

REVIEW ARTICLE

GPS technology and game performance in football training: a systematic review

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Abstract

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This study was conducted to investigate small-sided games (SSG) played in football training using Global Positioning System (GPS) technology. The research involved scanning relevant scientific publications in English, containing titles and abstracts related to football and GPS technology, between January 1, 2017, and September 20, 2022, using Web of Science, Pubmed, and Scopus databases. The database review resulted in finding 310 articles. After excluding 103 duplicate articles, 114 more articles were excluded during the examination of abstracts. Upon the examination of all remaining 93 articles, 59 related to match performance, 6 review articles, and 4 articles written in a language other than English were excluded. Following this comprehensive review, 23 studies were included in the quantitative synthesis. The study revealed a diversity of physical, psychophysiological, technical-tactical, surface-related, gender-related, and player position-related aspects in small-sided game research in football. Based on this systematic review, it is suggested that physical, psychological, and technical-tactical factors can be integrated with positional data using parameters such as player movement speed, spatial movement, playing areas, and intra-team and inter-team synchronization pairs.

Introduction

Football is an intermittent sport consisting of low-intensity activities combined with high-intensity short-term activities (Bianchi et al., 2022). In a football match, players cover an average distance of 9-13.5 km, and 1-3 km of the total distance covered consists of high intensity actions (Mohr et al., 2005). Nowadays, it is a common practice in professional football to monitor players' activities both during matches and training (Buchheit et al., 2014). Quantifying the physical demands of training is an integral part of monitoring training load and players (Buchheit et al., 2014). Athlete tracking systems have become widespread in professional team sports. As a result, teams that want to gain an advantage invest in technologies that can validly and reliably measure time-motion analyzes of training and matches (Torres-Ronda et al., 2022). Advanced systems like Global Positioning System (GPS) technology can now rapidly record the physical and physiological data of all players throughout an entire match or training session (Ingebrigtsen et al., 2015). The key features of such systems include ease of use, efficient result reporting, remote usability, the ability to convert data into simple outcomes, compatibility with different sports, and providing both individual and group responses (Cardinale and Varley,

2017). Measuring player workload involves analyzing the activities a player performs during training and matches (Varley et al., 2012). Wearable devices, on the other hand, provide crucial information such as speed, acceleration, change of direction, and running patterns that can be used to measure the amount of stress applied to specific parts of a player's body (Waqar et al., 2021). GPS is utilized to objectively measure the level of physical stress on players, analyze match performances, assess workload specific to different player positions, determine training intensity, and monitor physiological changes in players (Cummins et al., 2013).

Monitoring players' time-motion profiles during training and competition aims to objectively assess external load demands, optimize load models, enhance performance, and prevent injuries (Buchheit & Simpson, 2017). Training load is explained through two different concepts: internal load and external load (Cummins et al., 2013). External load is defined as all external stimuli a player is exposed to during training or competition (total distance covered, lifted weight, number of sprints, etc.), while internal load refers to the physiological and psychological responses given by the player to the external stimuli (heart rate, lactate concentrations, perceived

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difficulty, etc.) (de Dios-Álvarez et al., 2021). This has been demonstrated in research utilizing Small-Sided Games (SSGs) in football (Torres-Ronda et al., 2022).

Known as Small-Sided Games (SSGs) in the literature, a training method involving high-intensity exercises can simultaneously improve both technical-tactical and physical aspects. GPS is used during these trainings to understand whether the goals are achieved. Studies have been conducted to understand how SSGs can affect internal and external loads (Sannicandro and Cofano, 2023; Arslan et al., 2017; Soylu et al., 2022). Data generated from GPS is used to measure matches, Small-Sided Games (SSGs), technical and tactical applications, team physical fitness routines, individual physical fitness, or training-related activities like rehabilitation (Hennessy et al., 2018). An example of its use is tracking the intensity of SSGs (e.g., through changes in rules, field size, and the number of players) to replicate match intensity (Lacome et al., 2018).

In this context, the existing literature has analyzed the effects of intervening in various variables on players' time-motion profiles during SSGs in football training (Coutinho et al., 2019; Ciocca et al., 2022). The aim of this study is to examine the use of GPS technology in football training and its impact on game performance.

Methods

This study represents a systematic review of articles from various peer-reviewed scientific journals aimed at examining game performance in football training using GPS technology.

