences to be successful. Instead, the length of the sequence should be adapted to the tactical conditions imposed by the opponent. Moreover, many studies to date have highlighted the importance of penetrative actions, especially at the beginning of the counterattack [17, 22].

Previous studies identified the number of participating players as another key performance indicator during counterattacks. During Champions League matches, Armatas et al. [3] showed that most of the goals achieved via counterattacks involved ≥3 attackers. Similarly, Turner and Sayers [42] indicated that successful transitions were associated with the participation of 1-3 attacking players, while Tenga et al. [41] showed that counterattacks were more effective than elaborate attacks when playing against an imbalanced defence in the Norwegian League. Defensively, Gonzalez-Rodenas et al. [17] showed that playing against a low initial number of opponents (≤3) increased the effectiveness of creating scoring opportunities in recoveries for the Spanish national football team during the 2010 World Cup. During counterattacks in MLS [18], researchers concluded that the presence of a meso-group of defenders (4-6) increased the probability of conceding a scoring opportunity compared to a macro-group of defenders (≥7).

Existing studies in performance analysis have commonly used bivariate statistical analysis to discover whether relationships exist between two variables. However, using multivariate analysis in this study allowed us to analyse different factors of match performance that are typically difficult to measure directly, as well as their interdependency. Logistic regression analysis has been used infrequently to analyse match performance in soccer [19, 20].

Although previous research identified the importance of counterattack play style on both match outcome and attack effectiveness, the conducted literature analysis reveals few studies on counterattacking and its components. Therefore, this study aimed to investigate factors associated with final attempts during counterattacks in Champions League 2018-2019 knock-out matches.

Material and Methods

Sample

For this study, 16 of the 29 knock-out matches of the Champions League 2018-2019 were randomly selected.

Table 1. Classification of ball recovery based on the subsequent possession

	N	%
Organized attack	828	58.5
Counterattack	185	13.1
Mixed attack	143	10.1
Tactical foul	69	4.9
Possession lost	190	13.4
Total	1415	100

Only the top 16 European teams participated in the final stage, which reduced the impact of the competitive level [30]. Extra-time was also excluded from the sample to ensure homogeneity of the matches. During the selected matches the teams performed 1463 ball recoveries. A total of 48 cases were omitted due to action replays, leaving 1415 recoveries for analysis.

The selected ball recoveries were classified as one of five categories (Table 1) based on their subsequent possession: 1) Organized attack: Possession begins by winning the ball in play or restarting the game; this kind of possession allows the opponent more opportunity to minimize surprise, reorganize their system, and be prepared defensively; the progression towards the opponent's goal can be combinative (high percentage of non-penetrative and short passes over a long duration) or direct (long pass, evaluated qualitatively) [24, 41]. 2) Counterattack: Possession begins by winning the ball in play; the first or second player in action uses penetrative passes or dribbles to penetrate; the progression towards the opponent's goal has a high percentage of penetrative passes over a short duration (evaluated qualitatively); this type of possession tries to deny the opponent the opportunity to minimize surprise, reorganize their system, and be prepared defensively [24, 41]. 3) Mixed attack: Possession starts by winning the ball in play and combines the previous two types; it starts with the characteristics of a counterattack, but the opponent's reorganization can make the progression towards the opponent's goal combinative (a high percentage of non--penetrative and short passes over a long duration) or direct (long pass, evaluated qualitatively). 4) Tactical foul: An intentional violation of the rules of the game, occurring within 5 seconds, to interrupt the opponent's action (this kind of rule violation can be considered an "illegal" move within the game; that is, it is a violation with in-game consequences such as penalties, free kicks, or yellow cards) [23]. 5) Possession lost: Possession starts by winning the ball in play or restarting the game; the attacking team loses possession of the ball when the receiving player fails to control the ball for 3 or more touches or cannot attempt a subsequent ball distribution [37].

Procedures

Before data collection, the Bioethics Committee of the School of Physical Education and Sport Science at the National and Kapodistrian University of Athens granted ethical approval for this study. The selected matches were downloaded from the Wyscout platform (Wyscout Spa, Italy) and analysed with Lince software [13]. Lince is a multimedia interactive computer software that enables simultaneous viewing and registering of the filmed match to support the observational analysis and has been used in many investigations [27].

Observational instrument and operational definitions

The study design included the analysis of four independent defensive performance indicators: 1) recovery type, 2) defenders' position, 3) number of defenders, and 4) initial pressure, and seven independent offensive performance indicators: 1) invasive zone, 2) passes, 3) penetrative passes, 4) number of attackers, 5) duration, 6) half pitch, and 7) pitch sector. The possession result, "final attempt" or "no final attempt", was used as a dependent variable. Operational definitions of the selected indicators are provided in Table 2. Moreover, every shot and assist before every shot were labelled according to the area of the field where they occurred.

Table 2. Operational definitions for the observational instrument

Indicator	Definition
Recovery type	1) Steal: A defending player prevents the ball passed by an opponent from reaching its intended receiver by contacting the ball and maintaining his team's possession of the ball [4]. 2) Duel: A defending player dispossesses an opponent of the ball through a physical challenge or defensive pressure [4, 33]. 3) Turnover: A defending player collects the ball lost (via clearance or a missed pass) by the opposing team [15]. 4) GK action: The goalkeeper recovers the ball after an opponent's shot, cross, turnover, etc. [4].
Defenders' position	Opponents' position on the field when team possession starts, omitting the goalkeeper: 1) High: The furthest-back opponent is in the opposing half. 2) Medium: The furthest-back opponent is closer to the midline than to their own goal. 3) Low: The furthest-back opponent is closer to their own goal than the midline [18].
Number of defenders	The number of defending players located between the ball and their goal when possession starts: 1) 1-2, 2) 3-4, or 3) ≥6.
Initial pressure	1) Pressure: One or several opposing players pressure the attackers within the first 3 seconds of the possession – the defender(s) are always located within 1.5 meters of the first attackers. 2) No pressure: No player pressures the attackers during the first 3 seconds of the possession [18].

Invasive zone	The area within the opponent's space of defensive occupation (SDO) where team possession starts [38]: 1) Non-invasive: Possession starts between the medium area of the opponent's SDO and their own goal line. 2) 1st zone: Possession starts within the medium area of the opponent's SDO. 3) 2nd zone: Possession starts between the medium area of the opponent's SDO and the opponent's goal line.
Passes	Passes performed by attacking players during team possession: 1) zero, 2) 1-2, 3) 3-4, or 4) ≥5.
Penetrative passes	Percentage of passes that passed defending player(s) in relation to the total number of passes during team possession: 1) zero, 2) 1-33%, 3) 34-66%, or 4) 67-100%.
Number of attackers	The number of attacking players that actively participated during their team's possession: 1) 1-2, 2) 3-4, or 3) ≥6.
Duration	Seconds that the team possession lasts: 1) 1-5 seconds, 2) 6-11 seconds, or 3) ≥12 seconds.
Half pitch	The half of the playing field where team possession starts: 1) defensive half, or 2) offensive half.
Pitch sector	The sector of the playing field where team possession starts: 1) defensive, 2) pre-defensive, 3) pre-offensive, or 4) offensive.
Result	1) Final attempt: The attacking team has a clear opportunity to score during possession. This includes goals, shots on target, and shots off target. 2) No final attempt: The attacking team has no chance to score during possession.

The field was divided into 10 zones (Figure 1) based on Rathke's [31] study on the expected goals metric.

Reliability

To ensure the intra- and inter-reliability of the observational instruments, two expert analysts were tested using a 21-day test-retest protocol to exclude any learning effects with 20% of the data, as recommended by Tabachnick and Fidell [40]. The observers were trained in the use of the observational instruments following Losada and Manolov's [26] protocols. Kappa's coefficient was calculated for each variable, with mean kappa statistics of $\kappa = 0.93$ and $\kappa = 0.90$ classified as "perfect" intra- and inter-observer agreement, respectively [32].

Statistical analysis

The statistical analyses were conducted in IBM SPSS v. 26.0 (IBM Corp., USA). First, a chi-squared test of independence (χ^2) was used to examine the possible differences between the counterattacks with a final attempt and those without a final attempt. The effect size was estimated by calculating Phi (for 2 × 2 comparisons) and Cramer's V (for more than two comparisons) correlation coefficients, considering small ($\varphi = 0.10$, $V = 0.05$), medium ($\varphi = 0.30$, $V = 0.15$) and large ($\varphi = 0.55$, $V = 0.25$) effects [12]. χ^2 was also used to examine whether there was a difference between zones leading to final attempts after counterattacks.

Finally, a binary logistic regression was performed to explore the influence of the studied performance indicators on the odds of final attempts. The model thus constructed included 10 performance indicators as predictors and the dichotomous "Result" as the predicted (dependent) variable. The backward Wald method was used and all assumptions of binary logistic regression were met [40]. The theoretical model tested is shown below:

Final attempt $f_{(x)} = \alpha + \beta_1$ (defenders' position) + β_2 (number of defenders) + β_3 (invasive zone) + β_4 (initial pressure) + β_5 (recovery type) + β_6 (passes) + β_7 (penetrative passes) + β_8 (number of attackers) + β_9 (duration) + β_{10} (half pitch) + ε.

Results

Of the 185 counterattacks examined, 106 resulted in no final attempt and 79 in final attempt, of which 19 (10.3%) resulted in goals. Table 3 shows descriptive statistics and the χ^2 values for the studied performance indicators. In detail, "Defenders' position" ($\chi^2 = 6.884$, $p = 0.032$), "Invasive zone" ($\chi^2 = 15.100$, $p = 0.001$), "Passes" ($\chi^2 = 8.721$, $p = 0.033$), "Duration" ($\chi^2 = 14.826$, $p = 0.001$), "Half pitch" ($\chi^2 = 11.875$, $p = 0.001$) and "Pitch sector" ($\chi^2 = 13.398$, $p = 0.004$) were significantly associated with the final attempt from counterattack.

Counterattacks in Champions League knock-out matches resulted in final attempts more frequently when they were taken against defenders in medium positions (39.2%), started inside the 1st invasive zone (38%), had 1-2 and 3-4 passes (38%), were of medium duration s(6-11 seconds) (45.6%), and the ball was recovered in the defensive half of the pitch (54.4%), specifically, in the pre-offensive pitch sector (39.2%).

Significant differences were observed between assisting zones ($\chi^2 = 15.397$, $p < 0.05$) and final attempt zones ($\chi^2 = 17.231$, $p < 0.05$). Specifically, spatial analysis, shown in Figure 1, indicated that final attempts from

Table 3. Frequency and percentage of counterattacks with and without final attempts during Champions League 2018-2019 matches

		Total N = 185		NFAtt N = 106		FAtt N = 79		
Indicators	Dimensions	N	%	N	%	N	%	χ^2(df), p
Defenders' position	low	42	22.7	17	16.0	25	31.6	$\chi^2(2) = 6.884$, $p = 0.032$ V = 0.195
	medium	88	47.6	57	53.8	31	39.2	
	high	55	29.7	32	30.2	23	29.1	
Number of defenders	1-3	45	24.3	23	21.7	22	27.8	$\chi^2(2) = 2.435$, $p = 0.296$
	4-5	92	49.7	52	48.1	40	51.9	
	≥6	48	25.9	32	30.2	16	20.3	
Invasive zone	non-invasive	80	43.2	55	51.9	25	31.6	$\chi^2(2) = 15.100$, $p = 0.001$ V = 0.295
	1st zone	71	38.4	41	38.7	30	38.0	
	2nd zone	34	18.4	10	9.4	24	30.4	
Initial pressure	pressure	140	75.7	82	77.4	58	73.4	$\chi^2(1) = 0.382$, $p = 0.537$
	no pressure	45	24.3	24	22.6	21	26.6	
Recovery type	steal	63	34.1	41	38.7	22	27.8	$\chi^2(3) = 2.435$, $p = 0.487$
	duel	65	35.1	35	33.0	30	38.0	
	turnover	43	23.2	23	21.7	20	25.3	
	GK action	14	7.6	7	6.6	7	8.9	
Passes	zero	7	3.8	2	1.9	5	6.3	$\chi^2(3) = 8.721$, $p = 0.033$ V = 0.226
	1-2	69	37.3	39	36.8	30	38.0	
	3-4	87	47.0	57	53.8	30	38.0	
	≥5	22	11.9	8	7.5	14	17.7	
Penetrative passes	zero	24	13.0	11	10.4	13	16.5	$\chi^2(3) = 2.065$, $p = 0.559$
	1-33%	54	29.2	31	29.2	23	29.1	
	34-66%	69	37.3	43	40.6	26	32.9	
	67-100%	38	20.5	21	19.8	17	21.5	
Number of attackers	1-3	109	58.9	68	64.2	41	51.9	$\chi^2(2) = 3.162$, $p = 0.206$
	4-5	69	37.3	37	34.9	32	40.5	
	≥6	7	3.8	1	0.9	6	7.6	
Duration	1-5"	21	11.4	6	5.7	15	19.0	$\chi^2(2) = 14.826$, $p = 0.001$ V = 0.307
	6-11"	112	60.5	76	71.7	36	45.6	
	≥12"	52	28.1	24	22.6	28	35.4	
Half pitch	defensive half	126	68.1	83	78.3	43	54.4	$\chi^2(1) = 11.875$, $p = 0.001$
	offensive half	59	31.9	23	21.7	36	45.6	$\varphi = 0.261$
Pitch sector	defensive	36	19.5	21	19.8	15	19.0	$\chi^2(3) = 13.398$, $p = 0.004$ V = 0.271
	pre-defensive	90	48.6	62	58.5	28	35.4	
	pre-offensive	52	28.1	21	19.8	31	39.2	
	offensive	7	3.8	2	1.9	5	6.3	

Note: FAtt – final attempt, NFAtt – no final attempt, χ^2 – chi-square, p – probability value, φ – phi, V – Cramer's V counterattacks were most frequently assisted from Zone 7 (23%), while finishing was most frequently executed from Zone 4 (30.4%).

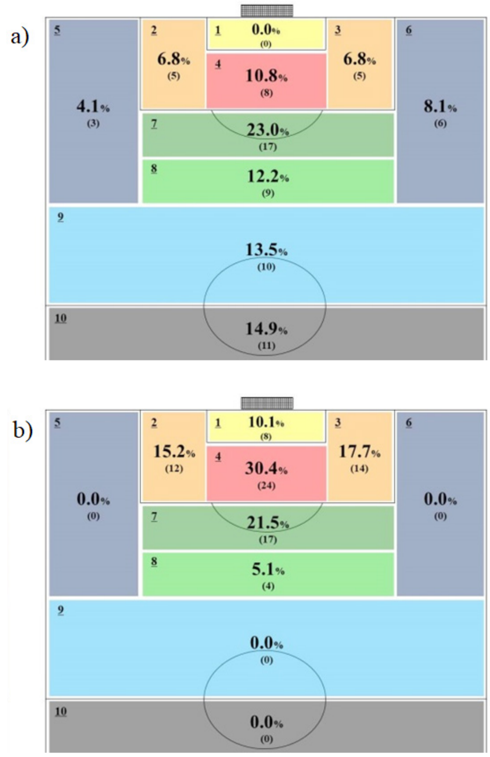

Figure 1. Percentage of total counterattacks in Champions League 2018-2019 matches in relation to the number of: a) assist zone (N = 74) and b) final attempt zone (N = 79)

The regression model showed that "invasive zone", "penetrative passes", and "number of attackers" were significant predictors for final attempts during Champions League knock-out matches (χ^2 = 35.813, p < 0.00011) and accurately predicted 67% (Table 4) of final attempts. The predictive power was moderate (R^2 = 23.7%) (Nagelkerke) and the goodness of fit as analysed by the Hosmer–Lemeshow test was also adequate (HL: $\chi^2(8)$ = = 1.930, p = 0.983).

The coefficients for "Invasive zone" were positive (B = 0.912 and B = 2.402), indicating that the likelihood of a final attempt following a counterattack increased by 2.5 times when possession started within the 1st zone and 11 times when possession started within the 2nd zone compared to starting in the non-invasive zone. The coefficient for "Penetrative passes" was positive (B = 0.567), indicating that an increase of one penetrative pass increased the likelihood by 2 times for a final attempt following a counterattack. Finally, the coefficients for "Number of attackers" were positive (B = 1.077 and B = 4.226), indicating that the likelihood of a final attempt following a counterattack increased 3-fold when 4-5 attackers participated and 68 times when 6 or more attackers participated when compared to 1-3 attackers.

Discussion

This study sought to investigate the factors associated with final attempts during counterattacks in Champions League 2018-2019 knock-out matches. To the best of our knowledge, this is the first study to distinguish the offensive transition phase from counterattacking play styles. The classification of possession after ball recoveries into five categories revealed how teams in Champions League knock-out matches behave after regaining possession. The descriptive results indicated that teams mainly used organized attacks (58.5%) and

Table 4. Logistic regression model based on teams' effectiveness at Champions League 2018-2019

	B	S.E.	Wald	p	OR [C.I.]
Non-invasive zone			19.536	0.000**	
vs 1st zone	0.912	0.396	5.307	0.021*	2.490 [1.146-5.411]
vs 2nd zone	2.402	0.543	19.535	0.000**	11.044 [3.807-32.042]
Penetrative passes	0.567	0.260	4.754	0.029*	1.763 [1.059-2.936]
Number of attackers: 1-3			9.644	0.008**	
vs 4-5	1.077	0.496	4.723	0.030**	2.937 [1.112-7.761]
vs ≥6	4.225	1.406	9.030	0.003**	68.386 [4.347-1,075.90]
Constant	−1.399	0.588	5.660	0.017*	0.247

*p < 0.05, **p < 0.01

Note: B – estimated coefficient, S.E. – standard error, p – probability value, OR – odds ratio, C.I. – confidence interval less frequently counterattacked (13.1%), which agrees with the findings of Yi et al. [45], suggesting that the teams that qualified for the knock-out phase of the Champions League were better at retaining possession than non-qualified teams. A less-detailed categorization was adopted in a study by Gonzalez-Rodenas et al. [17], who examined how the Spanish national team created scoring opportunities during the 2010 World Cup. Thus, after each ball recovery resulting in a scoring opportunity the authors used the variable "type of progression" to classify the subsequent attacking sequence as "elaborate attack" or "counterattack".

Moreover, the identification of mixed attacks and tactical fouls was a novel finding of this study, although both occurred less frequently among the five categories. Mixed attacks, after organized attacks, constituting the greatest proportion, may imply the technical and tactical ability of the teams competing in the Champions League knock-out phase, which could adapt their style of play to the situation in each game. Although tactical fouls were present during competitive matches at all levels, to the best of our knowledge they have not been included in match analysis studies so far. Ole Gunnar Solskjaer stated before Manchester United's match against Manchester City, "We have got to be ready for their pressing… when we win it (the ball) we have got to be ready for their aggression… They are not going to allow us easy counterattacking because there will be fouls…" [43]. Furthermore, in a recent survey study on injuries the participants were asked to provide an assessment of foul plays and the respondents identified tactical and professional fouls [14]. More studies are needed in this area to generate comparable results on how teams progress after regaining possession and, especially, if and how they use tactical fouls in the transition phase.

The descriptive results revealed how elite teams that competed in the knock-out phase of the Champions League utilized counterattacks. Regarding the defensive indicators, teams used medium defensive positioning with 4-5 defending players and the possession started in non-invasive zones with initial pressure. In contrast, Gonzalez-Rodenas et al. [18] found that MLS teams used advanced defensive positioning and 7 or more defenders without initial pressure. The authors found similar results concerning invasive zones, supporting the finding that possession started in non-invasive zones. Regarding the offensive performance indicators, teams stole the ball to recover possession, used 3-4 passes, of which 34-66% were penetrative, with 1-3 attacking players, for a duration of 6-11 seconds, and possession started in the defensive half, specifically, in the pre-defensive sector. These results are in line with previous studies [18, 22] in terms of the type, half, and pitch sector of recovery and the number of passes. Likewise, Fleig and Hughes [10] argued that successful counterattacks in the 2002 World Cup lasted between 10 and 15 seconds and consisted of 4-8 actions. Armatas et al. [3] discovered that the majority of counterattacks in the Champions League involved 2-3 attacking players. Contrarily, Gonzalez-Rodenas et al. [18] found that MLS teams presented a higher proportion of penetrative passes during counterattacks. Moreover, the results of the bivariate analysis showed that the performance indicators associated with counterattack success were the defenders' position, invasive zone, number of passes, duration, recovery half pitch, and pitch sector. These results corroborate Gonzalez-Rodenas et al.'s [18] findings in MLS 2014.

Concerning the assisting and final attempt zones, the results supported the previous findings that teams tend to use central areas outside and inside the box, respectively [16, 39]. Moreover, a significant proportion of assists (14.9%) were taken from the defensive half, referring to long passes before goals were scored. Similarly, Hughes and Lovell [22] stated that starting a transition from a team's own half with a long pass increased the prospect of scoring. Alternatively, although crosses have been found to facilitate a good proportion of goal-scoring opportunities during open play [28, 39], this study found that during counterattacks, wide areas and crosses were used infrequently (left: 4.1%, right: 8.1%). When considering the final attempt zones, there was a higher proportion of final attempts inside the box (73.4%) and central zones (40.5%), as found in previous studies [2, 16].

A key finding of this study is that the likelihood of a final attempt following a counterattack increased when possession started within the opponent's invasive zones compared to starting in the non-invasive zone. The concept of the SDO, which describes the invasive zones, was introduced by Seabra and Dantas [38] based on Grehaigne's previous work. Although SDO enables the spatial modelling of the game based on the organizational structure of the opposing team's defence, few researchers have used this observational system. Gonzalez-Rodenas et al. [18] argued that starting in the invasive zone registered higher probabilities of conceding a scoring opportunity in MLS than starting in the non-invasive zone. In a later study on MLS the same authors investigated the effects of organized attacks and counterattacks on the final action in scoring opportunities and found that final attempts derived from counterattacks started more frequently in invasive zones than organized attacks did [19]. Bondia et al. [6] revealed how Real Madrid and Barcelona create goal-scoring opportunities with a high proportion of ball recoveries in their opponents' invasive zones. The results indicate the importance of starting in the opponent's invasive SDO zones to create final attempts in elite matches.

The multivariate analysis revealed that after regaining possession execution of a high proportion of penetrative passes increased the odds of final attempts. The initial penetrative action seems to play a significant role in the development and effectiveness of a counterattack [29]. More specifically, Gonzalez-Rodenas et al. [20] supported this statement, finding that the first 3 seconds after ball recovery are crucial to increase the chance of a scoring opportunity. Hughes and Lovell [22] found similar results during the Champions League 2014-2015. Likewise, Sarmento et al. [34] conducted interviews with coaches, reporting that "There is a pass, a quick conduction of the ball to a player positioned far ahead. Immediately 6-7 players from the opposing team become completely out of play, and there is a need to make the most out of this brief imbalance we were able to create". These results indicate the importance of taking advantage of the first few seconds after recovering possession to exploit an opponent's defensive imbalance.

Another key finding of this study was that the greater the number of attacking players involved, the higher the odds of executing a final attempt during counterattacks. Turner and Sayers [42] indicated that successful transitions were associated with the participation of 1-3 attacking players, while Armatas et al. [3] found that a majority of counterattacks involved ≥3 attacking players. Similarly, Tenga et al. [41] showed that counterattacks were more effective than elaborate attacks when playing against an imbalanced defence during the Norwegian League. These conflicting results may derive from the different methodologies used in these studies. Although our results are not surprising, as having more attacking players improves the odds of a goal-scoring attempt, the number of defenders is also critical. This study did not examine the defender–attacker ratio during counterattacks, but the bivariate analysis showed that the participation of 4-6 defenders was more likely during final attempts after counterattacks. In a recent study, Freitas et al. [11] found that defensive transitions started with defenders' numerical superiority and were associated with an increase in the opponents' goal-scoring situations.

The following limitations of this study should be noted. Situational variables, such as match location, match status, and opposition level, were not measured and previous studies suggest that these indicators could affect how teams behave during matches. Another limitation is that a specific international league was observed only during the 2018-2019 season. Therefore, the data cannot be generalized to other competitions with different characteristics.

These findings have some practical implications for coaches. First, training drills that are designed to reproduce counterattacks should focus on 1) creating the tactical environment where play starts inside the opponent's invasive zones, 2) quickly changing behaviour to use as many penetrative passes as possible, 3) utilizing 4 or more attacking players, and 4) encouraging assisting and finishing actions inside the central corridor of the pitch, close to the penalty box. Moreover, coaches should consider and train not only the offensive organization, but also defensive positioning and team tactical behaviour during transition phases. Future research should continue to explore transition phases within men's, women's, and youth international soccer, incorporating attacking and defensive indicators and using multivariate statistics to predict success.

Conclusions

Previous studies found that counterattacks were more effective for scoring goals, despite occurring less frequently during soccer matches than organized attacks. Moreover, existing studies in performance analysis have commonly used bivariate statistical analysis rather than multivariate statistics. This study provides novel findings for coaches and managers who need to develop and train more effective playing styles and strategies. This information may suggest that to achieve successful Champions League counterattacks, utilizing recovery inside the opponents' invasive zones, a high proportion of penetrative passes and involving 4 or more attacking players are worthwhile. In the final phase of attack sequences the spatial analysis highlighted how elite teams used the central zones inside and outside the penalty area to assist and finish goal-scoring attempts, respectively.

Conflict of Interests

The authors declare no conflict of interest.

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ORIGINAL ARTICLE

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The effect of active myokinetic chain release and stretching on physical performance amongst young racquet sports players

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Abstract
Introduction. Muscle imbalance is frequently observed according to research findings. Muscles that have been shortened for a lengthy period become tight. Modalities, posture changes, and releases can all be used to treat this condition. Muscle soreness is a myogenic condition that results from deep releases. A joint's range of motion is reduced and pain is experienced as a result of adhesions and inflammation caused by the rupture of taut bands because of excessive pressure. Aim of Study. The aim was to examine the effects of active myokinetic chain release therapy (AMRT) and stretching on physical performance amongst adolescent racquet sport players with misalignment of fascial tissue. Material and Methods. Eighty racquet sports players having muscle imbalance as tested by the Bunkie test were randomly divided into two groups receiving AMRT and stretching, respectively. They were tested for different biomotor abilities, targeting lower back and hamstring flexibility, agility as well as endurance, with functional ability, speed of the racquet, pulse rate, and oxygen saturation used to assess physical performance. Results. AMRT resulted in better results in improving the biomotor abilities as compared to stretching in different biomotor abilities, but there was a significant change from pre- to post-assessment. Conclusions. While AMRT can increase biomotor and physical performance in elite athletes, there is no key procedure to apply this intervention to any player, yet this appears to be a very easy and adequate protocol for the athletic population to generate the immediate effect.

KEYWORDS: stretching, Bunkie test, racquet players, active myokinetic chain release therapy, biomotor abilities.