Inclusion Criteria

The study included research employing GPS technology in football training. Inclusion criteria considered articles published in English between January 1, 2017, and September 20, 2022, with a focus on scientific peer-reviewed publications. The scope of the study encompassed sections of research that investigated game performance during training by utilizing GPS devices on football players.

Studies lacking a focus on game performance were excluded from the review.

Research Strategy

The research was conducted by systematically reviewing relevant scientific publications in the Web of Science, Pubmed, and Scopus databases between January 1, 2017, and September 20, 2022. The search used keywords such as 'gps,' 'football,' 'training performance,' 'game performance in training,' and 'running distance in football.' After the database examination, 310 articles were initially identified, but 103 duplicates were removed, leaving 207 articles. Subsequently, after reviewing abstracts, 114 articles were excluded, and a total of 93 articles were thoroughly examined. Finally, 24 studies were included in the quantitative synthesis (Figure 1). The inclusion criteria for the study were determined using the PICO approach, as shown in Table 1.

Results

The results regarding the games played using GPS technology in football training are presented.

Upon reviewing the studies, it is observed that various Small-Sided Games (SSG) involving different dimensions and player numbers, such as goalkeeping (Kunrath et al., 2020; Coutinho et al., 2019; Canton et al., 2021; Folgado et al., 2019; Folgado et al., 2018; Giménez et al., 2018a; Giménez et al., 2020; Alcantara et al., 2022), goalkeeper-less (Giménez et al., 2018b; Mohr et al., 2022; Randers et al., 2020; Aquino et al., 2019; Ciocca et al., 2022; Bujalance et al., 2022; Lopez-Fernandez et al., 2019; Papanikolaou et al., 2021; Nunes et al., 2021; Sangnier et al., 2019), goalkeeper and goalkeeper-less (Younesi et al., 2021; Clemente et al., 2019), goalkeeper and joker player (Lemes et al., 2020), goalkeeper-less and joker player (Lozano et al., 2020; Asian-Clemente et al., 2021), have been conducted to enhance game performance in football training.

Table 1
PICO Criteria.

	Criteria
Population	Football players
Intervention	Use of GPS in football training
Comparison	Examination of game performance in football training
Outcomes	Psychophysiological responses (heart rate, physical performance measures), cognitive performance (environmental perception test, perceived difficulty level, visual analog scale), Technical responses.