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Introduction

Sports are an important part of our daily lives because they help us improve and maintain our physical, physiological, psychological, and social health [19]. Racquet sports players must be able to move and change directions quickly, speed up and slow down quickly while running, keep their balance and coordination, generate the right amount of force for each stroke, and do all of this repeatedly to do well in a game or tournament [11, 17]. To coordinate all the events, the primary factors in racquet sports are flexibility, endurance, muscle strength, speed, balance, and coordination, more precisely agility, response time, and cognition [8]. Young tennis players who are exceedingly active are more likely to acquire a harmful maladaptation in strength and flexibility in the area subject to repetitive tensile overload. The timing of the tournament or gameplay influences the improvement of maladaptation [14]. Maladaptation causes changes in joint biomechanics and force coupling of the muscles around the joint, as well as a reduction in force generation and a risk factor for injury [9]. On average, young players who participate in tennis or other sports sustain several injuries, which are directly related to the frequency, with which these individuals participate in the games [14].
The many components responsible for human body movement include muscles, tendons, bones, nerves

and arteries, among other things. Similarly, fascia is an important component that covers all the body's components responsible for movement and other work in a web-like structure [26]. According to evidence from the literature, fasciae can aid in venous return, dispersion of tensional stress at the site where a muscle, ligament, or tendon inserts into a bone [3], explaining the etiology of pain [16], and smooth interaction between muscles of the limb. Fascia is an important component in the maintenance of human posture and mobility. Finally, some research suggests that the continuity of the fascial system has a function in proprioception and conveys the organ sensations throughout the body [3, 16]. Trainers, coaches, and physiotherapists constantly encounter new challenges and use their knowledge to develop new exercise protocols aimed at improving performance and reducing injury and its risk factors in the sports population, as modern-day athletes are subjected to intense training programs to achieve an optimal level of performance in the competitive era of sport [5].

Different isometric tests are used to assess the balance and endurance kinetic muscle chains, but these are mostly isolated. Therefore, to assess the weak or wrong muscle activation and imbalance of muscle a simple, less expensive isometric test called "the Bunkie test" was developed over a period of 12 years by a South-African physiotherapist working with elite athletes [5, 7]. Repetitive movements in sports cause the fascia to shorten and thicken around the overused muscle and lengthen in another area of the body. The main goal of the Bunkie test was to find the obvious restriction of the kinetic chain along the fascial lines [23].

Among the several release techniques that have been examined to determine the advantageous effect of improving the effect of muscle soreness the active myokinetic chain release technique (AMRT) is one of the most commonly used in clinical practice [1, 28]. The purpose of the technique is to ease the pain and tightness and help the muscle to return to its normal position. The application of AMRT has provided a better improvement in increasing flexibility and the range of motion immediately after the treatment [1, 28]. Although AMRT is commonly used in clinical practice by physiotherapists, its effect on the sports population has not been scientifically studied. This new therapeutic strategy has been introduced to the sports population.

Aim of Study

The purpose of the study was to assess the misalignment and muscle imbalance using the Bunkie test so that the athletes could correct misalignment, activate the right muscle for the specific movement under the supervision of a physiotherapist, and examine the effect of AMRT on physical performance and specific biomotor abilities in adolescent racquet sport players.

Material and Methods

The inclusion criteria were 14-20 years old, regularly practising racquet sports, having at least one year of experience, no major injuries interfering with their game, and an incorrect kinetic chain diagnosed by the Bunkie test. Players with unstable pathology, severe neurological deficits, continuous neurological pain, cardiac or metabolic diseases that prevent them from testing, and players who successfully completed all five positions in the Bunkie test and those on any dietary supplements during the testing were excluded. The method of double-blinded randomization was used to allocate players into two groups. The present study used a quasi-experimental design with two experimental groups (the active myokinetic release group and the active stretching group).

Sampling

The calculation of the sample size was carried out using the G*Power version 3.1.9.7 program using A priori 't' test (means: difference between two independent means, two groups), with an α error of 0.05, power ($1 - \beta$ error) of 0.80, effect size of 0.5, resulting in a total of 128 participants. However, this was rounded to 150 considering the dropouts.

Procedure

After the clearance of the study by the ethical committee of the university (MRIIRS/FAHS/DEC/2021-S16 dated 12th April), the players were screened from different sports academies in Delhi and Faridabad (India). All the testing was conducted during the non-competitive phase of the season, and the academies continued with their normal training season around the time of testing. The nature, importance, and beneficial effect of the study were clearly explained to the players and coaches. Written consent was taken from the players, who volunteered themselves for the study and fulfilled the inclusion and exclusion criteria.

About 150 players were screened. These players were checked for their eligibility for enrolment based on the inclusion and exclusion criteria. The Bunkie test was performed to test fascial alignment as one of the inclusion criteria (Figure 1).

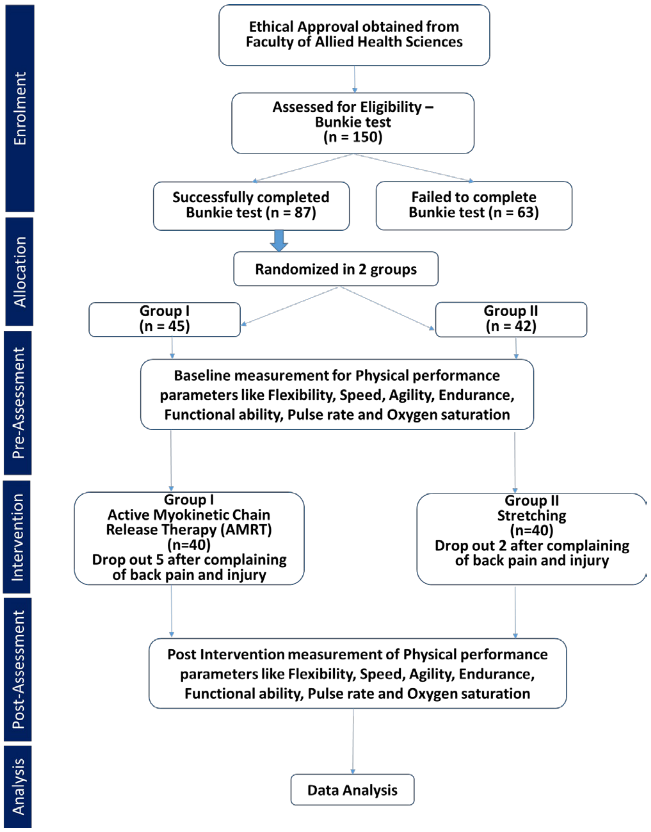

Figure 1. Flow chart of the study

The Bunkie test

The Bunkie test was demonstrated and clearly explained to all the players. The Bunkie test is comprised of five positions or functional lines, each performed on the left and right sides of the body, totaling ten positions. Postures included the posterior power line (PPL), anterior power line (APL), posterior stabilizing line (PSL), lateral stabilizing line (LSL), and medial stabilizing line (MSL). Each position is completed on a 30 cm high bench with the upper extremities resting on a mat placed on the floor below them. The athletes were allowed to try each position to familiarize themselves for 5 seconds, but no longer to avoid fatigue. Subjects were instructed to hold each position for 40 seconds, which is the duration required for elite athletes. Since this test is aimed to identify fascia restrictions in specific lines rather than measuring strength, therefore they were instructed to express the moment when they first felt any straining, cramping, pain or tension while holding a position [5]. These symptoms indicated that the fascia in that specific line was "locked-long", causing restrictions in the fascia and malalignments of the myofascia. The duration that the participant could hold each position without symptoms was recorded.

Intervention

Group I

Group 'A' received myokinetic therapy targeted at releasing muscles of the superficial back line, i.e., gastrocnemius, hamstrings, thoracolumbar fascia, and erector spinae. The release was applied passively by sustained pressure for 8-10 seconds. A gentle stretching force was applied to take up the slack until the muscle was released. The patient was next asked to apply a weak opposite force in the stretched position to improve the release. This protocol consisted of three sets with 2 minutes of rest for six sessions. Each session was given on alternate days. Each muscle group was released on the same day and during each session.

Group II

Group 'B' performed self-stretching of the gastrocnemius, hamstrings, thoracolumbar fascia, and erector spinae. The subjects used their own body weight without any extra help from the physiotherapist. Subjects were instructed to perform three sets of stretches for all the muscles. Each stretch was held for 20 seconds, alternating the left and right limbs. The subjects were next instructed in the self-stretching exercise of the erector spinae muscle and thoracolumbar fascia. Each session was given on alternate days. Each muscle group was released on the same day and during each session.

Testing, assessment, and evaluation

The assessment was done to assess the selected biomotor abilities using the sit and reach test (lower back and hamstring flexibility), half kneeling rotation of trunk in back (HKRTB), half kneeling rotation of trunk in front (HKRTF), sitting trunk rotation (STR) (for trunk flexibility), T-test (for agility), progressive aerobic cardiovascular endurance run test (for endurance), single limb timed side hop test (functional ability), speed of the racquet by speed gun (speed), pulse rate and oxygen saturation (using a pulse oximeter).

It was ensured that the Bunkie test was performed on the first day and the biomotor abilities were tested on the second day to avoid fatigue. All testing sessions were conducted in the mornings and players were tested individually. One researcher was present as an overseer during the testing. Testing started after a 10-minute dynamic warm-up routine. A 10- to 15-minute break separated the various tests.

Sit and reach test

The players sat on a rubber mattress with their legs extended and feet at the right angle to the floor, approximately hip-wide against each other. The rubber mattress was marked with a plus sign. The center of the plus sign was mounted with “0”. The line parallel to the leg and opposite to the player was mounted with 1, 2, 3, etc. in inches and the line towards the players with -1, -2, -3, etc. in inches. The feet were placed at the base of the horizontal line of the plus sign. Then players were instructed to extend their arms slowly forwards as far as they could by placing one hand upon another along the measuring line. With palms down, the player reached forward, slinging hands along the measuring scale as far as possible without bending the knee of the extended leg. The score was obtained according to the best distance covered by the middle finger with three attempts for each player.

Test for trunk rotation flexibility

The HKRTB, the HKRTF, and the STR were used to measure flexibility of trunk rotation. For the HKRTB, the participant was asked to place the left knee down on the ground and the right foot directly in front of the left knee [21]. A baseball bat was positioned behind the back and held in place by asking the participant to lock their arms around the bat while keeping their hands on their stomach. This position keeps the scapula in a retracted position, removing any range of motion that may occur from scapular movement. The examiner stood to the right of the participant and positioned the stationary arm of the goniometer parallel to the upper back. The participant was then asked to rotate as far to the right as possible without discomfort. As the participant rotated, the movable arm was aligned parallel to the upper back, and the angle between the stationary and moving arms was recorded. The test was repeated with the position of the legs switched to measure rotation to the left.

The HKRTF was performed in the same manner as the HKRTB, except that the bat was placed across the chest instead of behind the back [21]. This test allows movement of the scapula over the rib cage and measurement of the rotation flexibility achieved by scapular and spine movement. The test was repeated with the position of the legs switched to measure rotation to the left.

For the STR, the participant was asked to sit in a chair with their feet together and touching the ground, their body in an erect upright posture, and their arms across their chest [24]. They were then instructed to rotate to the right as far as possible without discomfort. A goniometer was used to measure the amount of rotation with the same alignment as the HKRTB and HKRTF. The test was repeated with rotation to the left. For all flexibility measures, an average of three trials was used for analysis.

Agility T-test

T-test was performed by using the four cones placed in the shape of a “T”, where the second cone was kept at a distance of 9.14 meters and the other two cones were kept at a distance of 4.57 meters from the second cone. The time from the crossing of the first cone at the start to the ending of the same cone on the return was measured using a stopwatch. The players were instructed to sprint forward 9.14 meters from the starting cone and touch the tip with their right hand, then side sprint to the left and touch the third cone with their left hand, and finally side sprint 9.14 meters to the right and touch the fourth cone with their right hand, then side sprint to the second cone and touch it with their left hand, and finally return to the first cone with a backward sprint. Three attempts were made for each player, out of which the best one was taken [22]. Trials were found to be unsuccessful if the player failed to touch the cone, had their leg crossed during a side sprint, or did not face forward during each attempt. One minute of recovery was given between each attempt.

Pacer/beep test

Players were instructed to run between two lines 20 meters apart, reaching each line in synch with the corresponding beep. According to the improvement of running speed, the beep interval decreases slowly as the testing progresses. Players can withdraw themselves from the test when fatigued, or after missing the line once, unable to attempt the line on the next beep, or being eliminated by the experimenter after attempting to reach the line, but missing two beeps consecutively. The score was calculated by adding the number of attempts, shuttle type, and level completed [18].

Single legged timed side hop test

With the adherence tape, three boxes of 46 × 46 cm in length and width were secured to the floor. The players were encouraged to side hop to the next box as fast as possible by maintaining their balance and the time was noted down with the help of a stopwatch, which represented the score. A score of zero was obtained if the player was unable to cross the lines, double bounce between the hops, or was not able to hold the balance during landing [6].

Speed of racquet

The speed of the racquet was measured using a velocity speed gun or radar gun [25]. Serving and smashing speeds were measured in tennis and badminton players, respectively.

Oxygen saturation and pulse rate

Both oxygen saturation and pulse rate were measured with a pulse oximeter at a basal level [20]. The players were instructed not to do any vigorous physical activity and to breathe gently before measuring. All the measurements were made in a calm and quiet place.

Statistical analysis

All statistical analyses were carried out using the SPSS version 21. The normality distribution of all variables was verified using the Shapiro–Wilk test. An independent test was used to examine the difference between groups for demographic characteristics and outcome measures at baseline. A 2 × 2 mixed model ANOVA was used to consider within subjects' effects (baseline and post-intervention values) and the between subjects' effect (AMRT and stretching groups) to determine the main effects (time and group effect) and the time × group interaction. If baseline values showed a significant difference, then 2 × 2 ANCOVA was applied to find the main effects (time and group effect) and the time × group interaction using baseline values as covariates. Partial eta square was performed to check the ratio of variance explained in the dependent variable by a predictor while controlling the other predictors. All the descriptive data are presented as means and standard deviations. A p-value of ≤0.05 was taken as the significant level for all variables.

Results

A total of 150 players were screened in the study. Sixty-three players were excluded based on the successful completion of the Bunkie test during the study, and 7 players [group 1 (n = 5) and group II (n = 2)] who had severe back pain while performing biomotor tests were also excluded. Therefore, 80 players who successfully completed the Bunkie test (taking less than 40 seconds

Table 1. Baseline demographic characteristics of participants in group I and II represented as Mean ± SD

Independent variables	Group I (AMRT) (n = 40)	Group II (stretching) (n = 40)	p-value
Age (years)	17.97 ± 2.04	18.12 ± 1.38	0.720
Height (meter)	1.66 ± 0.04	1.64 ± 0.07	0.178
Weight (kg)	50.76 ± 4.40	52.34 ± 2.75	0.094
BMI (kg/m²)	18.20 ± 1.31	19.33 ± 1.57	0.004*
Sleeping duration (hours)	9.24 ± 0.68	9.16 ± 0.80	0.661
Hydration status (litres/day)	3.14 ± 0.90	4.31 ± 0.99	0.001*
Training duration (hours/week)	11.10 ± 2.88	12.88 ± 2.26	0.01*
Playing since (years)	2.36 ± 0.73	1.98 ± 0.86	0.072
Pulse rate	93.24 ± 9.36	92.31 ± 8.11	0.68
Oxygen saturation (%)	98.03 ± 2.24	92.16 ± 3.47	<0.001*
Sit and reach test	16.8 ± 0.87	16.63 ± 1.5	0.585
Trunk rotation	87.29 ± 4.97	85.94 ± 5.06	0.3
Agility	12.82 ± 1.1	13.61 ± 1.34	0.015*
Speed of racquet	227 ± 28.83	197.16 ± 30.66	<0.001*
Endurance	5.8 ± 0.62	5.24 ± 0.77	0.003*
Functional ability (left limb)	2.87 ± 0.5	3.24 ± 0.8	0.033*
Functional ability (right limb)	2.61 ± 0.52	3.15 ± 0.6	0.001*

Note: AMRT – active myokinetic chain release therapy, BMI – body mass index, SD – standard deviation
* signifies the level of significance $p < 0.05$

to perform five positions or functional lines) were included in the study. Among the demographic variables, three variables were found to be significantly different between group I and group II, i.e., BMI ($p \leq 0.004$), hydration status ($p \leq 0.001$), and training duration ($p = 0.01$) (Table 1).

The variables with no significant difference between the two groups at the baseline were flexibility (sit and reach test and trunk rotation) and pulse rate. A univariate test was used to determine the time effect and the time × group interaction, and a multivariate test was used to identify the group effect in these two variables. The variables with significant differences between the two groups at the baseline were agility, speed, endurance, functional ability (left and right) and the percentage of oxygen saturation. Box's test of equality of covariance matrices was applied to analyze the time effect, time × variable covariate interaction and time × group interaction. From the result of analyses of variances (ANOVA) it was found that flexibility using the sit and reach test and trunk rotation,

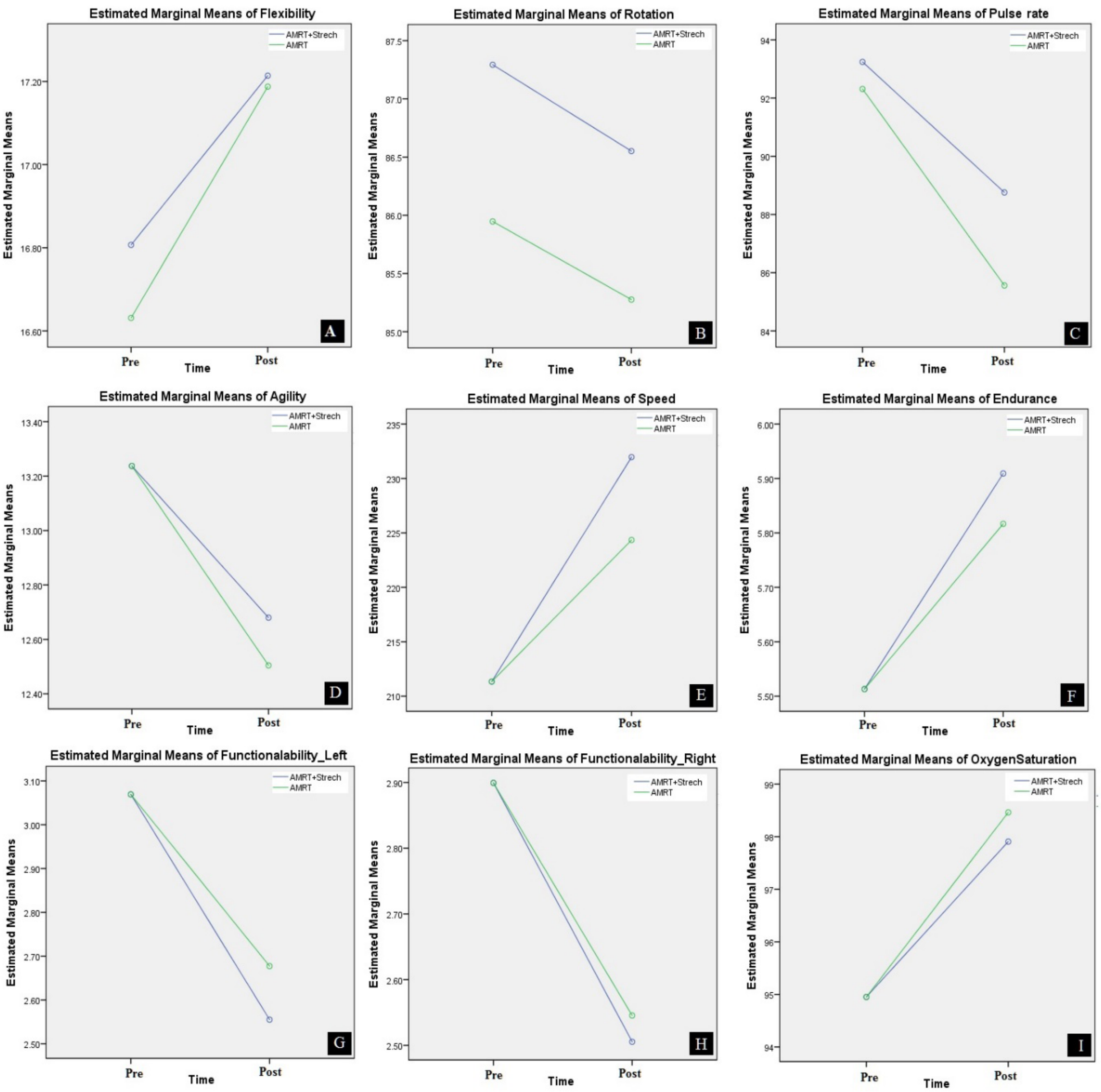

Figure 2. ANOVA plot of the mean (A) flexibility, (B) rotation, (C) pulse rate; ANCOVA plot of the mean (D) agility, (E) speed, (F) endurance, (G) functional ability (left), (H) functional ability (right), (I) oxygen saturation percentage – score for group I (active myokinetic chain release therapy) and group II (stretching)

and pulse rate showed significant changes in time ($p < 0.001$), whereas the group and time × group interaction was not found to be significant (Table 2).

Table 2. Results of the 2 × 2 mixed model analyses of variance (ANOVA) for flexibility and pulse rate

Outcome measures	Source	F-value	Partial eta	p-value
Flexibility				
sit and reach test	time (T)	96.18	0.62	<0.001*
	group (G)	0.109	0.002	0.743
	time × group	2.313	0.038	0.134
trunk rotation	time (T)	52.14	0.469	<0.001*
	group (G)	1.016	0.017	0.317
	time × group	0.131	0.002	0.719
Pulse rate	time (T)	44.11	0.428	<0.001*
	group (G)	1.265	0.021	0.265
	time × group	1.80	0.03	0.185

* $p < 0.05$

Results of ANCOVA revealed that agility ($p = 0.05$), speed (p = 007), endurance ($p = 0.011$), functional ability on the left limb ($p = 0.021$), functional ability on the right limb ($p = 0.001$) and oxygen saturation ($p < 0.001$) were found to be significant for the time effect, whereas the group effect and the time × group interaction were not significant for all outcome measures (Table 3).

Table 3. A summary of analyses of covariance (ANCOVA) for agility, speed, endurance, functional ability left and right and oxygen saturation percentage

Outcome measures	Source	F-value	Partial eta square	p-value
Agility	time	3.956	0.064	0.05*
	group	0.92	0.016	0.342
	time × group	0.92	0.016	0.342
Speed	time	7.726	0.118	0.007*
	group	2.274	0.038	0.137
	time × group	2.274	0.038	0.137
Endurance	time	6.906	0.106	0.011*
	group	0.836	0.014	0.364
	time × group	0.836	0.014	0.364
Functional ability (left)	time	5.607	0.088	0.021*
	group	1.952	0.033	0.168
	time × group	1.952	0.033	0.168
Functional ability (right)	time	13.564	0.19	0.001*
	group	0.138	0.002	0.711
	time × group	0.138	0.002	0.711
Oxygen saturation percentage	time	52.967	0.477	<0.001*
	group	0.443	0.008	0.508
	time × group	0.443	0.008	0.508

* $p < 0.05$

The plot of the mean "flexibility, rotation, pulse rate, agility, speed, endurance, functional ability (left), functional ability (right), oxygen saturation percentage" score for group I (AMRT) and group II (stretching) is plotted in a line graph, as shown in Figure 2.

Discussion

AMRT is a popular method to potentially increase the compliance and extensibility of the fascia and reduce muscle stiffness [30]. AMRT has been associated with positive linkage with physical performance, increasing the range of motion and athletic performance. The study was designed to check the effect of AMRT among adolescent racquet sports players, taking various physical performances of the players into consideration. The study has revealed the importance of muscle functioning in the kinetic chain and not in isolation, as well as the influence of malfunction in these chains on the biomotor abilities and other functional parameters. The correction of these kinetic chains is absolutely necessary to improve the biomotor abilities as well as the functional parameters. Stretching exercises alleviate the pain and have been found to be useful in decreasing joint stiffness and increasing the range of motion. The lengthening of connective tissue, which makes muscles more flexible when they break or become inflamed, is also a major physiological effect that makes people more likely to use stretching to shorten muscles [29]. To this end, the findings of this study have improved our understanding of the functions of muscles in the kinetic chain as well as given a practical tool for therapists, coaches, and players to improve the physical performance of athletes.

The outcome variables such as flexibility (lower back and hamstrings measured by the sit and reach test and trunk rotation measured by the trunk rotation test) show their significance with respect to time in both groups. Both groups saw a considerable increase in pulse rate and agility with time. The speed and endurance are important factors for racquet sport players. The functional ability of the lower limb for both the left and right side show its significant result with respect to time. Figure 2 shows that the effect of time on the percentage of oxygen saturation was important.

Despite an increase in the baseline values for the sit and reach test, the impact of AMRT appears to be more significant than that recorded in the stretching group. Further, the average pre- to post-measurement for flexibility appears to be greater following AMRT as compared to stretching, suggesting that there is a main effect of time as well. The findings of the means of trunk rotation in the stretching and AMRT groups hardly showed any significant difference. However, the effect of these techniques indicated decreased rotation, which was significant in group II receiving stretching as compared to group I receiving AMRT. In addition, the pre- to post-measurement of rotation following stretching was higher than AMRT, suggesting that there is a main effect of time (pre-post).

A recent study explained that ART was given to a patient with chronic muscular neck pain and the therapy was effective in muscle soreness and pain where the release was given to lengthen the area [15]. This study concluded that the release given towards the painful area improves both the range of motion (flexibility) and alleviates pain, but the release opposite to the painful area improves only the range of motion, not the pain.

When the muscle is worked for a longer period or due to the overuse of the muscle in the athletic population, both the muscle and the fascia become shortened. As the fascia is shortened, the muscle spindle and muscle fibers get close to the shortened area, because of which the myofascial system becomes strong and non--breakable [2, 4, 27]. In this study, the intervention that is the release was given towards the lengthened area to break the adhesion, which was formed in the shortened area and improved the blood circulation in the weak area.

The results of this study confirmed that there is a clinical significance between pulse rate and time and intervention. The effects of both AMRT and stretching techniques have shown significant impact in relation to the time of exposure, but this was not significant between AMRT and stretching. All the other variables, including agility, speed, endurance, functional ability (left and right), and oxygen saturation percentage improved in the stretching and AMRT groups. For the main effect of pre- to post--measurement there was no significant difference in agility, while there was a significant difference in speed, endurance, functional ability (left and right), and oxygen saturation percentage (Figure 2).

Several studies have looked into the benefits of reducing muscle soreness. The myokinetic active release technique is widely used in clinical practice. The patient is asked to actively move the tissue from a shortened to an extended position, breaking the adhesion produced. It helps relieve pain and tightness while repositioning the muscles. ART has improved flexibility and the range of motion shortly after treatment [1, 28].

Nowadays, various soft tissue release techniques such as e.g. self-myofascial release using a foam roller, or manual myofascial release using different methods of application are practiced [10, 13]. Myokinetic chain active release therapy is used for treatment purposes, which ultimately helps in adhesion break, increases the blood flow and lymphatic drainage, resulting in increased flexibility of the soft tissues, while it also improves the range of motion and muscle strength. Active myokinetic strain release is a technique that involves the application of deep tension over the tenderness and instructs the players to actively move the tissue from the shortened to the lengthened position, which results in breaking the adhesion [12]. Although this study did not result in any significant changes in racquet players with muscle imbalance, in the future this AMRT may be applied to diseased, disabled, and recreational athletes. In addition, this technique may be assessed in other games at different levels.

Conclusion

While computing the effectiveness of AMRT on the physical performances of adolescent racquet sports athletes, it is concluded that although AMRT has better results than stretching, this difference is not significant. The active myokinetic release technique has been used by physiotherapists for the treatment of tenderness/stiffness at various joints. From the practical point of view, we can suggest that the active myokinetic technique is effective in the release of the myofascia and, in turn, improves the sports specific parameters of racquet sports players. Stretching also impacts and improves the adhesions, increases the blood flow and lymphatic drainage, resulting in an increase in soft tissue extensibility and improves range of motion and muscle strength. The myokinetic active release technique is the application of deep tension over the tenderness and asking the patient to actively move the tissue from the shortened to the lengthened position, thereby breaking the adhesion. Both these techniques can be treatment of choice in young racquet sports players to improve their sports performance.