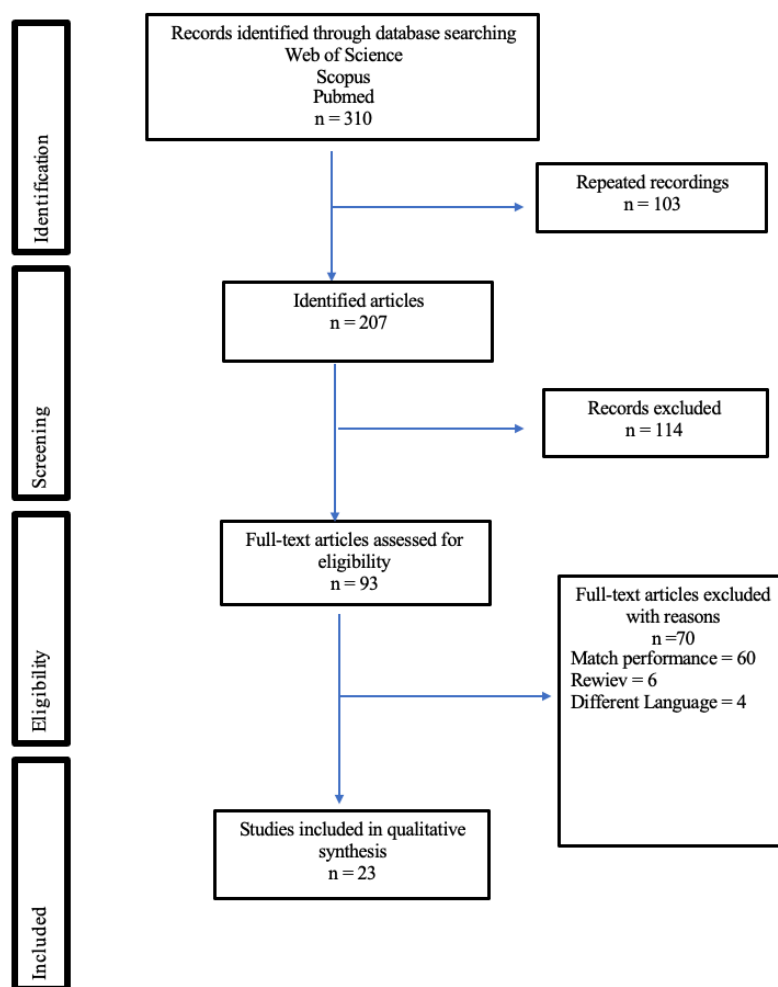


Figure 1. Study selection flowchart

Kinematic Responses

In the study by Lemes et al. (2020), it was observed that games played in a larger field size of 36x27m and 40x29m, involving goalkeeping and a joker player with a 3vs3 setup, resulted in covering a greater distance. However, two studies incorporating games without goalkeeping but with a joker player presented conflicting findings. The first of these studies analyzed 19 official matches alongside two different Small-Sided Game (SSG) applications: 5vs5+5+2 with a joker and 5vs5+1 with a joker. The 5vs5+1 with a joker game resulted in covering a greater total distance, distance covered at high speed, distance covered at very high speed, and a higher number of accelerations and decelerations compared to the 5vs5+5+2 with a joker game. Furthermore, when compared to official matches, both SSGs achieved higher results in the distance covered at high speed and the number of accelerations and decelerations (Asian-Clemente et al., 2021). On the contrary, Lozano et al. (2020) stated that in the Small-Sided Games (SSGs) played as 4vs4+2 with a joker and 8vs8+1 with a joker, the

use of a joker reduced the physical demands. In games played as 8vs8+1, the physical demands on regular players increased compared to the regular players in the 4vs4+2 game. Additionally, when Small-Sided Games (SSGs) and matches were compared, it was observed that the running distances at high and very high speeds were lower in SSGs. In the study by Gimenez et al. (2018b), where they conducted a 4vs4 game with single touch, two-touch, and free-touch conditions using mini-goals, it was noted that games played with a single touch had the highest exercise intensity but the highest value at walking speed. Games played with T2 and FT had more actions at low or moderate intensities and fewer actions at high intensities. Contrary to these findings, Younes et al. (2021) stated in their study, where they conducted games as 3vs3-4vs4-6vs6, that there was no significant effect of touch restrictions and the presence of a goalkeeper in any of the games. In their study, Gimenez et al. (2020) examined five different games, including CT (circular 1v1 ball possession training), SSG, LSG, MG (mini-goal game), and FM (Friendly Matches), and discussed which game might be more effective based

on the physical outputs of the football players. In games played on different surfaces and field sizes, it is observed that the total distance covered on grass fields is lower compared to other surfaces, and the smallest-sized games have the lowest values (Lopez-Fernandez et al., 2019). Additionally, it has been suggested that Small-Sided Games (SSGs) with areas of 115, 150, 225, and 280 m² are required for strength, endurance, power, and sprint development at different field sizes (Sangnier et al., 2019).

Kinematic and Cognitive Responses

Ciocca and colleagues (2022), who conducted Small-Sided Games (SSGs) with 5vs5 using GPS, demonstrated that the application of mental fatigue before SSGs did not impair performance in terms of physiological and technical aspects. However, Kunrath and colleagues (2020), in their study involving goalkeeping 3vs3 games, stated that players, following the Stroop task conducted before SSGs, exhibited less efficiency in performing actions related to tactical principles when they were mentally fatigued.

Kinematic and Technical-Tactical Responses

In addition to studies investigating the effects of mental fatigue on technical responses in game performance (Ciocca et al., 2022; Kunrath et al., 2020), there are studies that explore the effects of different tactical tasks (Coutinho et al., 2019). In goalkeeping 8vs8 games, midfield players not only presented higher total distances covered and effort index values but also, in the longitudinal displacements of the pairs formed by midfield players, it was observed that they were less synchronized compared to the pairs of defensive and offensive players (Folgado et al., 2018). Canton et al. (2021) mentioned that in goalkeeper-included 5vs5 games where the goals were placed opposite each other, to the right diagonals, and to the left diagonals, individual behaviors such as the distance covered were similar. However, they noted that in the scenario where the goals were placed diagonally, the width of the defense increased. Folgado et al. (2019) indicated that in games with goalkeeping played in two different areas, more distance, passes, and dribbling were observed in the 40x30m area. In contrast, in the 30x40m area, less distance was covered, but there were more shots, lateral passes, and a wider team position. Additionally, it was observed that there was a more consistent distance between the offensive and defensive players on the 40x30m field. In a similar study, it was observed that Small-Sided Games (SSGs) played on small-medium-large fields as 4vs3-4vs4-4vs5,