The subjects were not divided based on their experience, level of play or gender, as that could impact the results. The history of past training was also not collected in this research. The long-term effect was not studied.

Conflict of Interests

The authors declare no conflict of interest.

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Leisure time analysis and comparison of secondary school male students in terms of selected regions of Slovakia: a cross-sectional study

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Abstract
Introduction. **Accumulating evidence indicates that leisure time lowers stress and depression and improves your quality of life, thus being something worth making time for. However, most secondary school students do not make effective use of their leisure time.** Aim of Study. **Our study was aimed at analysing and comparing leisure time of secondary school male students in terms of selected regions of Slovakia.** Material and Methods. **A non-standardized survey of leisure time was carried out through an intentional sampling with the survey group size of 1830 secondary school male students (aged 17.35 ± 0.82 years) who attended the final year (4th) of grammar and vocational secondary schools. Basic descriptive statistics and the chi-square test (χ^2) were used to analyse and compare the data. Data on leisure time was collected from January to June, 2021.** Results. **After analysing the survey answers, on average 43.98% (n = 805) of the survey group declared 1 to 3 hours/day of leisure time during the working week vs 5 hours/day of leisure time during the weekend ($p < 0.01$). In terms of spending their leisure time being active was declared by 58.94% (n = 1078) of the survey group ($p < 0.01$).** Conclusions. **Leisure time of the survey group differs significantly in terms of hours/day, way of spending and interest area ($p < 0.01$; 0.05). An example is average leisure time of the survey group during the working week and weekend, because in terms of selected regions of Slovakia the results revealed statistical differences ($p < 0.01$; 0.05); in particular between the selected regions of western (Bratislava Region), eastern (Košice Region, Prešov Region) and northern (Žilina Region) Slovakia.**

KEYWORDS: leisure time, secondary schools, adolescent boys, selected regions of Slovakia.

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Introduction

Each generation of adolescent boys is shaped by social, political and economic events of the day. Today's adolescent boys are no exception compared to previous generations of adolescent boys [25]. In today's hectic world with a constant increase in the standard of living, the space for utilization of leisure time expands, in which regular physical activity should be adequately represented. Regular physical activity should be part of the way of life of the current generation of adolescent boys; however, its representation in their regimen is absent or insufficient to meet the requirements of today's world. As a consequence a majority of the current generation of adolescent boys is not meeting the physical activity and sedentary guidelines. In 2012, only 2% of adolescent boys aged 13-17 met both the physical activity and sedentary screen-based behavioural guidelines. In 2018, ±20% of adolescent boys were overweight and obese. A global population-based measurement study of obesity in the age group of 5-19 years increased from 0.9% in 1975 to 7.8% in 2016. Within the last 40 years, in the group of adolescent boys a 12-fold increase of obesity was recorded from 6 million in 1975 to 74 million in 2016 [16].

Adolescence represents a crucial period of development because of hormonal changes and obviously other interests arise in the form of restricted regular physical activity and decline of physical fitness [22]. Adolescence represents an important stage in a life for improving attitudes towards physical activity habits. Parents and peers are considered to play an important role in influencing adolescent boys' physical activity, since they are the ones who have to lead them to spend their leisure time meaningfully. A positive correlation was observed between the physical activity of adolescent boys and their parents; in other words, an active parent was significantly associated with adolescent boys' physical activity and/or sports participation [13].

Adolescent health is a strong predictor of adult health. Adolescent boys with a lower leisure-time physical activity are reported to have mental health problems and increased substance use [26]. Structured leisure-time physical activity contributes to adequate levels of intrinsic motivation and positive development in adolescent boys [14]. Leisure-time physical activity has a positive effect on psychosocial and musculoskeletal health and reduces the impact of other risk factors, in particular overweight and obesity, high blood pressure and elevated blood cholesterol level. The frequency of spontaneous physical activity decreases, that is why taking part in structured leisure-time physical activity is associated with increasing physical activity levels and improving attitudes towards physical activity in adolescent boys [5]. Many adolescent boys do not participate in sports (organized) and physical education on a regular basis. When adolescent boys are asked to give reasons for not participating in sports and physical education, a lack of time is mentioned almost routinely [2]. Physical activity represents another important leisure activity of adolescent boys, which in contrast to media use remained almost unchanged during the last decade. The growing use of electronic media has raised concerns as leading to an increased prevalence of sedentary lifestyle, resulting in decreased physical activity levels of adolescent boys. Adolescent boys spent on average 6.1 hours/day of watching television and using a mobile phone/computer [1]. About 24% of Slovak adolescent boys reported watching television for 2 hours/day in their leisure time during the working week [11]. Existing evidence shows that American adolescent boys spend an extreme average of 9 hours/day using digital technology (e.g. playing console games and listening to music) [23].

Aim of Study

Our study attempts to bridge the survey gap with data concerning the analysis and comparison of leisure time in adolescent boys and for that reason the present study was aimed at analysing and comparing leisure time of secondary school male students in terms of selected regions of Slovakia.

Material and Methods

Participants

In accordance with the survey aim, the target population consisted of adolescent boy attending the final year (4^{th}) of grammar and vocational secondary schools in selected regions of Slovakia. Adolescent boys consisted of the convenience sample, which was recruited through various available sources; in particular social media (e.g. Facebook), or assistance of their school director/physical education teachers. The recruitment process was adjusted regularly (every 2 weeks) to ensure intentional sampling regarding age, gender and year of study. A total of 1,855 filled-in debriefing forms were included in the cross-sectional study data interpretation process; however, 1.34% (n = 25) did not meet the inclusion criteria: 1) not having health problems (e.g. being ill for a long time and medically exempt from physical education), 2) pre-selected gender (male), 3) pre-selected year of study (4^{th}). After meeting the inclusion criteria, the survey group consisted of 1830 (100%) grammar and vocational secondary school students (adolescent boys) aged 17.35 ± 0.82 years. The distribution of the survey group was as follows: 1) the Banská Bystrica Region (30.25%, n = 554), 2) the Bratislava Region (14.35%, n = 263), 3) the Košice Region (9.82%, n = 180), 4) the Prešov Region (27.46%, n = 501), and 5) the Žilina Region (18.12%, n = 332).

Procedures

A single-measure descriptive cross-sectional study was carried out. The research instrument of the non--standardised survey was specially developed and consisted of 2 sections: 1) basic demographic information (e.g. age, gender, year of study and selected region), 2) survey questions, which consisted of 3 closed questions, concerned with: (a) average leisure time during the working week (Monday–Friday, 4 closed answers: <1 hour, 1-3 hours, 3-5 hours, >5 hours); (b) average leisure time during the weekend (Saturday–Sunday, 4 closed answers: <1 hour, 1-3 hours, 3-5 hours, >5 hours); (c) interest area related to spending leisure time – 6 closed answers: (i) cultural leisure activity –

receptive cultural “passive” leisure activity – consumption of culture/attending cultural events in the role of audience/ spectator (outside home) and creative cultural “active” leisure activity – art making and creative expression; (ii) leisure sport activity – freedom, voluntary and non-competitive activity, aimed at regulating the mental state and well-being, not as a specific sport project, but a kind of social existence form of sport; (iii) media leisure activity – internet-based applications, aimed at building an ethical and technological foundation and promoting physical activity (e.g. Facebook, Instagram and YouTube); (iv) technical leisure time – using a smart device (e.g. a watch/a smartphone), aimed at promoting physical activity and rhythmic game series (e.g. YouTube, Just Dance); (v) nature-based leisure time activities – spending time outdoors, amidst nature and with the focus on engaging in physical activity (e.g. brisk walking up a hill and mountain biking and skiing); (vi) social leisure time – a concept, aimed at involving leisurely activity in a social setting (e.g. extracurricular activity with a peer/a partner and one’s family).

During an unlimited time session the survey group (n = = 1830) answered the non-standardised survey questions, which were available online at all times and reviewed the survey data, in order to clarity the non-standardised survey (allowed only to adolescent boys being of age). An online feedback during the unlimited time session did not indicate any issues with the cross-sectional design (technical) and non-standardised survey (grammar/ vocabulary). In the case of not being an adolescent boy of legal age (i.e. being a minor), the debriefing survey forms of the non-standardised survey were distributed (face-to-face) by the authors (meeting the parental consent requirements) in their native language and did not involve any information concerning the respondents’ identity. Incentives were not given for voluntary participation; however, the survey group received the report with their personal results afterwards. An online version of the non-standardised survey was selected due to its cost effectiveness, time saving, easy accessibility and the rapidly changing epidemic situation in the Covid-19 pandemic. The online non-standardised survey was created and distributed using an online survey portal – Microsoft Forms, Office 365 (Microsoft Corp., Redmond, WA, USA). Survey data was collected through the survey distributed from January to June, 2021. After the permission (a school director’s and parental consent) to carry out the cross-sectional study, the survey group consisted of adolescent boys attending the final year (4th) of grammar and vocational secondary schools in selected regions of Slovakia. The Covid-19 pandemic has caused huge costs in terms of human lives lost and the burden on the health care system. As a consequence, various restrictions (lockdowns) imposed to limit the spread of the virus have slowed down the entire sectors of activity and led to an economic recession. Already before the epidemic outbreak the regional gap in the gross domestic product per capita increased over the last 16 years in Slovakia. The faster growth of the gross domestic product in the country’s richest region – Bratislava has widened the regional gap in relation to the poorest regions (the Košice Region and the Prešov Region) of eastern Slovakia. In terms of the gross domestic product per capita, the figure for the country’s richest region is now almost 3.5 times higher than that of the poorest regions of Slovakia. In 2016, Slovakia had the 2nd highest regional disparities among the 33 OECD member countries. The Bratislava Region, the country’s richest region, experienced the uppermost productivity of growth in 2000-2016 at 3.7%/year. Regional gaps and disparities (2nd) were the reasons of choosing the selected regions of Slovakia.

Statistical analysis

All survey data was tabulated (figured) in a database designed precisely for the cross-sectional study. Taking into account the incidence of responses, each survey answer of the survey group (n = 1830) and the selected regions of Slovakia were analysed, compared and evaluated using the programme of Tap3 – Gamo (Banská Bystrica, Slovakia). All survey data of the survey group was polled after cleaning and analysed using the basic descriptive statistics, in particular the percentage frequency analysis (%), arithmetic mean ($\bar{x}$) and multiplicity (n). The percentage value (%) was applied in the survey questions with the single choice answer, while the differences in thepercentage values (%) were applied in the survey questions with the single choice answer, differences between each region were evaluated by the method of inductive statistics – chi-square test (χ^2), of which the significance level (α) was 0.01 and 0.05.

Results

In accordance with the survey aim, Figure 1 illustrates the average leisure time of the survey group (n = 1830) during the working week and confirms that the survey answer of 1-3 hours predominated at 52.44% (n = 960), with the incidence of responses ranging from 34.73% (n = 174, Prešov Region) to 52.44% (n = 290, Banská Bystrica Region). The survey answer of 3-5 hours was declared by 28.32% (n = 518) of the survey group, with the incidence of responses ranging from 22.78% (n = = 41, Košice Region) to 32.53% (n = 162, Prešov Region). Another survey answer of >5 hours was selected by 19.14% (n = 350) of the survey group, which showed a lower incidence of responses (28.32% vs 19.14%) than the previous survey answer (Figure 1). The percentage value of 8.56% (n = 156) was recorded for the survey answer of <1 hour, which was the lowest incidence of responses within the average leisure time in the survey group during the working week.

Taking into account the incidence of average leisure time in the survey group (n = 1830) during the working week, the intergroup difference of the survey group and each region revealed the statistical significance ($p < 0.01$; $p < 0.05$) within the majority of selected regions of Slovakia, with the exception of the mutual statistical comparison between the Banská Bystrica Region vs the Bratislava Region and the Žilina Region vs the Prešov Region ($p > 0.05$) (Table 1).

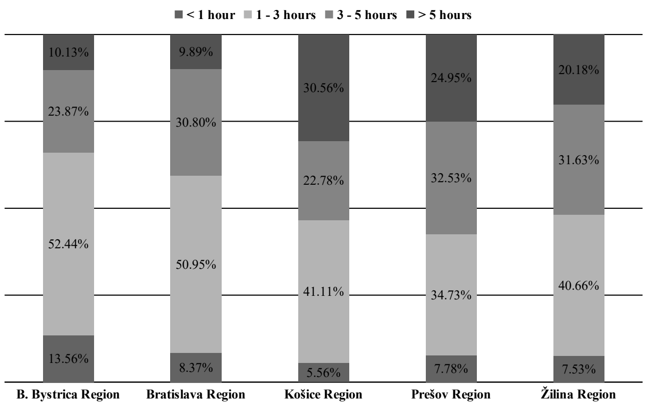

Figure 1. Average leisure time of the survey group (n = 1830) during the working week

After evaluating the previous survey question, Figure 2 illustrates the average leisure time of the survey group (n = 1830) during the weekend and confirms the greater variety of responses than the previous survey answers. For instance, the survey answer of >5 hours reached the highest incidence of responses (63.11%, n = 640) within the survey group from the northern (Žilina Region: 61.75%, n = 205) and eastern (Košice Region: 63.33%, n = 114 and Prešov Region: 64.27%, n = 322) Slovakia. The incidence of responses from the other regions of Slovakia decreased by 36.49% (n = 422). The survey answer of 3-5 hours was given by 25.05% (n = 458) of the survey group, with the incidence of responses ranging from 12.78% (n = 23, Košice Region) to 36.50% (n = 96, Bratislava Region). The incidence of the following responses was not much different, because on average 22.34% (n = 408) of the survey group declared 1-3 hours, which ranged from 10.98% (n = 55, Prešov Region) to 37.64% (n = 98, Bratislava Region). In turn, 4.08% (n = 75) of the survey group gave the survey answer of <1 hour.

Taking into account the incidence of average leisure time in the survey group (n = 1830) during the weekend, the intergroup difference of the survey group and each region revealed the statistical significance ($p < 0.01$; $p < 0.05$) within the majority of selected regions of

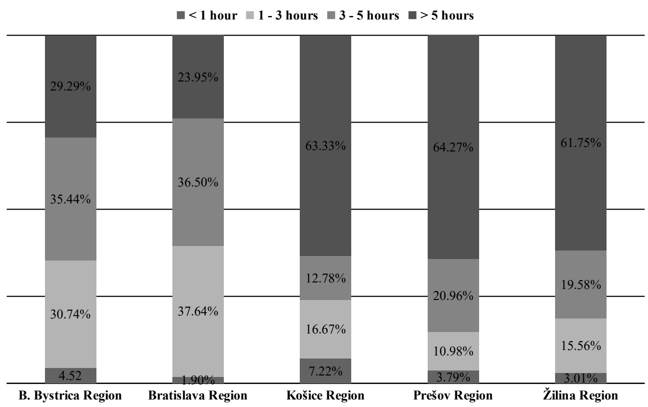

Figure 2. Average leisure time of the survey group (n = 1830) during the weekend

Table 1. Statistical interpretation of average leisure time of the survey group (n = 1830) during the working week

	Survey group				
Region	Banská Bystrica	Bratislava	Košice	Žilina	Prešov
Banská Bystrica	–	0.059793	1.66E-10**	4.26E-07**	1.44E-14**
Bratislava	0.059793	–	9.2E-07**	0.00359**	7.38E-07**
Košice	1.66E-10**	9.2E-07**	–	0.027376*	0.042485*
Žilina	4.26E-07**	0.00359**	0.027376*	–	0.268805
Prešov	1.44E-14**	7.38E-07**	0.042485*	0.268805	–

* significance level of 0.05; ** significance level of 0.01

Table 2. Statistical interpretation of average leisure time of the survey group (n = 1830) during the weekend

Survey group					
Region	Banská Bystrica	Bratislava	Košice	Žilina	Prešov
Banská Bystrica	–	0.050302	1.41E-16**	1.81E-19**	1.14E-29**
Bratislava	0.050302	–	7.7E-19**	1.53E-19**	6.51E-29**
Košice	1.41E-16**	7.7E-19**	–	0.048847*	0.009389**
Žilina	1.81E-19**	1.53E-19**	0.048847*	–	0.245906
Prešov	1.14E-29**	6.51E-29**	0.009389**	0.245906	–

* significance level of 0.05; ** significance level of 0.01

Slovakia, with the exception of a mutual statistical comparison between the Banská Bystrica Region vs the Bratislava Region and the Žilina Region vs the Prešov Region ($p > 0.05$) (Table 2).

When evaluating the last survey question, Figure 3 illustrates the interest area of spending the leisure time of the survey group (n = 1830) and confirms that the survey answer of leisure sport activity predominated (45.64%, n = 835) with the incidence of responses ranging from 31.56% (n = 83, Bratislava Region) to 54.69% (n = 274, Prešov Region). The survey answer of media leisure activity was declared by 20.01% (n = 402) of the survey group, with the incidence of responses ranging from 8.37% (n = 22, Bratislava Region) to 36.45% (n = 121, Žilina Region). The survey answer indicating cultural leisure activity was given by 12.97% (n = 238) of the survey group. A lower percentage value of 5.79% (n = 106) was found for the survey answer of technical leisure activity, which represented the lowest incidence of responses within the interest area of spending the leisure time in the survey group. The difference of 0.24% (n = 4) represented the proportion between the survey answer of technical and nature-based leisure activity (5.79%, n = 106 vs 6.03%, n = 110). Not so different was the incidence of the following responses, because 7.53% (n = 138) of the survey group selected the survey answer of social leisure activity, ranging from 4.19% (n = 22, Prešov Region) to 15.59% (n = 42, Bratislava Region).

Taking into account the incidence of interest area of spending the leisure time, the intergroup difference of the survey group and each region revealed the statistical significance ($p < 0.01$; $p < 0.05$) within the majority of selected regions of Slovakia, with the exception of the mutual statistical comparison between the Banská

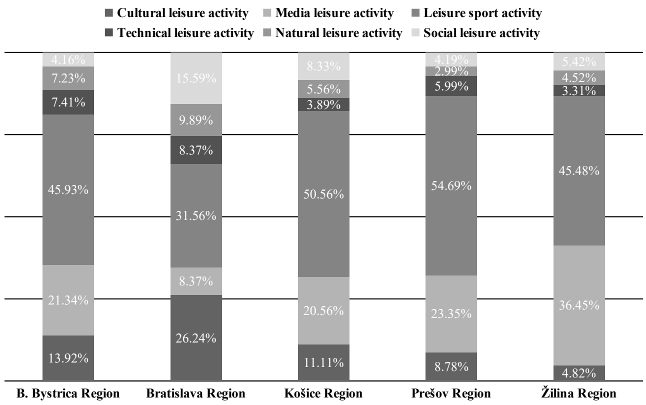

Figure 3. Interest area of spending leisure time of the survey group (n = 1830)

Table 3. Statistical interpretation of interest area of spending leisure activity in the survey group (n = 1830)

Survey group					
Region	Banská Bystrica	Bratislava	Košice	Žilina	Prešov
Banská Bystrica	–	2.49E-14**	0.102477	3.66E-08**	0.001049**
Bratislava	2.49E-14**	–	2.21E-08**	1.7E-26**	2.05E-24**
Košice	0.102477	2.21E-08**	–	0.002224**	0.094737
Žilina	3.66E-08**	1.7E-26**	0.002224**	–	0.000175**
Prešov	0.001049**	2.05E-24**	0.094737	0.000175**	–

Note. * – Significance level of 0.05, ** – Significance level of 0.01

Bystrica Region vs the Košice Region and the Košice Region vs the Prešov Region ($p > 0.05$) (Table 3).

Discussion

Adolescent boys are spending their leisure time in a different way than they did a decade ago; devoting more leisure time to sleep and screen-based activity and less of that time to the process of socialising; however, there is no consistent evidence that leisure-time physical activity in adolescent boys has changed throughout the years [29]. Additionally, there is an upward trend in Finnish and Norwegian adolescents' leisure-time physical activity, in particular an increase of that activity among adolescent girls [14]. Existing evidence shows that among 405 adolescent boys (aged 17 ± 1.2 years), 67% of them participated in some form of leisure-time physical activity for more than 10 minutes/day and for 52% it was 49 minutes/day. An average for leisure-time physical activity was different in adolescent boys (55 minutes/day) compared to adolescent girl (38 minutes/day) [19]. Another existing evidence of Brazilian data shows that the prevalence of leisure-time physical inactivity was different (54.3%) in adolescent boys (38%) compared to adolescent girls (70.7%). In turn, evidence from a Polish project (2003-2005) revealed that nearly 35% of Polish adolescent boys and girls are not active during their leisure time, only 17% of them are occasionally engaged in any exercise and over 50% of them do not participate in any kind of recreational leisure time activity [8]. Almost 25% of European adolescent boys and girls do not engage in leisure-time physical activity and this ratio increases with age [27]. German adolescent boys and girls show that a majority of them participated in leisure-time physical activity; 66.6% of them more than 2 hours/week [12]. Compared to 2000, adolescent boys and girls in 2015 spent less of their leisure time on physical activity, sports and cultural pursuits [4].

Adolescent boys now spend more than 5 hours of leisure time/day (5 hours and 44 minutes). During the working week and weekend adolescent boys and girls performed physical activity more than 3 hours/day, while with an increasing age their physical activity decreased and at the age of 15 it was only 49 minutes/day of the working week. During the weekend it was only 35 minutes/day [15]. In a study carried out in eastern Slovakia adolescent boys spent their leisure time more actively during the working week compared to adolescent girls. In terms of its duration, adolescent boys spent 41.5 minutes/day at leisure-time physical activity and adolescent girls only 11 minutes/day. During the weekend adolescent boys were again more physically active than adolescent girls (71.7 minutes/day vs 11.7 minutes/day of leisure-time physical activity) [29].

Existing evidence provided by television news (ABC News, CBS News, CNN News) shows that adolescent boys spend an average of 7 hours and 22 minutes of leisure time/day, of which they spend massive amounts of screen time as a form of leisure activity. Given evidence does not correlate with our results, because the survey answer of 1-3 hours dominated (52.44%, n = 960), with the incidence of responses ranging from 34.73% (n = 174, Prešov Region) to 52.44% (n = 290, Banská Bystrica Region) (Figure 1). Existing evidence shows that almost every adolescent boy and girl (in Slovakia) watches television every day (98.5%), while 64% of them every day play computer games. Slovak adolescent girls watch television on average 2.31 hours/day, while Slovak adolescent boys watch television for 2.21 hours/day; however, they spend more time playing computer games (1.13 hours/day) than Slovak adolescent girls (0.72 hours/day; $p < 0.001$) [28]. A study carried out in Poland included information concerning the negative amount of passive leisure time among the schoolchildren who spent on average 2.5 hours/day watching television and 1.6 hours/day playing computer games. According to that study, these types of sedentary activities increased on weekends [21]. Another Polish study revealed that over 42% of adolescent boys and girls spent more than 3 hours/day in front of the television and a computer monitor [8]. Watching television and playing computer games are the most common ways of spending leisure time among Hungarian adolescents. As shown by a Hungarian study, a majority of adolescent boys and girls (residents of Debrecen, Hungary) play (engage in) sports on a regular basis, while they spend on average 3 hours/working day of leisure time and 6.5 hours/weekend at leisure time activities. Only 22.7% of adolescent girls play computer games, which is 85.5% in the case of adolescent boys. Their percentage engaged in daily out-of-school leisure time activity is 22.9%; however, 89.5% of them do out-of-school leisure time activity 2-3 times/week [27]. Slovak adolescent boys and girls make adverse choices concerning their leisure time, as they take over and similarly follow the preferences of their foreign peers to spend leisure time mainly in a sedentary activity [28]. The survey answer of 3-5 hours was selected by 28.32% (n = 518) of the survey group (n = 1830) (leisure time/working week). When comparing Czech adolescent boys they spent 2.8 hours/working day doing schoolwork during the spring lockdown 2020, when they devoted 5 hours/

working day to leisure time activity they enjoyed [24]. In 2003-2005 adolescent boys and girls averaged more than 5 hours/day in leisure time; 66.6% of them spent their leisure time passively [7]. In terms of leisure time/weekend, given evidence correlates with our results, because the survey answer of <5 hours reached the highest incidence of responses (63.11%, n = 640) within the survey group from the northern (Žilina Region: 61.75%, n = 205) and eastern (Košice Region: 63.33%, n = 114; Prešov Region: 64.27%, n = 322) Slovakia (Figure 2).

When adolescent boys use screen-based media more frequently, they are less active in leisure time [1]. Moreover, about 98% of adolescent boys used screen-based media. Screen time was 3.8 hours/day and 68% of adolescent boys reported its duration to be longer than recommended (>2 hours/day) [9]. The use of interactive media has increased in recent years [1, 3]. Existing evidence correlates with our results, because the survey answer of media leisure time was given by 20.01% (n = 402) of the survey group (n = 1830). The incidence of responses ranged from 8.37% (n = 22, Bratislava Region) to 36.45% (n = 121, Žilina Region). The survey answer of leisure sport activity dominated (45.64%, n = 835), with the incidence of responses ranging from 31.56% (n = 83, Bratislava Region) to 54.69% (n = 274, Prešov Region) (Figure 3). Engaging in most of the specific types of leisure time activity shows a serious decline from age 15 to 23 [10]. Peers and parents play an important role in influencing adolescent boys' leisure-time physical activity and in general, the life of an individual [20]. According to the common presumption, adolescent boys spend most of their leisure time in company of their peers who represent their alternative family [17]. On average, 7.53% (n = 138) of the survey group (n = 1830) selected the survey answer of social leisure time. Active participation in leisure time activities is associated with various aspects of successful aging, including psychosocial health and well-being. An exercise frequency of ≤3 times/week is a powerful predictor of adolescent health literacy and health-promoting lifestyle profile [6, 18].

Conclusions

The present study was aimed at analysing and comparing leisure time of secondary school male students in terms of selected regions of Slovakia, which differ not only by geographical location (landform – flat, Bratislava Region and hilly, Banská Bystrica Region), but mainly the economic character. An average leisure time of secondary school male students (adolescent boys) during the working week revealed significant differences ($p < 0.01$), in particular for the Košice Region (eastern Slovakia) compared to the other selected regions of Slovakia. When evaluating the average leisure time during the working week and weekend, a very similar finding ($p < 0.01$) was revealed. We consider it important that in terms of selected regions of northern (Žilina Region) and eastern (Košice Region and Prešov Region) Slovakia during the weekend more than 60% of secondary school male students spent >5 hours/day of leisure time, which is almost ½ more compared to the other selected regions of Slovakia (the Bratislava Region and the Banská Bystrica Region). The main interest area of spending leisure time for the survey group (n = 1830) is leisure sport activity (45.64%, n = = 835), which is popular in eastern Slovakia (more than 50% of the Košice Region and the Prešov Region). In contrast, the lowest incidence of such responses was recorded for Bratislava, the "country's richest region" (in terms of gross domestic product), where leisure sport activity dominated only in 31.56% (n = 83) of the survey group. For this reason we consider one of the "causes" to be associated with a relatively higher opportunity of cultural and social leisure activities (>26%), which exceed the activity 2- or even 6-fold in terms of the selected regions of Slovakia, while the content of their leisure time activity differed significantly ($p < 0.01$). In view of the above we see an important role of physical education teachers through their high-quality and well-managed pedagogical process to positively guide and motivate secondary school male students to actively participate in their own development (especially physically, mentally and socially). This needs to include an effective and meaningful use of leisure time with emphasis on the Bratislava Region, which in terms of its economic status reports the best results and creates prerequisites allowing secondary school male students to realize a wider spectrum of leisure time activities, even those more demanding (financially) when compared to the other selected regions of Slovakia. Leisure time used in this way will certainly bring various benefits, not only to secondary school male students (adolescent boys), but also to their primary social groups (friends/family), because adolescents who do not have meaningfully filled leisure time have a greater tendency to engage in risky behaviour.

Conclusions of any cross-sectional study require additional formulation in the light of existing methodological limitations, and therefore, we consider the carrying limit (number) of surveyed secondary school male students and their equal proportionality within the selected regions of Slovakia. Another limiting element was the use of a non-standardised survey, in which we did not manage to acquire feedback from the secondary school male students. Another limitation was certainly the lack of motivation and complete credibility of filling in the non-standardised survey by secondary school male students, since participation in the cross-sectional survey was voluntary and without any incentives. When being available online at all times (non-standardised survey), it certainly reduced the motivation of secondary school male students to participate in the cross-sectional study. An additional limitation of this cross-sectional study was the sample inhomogeneity related with the category of secondary schools (grammar and vocational schools) those students attended (full-time study) and which revealed significantly different requirements of theoretical and practical preparation of secondary school male students and was closely related with the amount of their leisure time. An additional limitation was connected with the evaluation of non-standardised survey results in terms of adolescent boys (secondary school male students) and without looking for intersex differences depending on selected regions of Slovakia, or such differences taking into account the category of secondary schools attended (grammar and vocational secondary schools). In terms of entire regions of Slovakia the complexity of this cross-sectional study was another limiting element, due to inability to acquire an adequate sample of secondary school male students from the Trnava Region, the Trenčín Region and the Nitra Region and with the regard to the global outbreak of the Covid-19 pandemic.

Conflict of Interest

The authors report no conflict of interest.

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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 ($ml \cdot kg^{-1} \cdot min^{-1}$)	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.

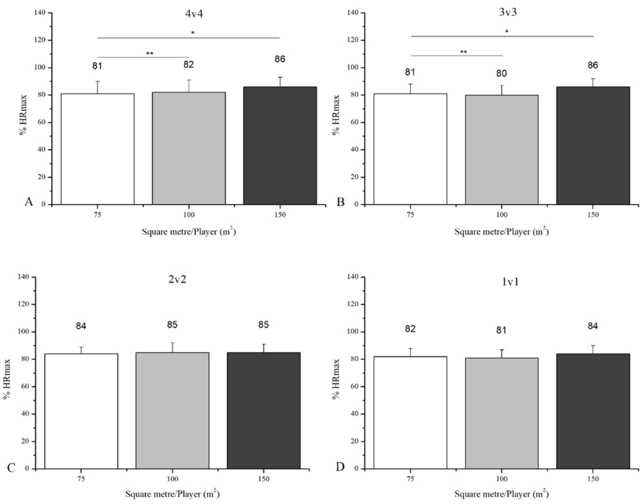
Table 2. Pitch sizes used for small-sided games

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 $p < 0.05$.

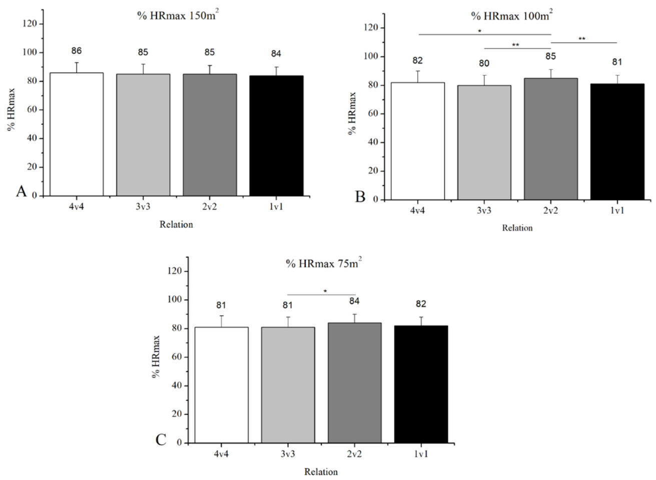
Results
Anthropometric characteristics and the results on fitness tests of the 16 participants are presented in Table 1.
The data analysis of SSGs 4v4 with different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player) revealed the following results, one of them being a difference in % 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

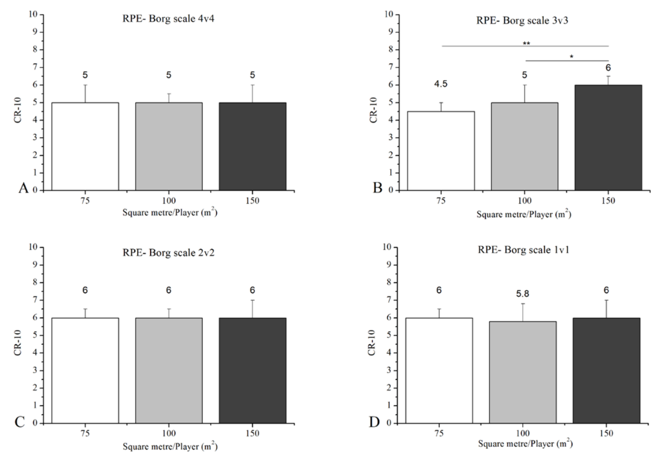
Regarding RPE in the course of the 4v4, 2v2, 1v1 formats with three different relative field sizes (150 m^2/player, 100 m^2/player, 75 m^2/player) there were no differences



* 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

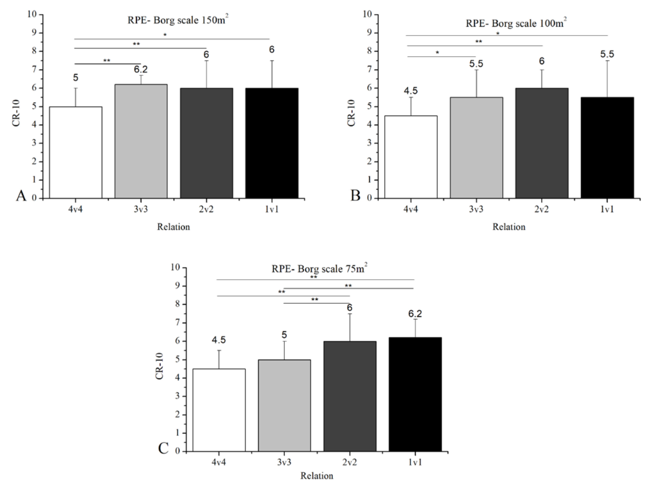
($x^2 = 0.311$, $p = 0.856$, $x^2 = 1.697$, $p = 0.428$, $x^2 = 4.667$, $p = 0.097$, respectively) (Figure 3). However, differences were found during the 3v3 format ($x^2 = 14.941$ $p = 0.001$), between the 150 m^2/player and 100 m^2/player ($Z = –2.072$, $p = 0.038$) and between 150 m^2/player and 75 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/s^2)	4v4	1 ± 0.8^{a,b,cc}	1 ± 0.5^{a,b,cc}	0.5 ± 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/s^2)	4v4	6 ± 1.7$^{*,\#,aa,bb,ccc}$	4 ± 2^{a,cc}	4 ± 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/s^2)	4v4	19.5 ± 2.5$^{**,\#,aaa,bbb,ccc}$	17.5 ± 2.4^{aaa,bbb,ccc}	17.6 ± 3.5^{aaa,bbb,ccc}
	3v3	13.1 ± 2.4^{bb,ccc}	12.7 ± 2.9^{ccc}	13.6 ± 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/s^2)	4v4	20.4 ± 2.9$^{**,\#,aaa,bbb,ccc}$	17.2 ± 3.1^{aaa,bbb,ccc}	17.8 ± 3.5^{aa,bbb,ccc}
	3v3	13.7 ± 2.9^{bbb,ccc}	13 ± 2.2^{bb,ccc}	13.9 ± 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/s^2)	4v4	5.4 ± 1.5^{aa,bb,ccc}	4.7 ± 1.4^{aa,b,ccc}	5 ± 1.2^{aa,bbb,ccc}
	3v3	3.2 ± 1	3.3 ± 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/s^2)	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 m^2/player ($p < 0.05$); ** denotes difference in row with 100 m^2/player ($p < 0.01$); *** denotes difference in row with 100 m^2/player ($p < 0.001$); $^{\#}$ denotes difference in row with 75 m^2/player ($p < 0.05$); $^{\#\#}$ denotes difference in row with 75 m^2/player ($p < 0.01$); $^{\#\#\#}$ denotes difference in row with 75 m^2/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 m^2/player, 100 m^2/player, 75 m^2/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/s^2) and Acc (3 to 5 m/s^2) 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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An evaluation of drill volumes in Division I women's lacrosse

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Abstract
Introduction. **Monitoring athletes using microtechnology allows for coaches to observe how athletes respond to the physiological demands of training.** Aim of Study. **The aim of this study was to determine differences in intensities and demand by training mode and position in women's collegiate lacrosse athletes.** Material and Methods. **Global positioning systems and heart rate monitors were worn by 27 athletes to gather training volume metrics, including: distance rate, maximum speed distance, high-intensity distance (HID), sprint efforts, accelerations, decelerations, and sprint distance. All data were organized into drill classifications: stickwork (SW), small-sided games (SSG), skill-specific drills (SSD), and simulated game play (SGP). All training metrics, except distance rate and maximum speed, were analyzed per minute spent in the drill to control for time. The drill database consisted of 99 days of training, which included three drills for SW, four drills for SSD, five drills for SSG, and five drills for SGP.** Results. **There was no difference in training workload by position (p = 0.414), but there was a difference in workload by drill type (p < 0.001), and an interaction between drill type and position (p = 0.031). For distance and accelerations, SSD was less than all other types of drills (p < 0.001 for all), and SSD had fewer decelerations than SSG (p = 0.011). SW drills registered less HID and fewer decelerations than all other types of drills (p < 0.001), and fewer sprint repetitions, accelerations, and less sprint distance than SSG (p = 0.001-0.011) and SGP (p = 0.001--0.013).** Conclusions. **Coaches can use this information to provide more specific training for each position and to manage the training volume of their athletes. Drill intensities can also be compared to game intensities to provide more specific training for games.**

KEYWORDS: team sports, athlete monitoring, training volume.

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Introduction

Managing athlete training volume, which is the amount of physical activity an individual performs, is becoming increasingly more common throughout the collegiate sports world. Athlete monitoring utilizes wearable technology, global positioning systems (GPS) and heart rate (HR) monitors alongside self-reporting measures to provide insight to how athlete respond to stress [1, 8, 10]. External load data is collected through GPS technology that tracks player movement patterns, helping the sports medicine and coaching world improve performance outcomes [8]. HR monitors along with self-reporting measures, such as rating of perceived exertion (RPE), are used to monitor internal load [1, 10]. Obtaining training data over the course of a season allows acute to chronic workload ratio, which shows activity levels of one week (acute) divided by previous weeks (chronic), for any one metric to be determined and can help to prevent any sudden changes in training volume [10]. Balancing the intensity of the demands put on athletes is vital for preventing exhaustion and reducing the risk of injury [10]. This new standard practice for maximizing player performance is a constant struggle, as coaches must balance the total training volume with an athlete's capabilities to reduce the risk of injury while also preventing detraining. Monitoring training intensity is also a critical component to the process of creating an individualized periodization focused training plan [10]. Having the ability to quantify training load for various exercises and drills using a single term would be very useful in overall ease of program understanding and administration. Understanding the intensity of each practice drill assists coaches and clinicians in making decisions towards managing the workload of athletes, ensuring safe and productive practice sessions.

Literature surrounding women's lacrosse has investigated the external load of games, evaluated positional differences in speed, sprint, and distance, assessed external load metrics and game performance, and classified drills according to their intensity [6, 7]. Previous literature also has shown weekly variations in training loads in collegiate athletes, with game scheduling heavily influencing training load [5]. This information has assisted coaches in developing in-game strategies as well as managing training volume that meet the position specific demands of games. Alphin et al. [1] classified 56 unique lacrosse practice drills into low, moderate, and high intensity for the team collectively, but there were variations in these classifications based on player position. These drills were classified based primarily on internal and speed variables. Similarly, load differences have been identified based upon different types of training, with large and small sided game drills resulting in the greatest percentage of workload followed by aerobic conditioning drills [8]. It was also discovered that tactical drills had higher intensity levels while technical skills required greater total distance [8]. This suggests that team focused drills (i.e., running set plays) produce greater intensity levels over drills that focus on important individual skills (i.e., footwork, passing). Alphin et al. [1] and Kupperman et al. [8] showed similar results suggesting that most high intensity drills were team-oriented; however, there was also more skill specific drills included in high intensity. Classifying various workloads helps teams to become the best versions of themselves during games and practices. In lacrosse, there is variation among different drills with many of the conditioning and team drills categorized as high intensity, small-sided games categorized as moderate intensity, and drills related to stick work and individual skills categorized as low intensity [1]. However, these categories were only conducted with two internal load variables – training impulse and average heart rate – and average speed. Knowing which drills are more demanding in external load for the team and each position is vital to create a successful training plan. This is significant for developing training plans distinct to the intensity and recovery needs of the team, as well as managing injury risk.

Aim of Study

This study aimed to compare the different drill classifications used in women's collegiate lacrosse by external load and position. These data may be used by coaches to understand the specific mechanical demand of a drill type on a position player and thereby provide insight into managing the training volume of the athlete.

Material and Methods

Study design and participants

The study was an observational study where 27 (10 attackers, 11 midfielders, 6 defenders) Division I collegiate female lacrosse players participated. Individuals on the university varsity lacrosse team were eligible to participate in the study. Participants were excluded if they removed themselves from the team, were not approved for play by a healthcare provider, or were ineligible by the National Collegiate Athletic Association. Dependent variables included: distance rate, maximum speed distance, high-intensity distance (HID), sprint efforts, accelerations, decelerations, and sprint distance obtained from the GPS units worn by the athletes. The independent variables were the type of drill completed and the athletes' position. This study was approved by the university Institutional Review Board and all participants completed an informed consent prior to study participation.

Evaluation

VX Sport vests, GPS devices, and heart rate monitors (Wellington, New Zealand) were assigned to each athlete. GPS devices were activated at the beginning of practices and attached to the vest in addition to the heart rate monitor. Participants carried out training as recommended by their coaches. GPS metrics and heart rate were recorded in each practice session with various drills. At the end of each session the devices were collected, turned off, and stored. Data was uploaded from the devices using the VX Sport training tool, and each session was trimmed to exclude inactive times. Sessions were further split into separate drills based on what was accomplished in each practice according to pre-training plans and confirmed with coaches following training. Furthermore, scrimmages were divided into two categories: warm--up and scrimmage with inactivity and halftime being excluded from the data. Each individual athlete's maximum sprint speed was determined during the first week of the training season through a 20 m fly-in followed by a 30 m maximum effort sprint. The test was completed three times with a 2-minute rest between each bout. The maximum speed recorded was used to determine thresholds for external load variables. Total distance, HID, sprint distance, sprint repetitions, accelerations, and decelerations were used as metrics during data collection. Total distance is the distance traveled (m) for the duration of the segment, regardless of speed. HID is the distance travelled at speeds >60% of maximum sprint speed. Sprint distance is the total distance travelled for all five speed zones, while sprint repetitions is the total number of sprints completed in each speed zone. Accelerations and decelerations were determined by a change in acceleration more than ±3 $m \cdot s^{-2}$. These metrics were selected to align with previous literature in lacrosse [2, 3, 6, 9].

Drills were classified into four specific types including: stickwork (SW), skill-specific drills (SSD), small-sided games (SSG), and simulated game play (SGP). SW drills mainly focused on the stick mechanics of passing, catching, cradling, and picking up ground balls to help players perform the simpler aspects of the game under pressure. SSD prioritized skills that not every position might need for example, draw controls, shooting mechanics, or clears. SSG drills consist of altered formats of play, such as adjusting the number of players or the rules, where coaches can focus on specific tactics. SGP drills assist players in practicing under the pressure of game situations and often tries to simulate the intensity of competitions. The drill database consisted of 99 days of training, which included three different drills for SW, four drills for SSD, five drills for SSG, and five drills for SGP. Variables were divided by the amount of time spent training in each drill to control for this variation.

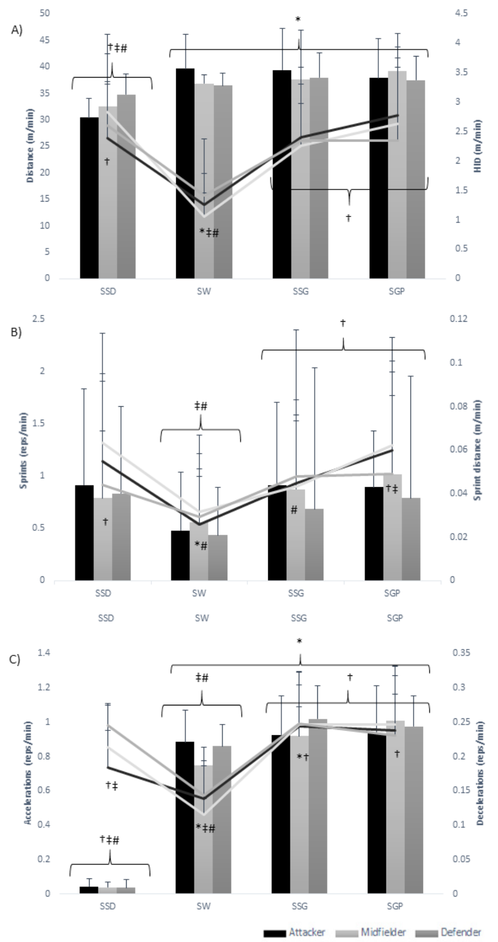
Statistical analysis

Data were organized by drill class and workload per minute of the drill were calculated. The mean of each metric per minute of play was calculated for each athlete for each drill type. Thus, an athlete's data consisted of several means, one for each drill type, for each training metric evaluated.

Data were determined to be normally distributed via a Shapiro–Wilks test. A 4 × 3 repeated measures analysis of variance (RM-ANOVA) was used to evaluate differences in training volume by type of drill (SW, SSD, SSG, SGP) and by position (attacker, midfielder, or defender). If there was a significant main effect, univariate analyses were used to determine differences between drill types for specific metrics, and an LSD post-hoc analysis was used to determine differences by position. Partial eta squared effect sizes (ES) were calculated to determine the magnitude of difference. ES were interpreted as small (0.01), moderate (0.06), and large (0.14) [4]. All analyses were conducted using SPSS, version 27 (Chicago, IL) and an alpha level of 0.05 was used to determine significance.

Results

The RM-ANOVA indicated that there was no difference in training workload by position (*Lambda*(14,36) = 1.071,



* represents a difference from SSD ($p < 0.05$), † represents a difference from SW ($p < 0.05$), ‡ represents a difference from SSG ($p < 0.05$), # represents a difference from SGP ($p < 0.05$)

Figure 1. Means and standard deviations by position for each drill type for A) distance represented in the bars and HID represented by the lines, B) sprint repetitions represented in the bars and sprint distance represented by lines, and C) accelerations represented in bars and decelerations represented by lines

$p = 0.414$, ES = 0.294, large). There was a difference by drill type (*Lambda*(28,325) = 100.454, $p < 0.001$, ES = = 0.870, large), and there was a main effect interaction between drill type and position (*Lambda*(56,490) = = 1.415, $p = 0.031$, ES = 0.109, moderate). By drill type, univariate tests showed differences in distance ($p < 0.001$, ES = 0.959, large), HID ($p < 0.001$, ES = 0.948, large), sprint repetitions ($p < 0.001$, ES = 0.852, large), sprint distance ($p < 0.001$, ES = 0.862, large), accelerations ($p < 0.001$, ES = 0.908, large), and decelerations ($p < 0.001$, ES = 0.752, large). Univariate analyses did not show a difference in any of the training metrics for the interaction between drill type and position [distance ($p = 0.129$, ES = 0.124, moderate), HID ($p = 0.909$, ES = 0.010, moderate), sprint repetitions ($p = 0.470$, ES = 0.064, moderate), sprint distance ($p = 0.556$, ES = 0.050, small), accelerations ($p = 0.438$, ES = 0.076, moderate), and decelerations ($p = 0.306$, ES = 0.093, moderate)].

Figure 1 A-C shows the comparisons for each training metric by drill type. For distance, SSD was less than all other types of drills ($p < 0.001$ for all). SW drills registered less HID than all other types of drills ($p < 0.001$). For sprint repetitions, SW was less than SSG ($p = 0.011$) and SGP ($p = 0.005$). For sprint distance, SW was less than SSD ($p = 0.001$) and SGP ($p < 0.001$). SSG was also less than SGP ($p = 0.009$). For accelerations, SSD was less than all other drills types ($p < 0.001$), SW was less than SSG and SGP ($p < 0.001$ and $p = 0.013$, respectively). For decelerations, SW was less than all other drills ($p < 0.001$) and SSD was less than SSG ($p = 0.011$).

Discussion

This study aimed to determine differences in workload by training mode and position in women's collegiate lacrosse athletes. Results indicated differences in training load by drill type as well as an interaction between drill type and position. Differences were found for all workload variables (distance, HID, sprint repetitions, sprint distance, accelerations, and decelerations) by drill type. There was no difference for any variable between drill type and position. Overall, SW was the drill mode with the lowest workload demand per minute, logging less HID, sprints repetitions, sprint distance, and decelerations than the other drills. SSD was the drill mode that logged the least amount of total distance.

This study compliments previous work by Alphin et al. [1] that classified various drills performed in training by a collegiate women's lacrosse team into low, moderate, and high intensity. SW presented with the lowest overall workload for athletes in this study with Alphin et al. [1] having similar findings as SW related drills were reported in the low intensity category. Bunn et al. [2] indicated that athletes' average HR was 77% of heart rate max during SW drills, likely due to the steadier state nature of these drills rather than high-intensity efforts. The nature of these drills often requires low intensity jogs or walking coupled with changes of direction at a moderate speed, which results in greater total distance and explains the higher number of accelerations (seen in Figure 1C) despite low HID and sprint distance. This contrasted with Kupperman et al. [8] that provided drill information in women's collegiate soccer, who found technical skills (similar to SW) showed the lowest overall distance. A likely explanation is differences in the two sports as technical skills in lacrosse (passing, cradling, etc.) includes being able to execute during movement, while technical skills in soccer (passing, crossing, heading) can be performed with less overall north/south and east/west movement across the field for each player. For the present study SSD showed the lowest total distance however, had comparative HID, sprint repetitions, and sprint distance to SGP. SSD provides the opportunity for athletes to progress through the stages of skill acquisition and include frequent repetitions to try and achieve autonomous skill mastery. These drills are often performed with a partner or on smaller scales trying to mimic the flow of gameplay while allowing for learning and retention, with the psychological aspect of trying to learn/improve skills possibly resulting in slower paced starts. This is a possible explanation as to why these drills were low in accelerations but performed at intensity levels comparative to SGP. These results agree with Alphin et al. [1] as most partner or goal-oriented drills were in the moderate and high intensity classifications.

Similar to Kupperman et al. [8], SSG was comparative to SGP (or large-sided games) for volume related metrics (total distance, sprint repetitions, accelerations, and decelerations) but presented lower for intensity related metrics (HID and sprint distance) which aligns with Alphin et al. [1]. SSG is a controlled combination of SGP and SSD drills that still allow for training in team tactics. For example, SSD may focus strictly on a defender receiving a clear pass from the goalie while SSG may have the goal of four defensive players clearing the ball into the offensive zone in less than ten seconds while facing pressure from four opposing players. This can result in high volume but slightly lower intensity as the team is trying to focus on the specific tactical issue at hand. For SGP, the greatest overall workload was seen as it was slightly higher than SSG for every variable except decelerations and comparative to SSD for HID. These results specifically were not surprising as SGP drills try to mimic almost every aspect of competitive gameplay allowing the team to apply what they have learned, on a skill based and tactile level, to game-like competition. Alphin et al. [1] reported drills focusing on transition, clears, and gameplay involving five or more players in the moderate and high-intensity categories, which aligns with the findings from this study regarding SGP. Similarly, Kupperman et al. [8] reported large-sided games with the greatest distance and distance/minute. Coaches often use SGP to help set an aerobic base while putting athletes under the pressure of game scenarios, and these findings are indicative of that.

When compared to external game demands of in-conference games (IC) and out-of-conference games (OC) in women's collegiate lacrosse, these findings reveal that drill demands are less than that of game play [9]. Total distance (IC 145.54 m/min PT; OC 100.78 m/min PT), HID (IC 10.85 m/min PT; OC 7.82 m/min PT) high-intensity sprints (IC 0.12 num/min PT; OC 0.09 num/min PT), accelerations (IC 4.41 num/min PT; OC 3.57 num/min PT), and decelerations (IC 1.01 num/min PT; OC 0.74 num/min PT) for games are all greater than the values for every drill type. Although this may not be true to every team, a possible explanation for this is significantly lower intra-squad competition on the team monitored compared to the competitive level of games. Lower intra-squad competition levels will result in slower paced drills, specifically SGP, that lack urgency in every play [9]. This could be caused by a large skill gap between key players and bench players with some athletes having the mindset that positions have already been taken, creating no need to show their capabilities in practice. Nevertheless, management of training volume could also play a role in these drills not matching the demands of game play.

This study was not without its limitations. One study limitation was that these data were collected from one team. Teams from other divisions or levels of play may have slight variations in how they run certain types of drills and the athletes may have varied levels in intensities and load that they are capable of. Due to the variety of these drills, this study did not include anaerobic conditioning drills in analysis. Although coaches often calculate the volume for these drills to maintain player fitness, intensity levels cannot be calculated accurately as players could potentially not give 100% of effort due to exhaustion. It is recommended for future research to consider including conditioning drills in analyses. Lastly, this study did not differentiate between starters and non-starters in the analysis, but evaluated general player drill load. Understanding the differences between these players in time spent in a drill and load of the drill would be beneficial in managing specific player workloads.

Conclusion

Drill classifications provide insight into the workload and efficiency of training that athletes are receiving. Greater drill intensities can challenge athletes to perform better, but may also increase the risk of injury when not properly managed. Drills of lesser intensities can help prepare athletes for an intense training session, but may also reduce the fitness and performance capabilities of an athlete when utilized too frequently. These data can help coaches formulate a well-balanced training regimen that can improve, challenge, and nourish a team to a successful competitive season. Continuously monitoring athletes across a season will be of great benefit when coupled with these findings as coaches can recognize when athletes need lighter or higher intensity practices to maintain fitness levels. Coaches can use these data to make more informed decisions for selecting drills based upon the type of training needed and the volume and intensity goals they have set for the practice or specific athletes. When lighter practices are needed, coaches may be more apt to choose drills from SW and SSD training modes and select options from SGP when higher intensity efforts are wanted.

Conflict of Interests

The authors declare no conflict of interest.

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UCP2	DD					ID					II				
Sex	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*	*N*	$\bar{x}$	*SD*	*Min*	*Max*
F	42	45.65	*6.14*	32.30	59.00	36	45.66	*7.18*	30.60	59.80	7	45.07	*7.60*	35.00	54.80
M	72	54.01[a]	*6.20*	40.30	79.00	70	55.60	*7.32*	42.30	76.80	12	59.07[a]	*9.04*	49.70	74.90

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