where a larger number of players were involved in larger play areas, promoted higher-intensity running, while the same area with fewer players encouraged tactical individual actions (Nunes et al., 2021). Furthermore, Alcantara et al. (2022) divided male young football players, comprising 53 individuals, into three groups based on their potential for the future: promising (PL), moderately promising (IL), and least promising (LPL). In goalkeeper-included 5vs5 Small-Sided Games (SSGs), they mentioned that there were no differences between groups in terms of anthropometric, maturation, and physical outcomes. However, they noted that PL (promising) players covered more distance in sprints and exhibited more offensive technical and tactical actions during SSGs compared to the LPL (least promising) group (Alcantara et al., 2022).

Kinematic and Psychophysiological Responses

In football Small-Sided Games (SSGs), parameters such as field size, number of players, duration of the game, rule changes, and the inclusion of goalkeepers can be manipulated to alter the game. The results of Small-Sided Games (SSGs) can vary with different game manipulations. For example, games played as goalkeeper-included and with a joker, in 3vs3 format, on fields of 36x27m and 40x29m resulted in covering more distance on the larger field. However, other variables (both physical and physiological) did not differ between field sizes (Lemes et al., 2020). In 5vs5 Small-Sided Games (SSGs) with formats of 6x3'/2' (6 sets/3 minutes/2 minutes rest) and 3x6'/2' (3 sets/6 minutes/2 minutes rest), there was no difference in heart rate and sprint distance. However, the 3x6' program was found to be more intense in terms of Ratings of Perceived Exertion (RPE) compared to the 6x3' program. In terms of running distance and total distance covered, the 6x3' program was higher than the other (Clemente et al., 2019). Gimenez et al. (2018a), in their study analyzing goalkeeper-included 4vs4 Small-Sided Games (SSG), goalkeeper-included 8vs8 Large-Sided Games (LSG), and the first 32 minutes of a friendly match, found that despite SSG and LSG having higher Ratings of Perceived Exertion (RPE) compared to the friendly match, there were significant differences in movement patterns. These differences included less running distance, lower running speed, lower work-to-rest ratio, more walking distance, and more decelerations and accelerations in SSG and LSG compared to the friendly match.

Table 2. A detailed overview of the works.

Study	Participants	Study design	Intervention Protocol	Measure	Results
Ciocca et al., 2022	Male football player n=10 (age:17.2±0.9)	Participants were randomly divided into two groups according to their playing positions. 1) VT 2) Control While one group performed the VT task on the first session day and the C task on the second session day, the other group did the opposite. The games were played as 5vs5, 2x7'/2' (2 sets/7 minutes game/2 minutes rest) on a 26x36m field.	In the VT condition, participants had to watch a video clip with the game situation on the screen and say the best tactical solution for the continuation of the game. The test consisted of 60 questions, 30 defensive and 30 offensive. Condition C consisted of watching a specially selected documentary of the same duration as the VT condition.	-TD -WD (0-7 km/h) -LSD (7-14 km/h) -HSD (14-20 km/h) -VHSD (>20 km/h) -TAcc and TDec -Technical Performances	Among all test parameters, there is a significant difference in favor of the VT condition compared to the Control condition, only in the technical performances of the total pass and successful pass parameters. Overall, it has been shown that a 30-minute video-based tactical task does not cause mental fatigue in a football SSG and does not impair subsequent physical and technical performance.
Coutinho et al., 2019	Young male football player n=12 (age:15.9±0.8)	The games were played on a 62x43m artificial grass field as Gk+6vs6+Gk and 3x6'/3'.	The study was conducted with a repeated measures approach under two experimental conditions. 1) A control condition played without dividing the field (CONTROL condition) 2) An experimental condition played by dividing the field into three lanes and three sectors (LINES condition).	-TD -VLSD (0-6.9 km/h) -LSD (7-9.9 km/h) -MSD (10-15.9 km/h) -HSD (>16 km/h) -Average displacement speeds of players -Location data	Creating reference lines by dividing the field resulted in a reduction in team synchronization levels and distances traveled at both average speed and different speeds. Players achieved increased movement synchronization, higher total distance at low and medium speeds, and average speed without reference lines.
Kunrath et al., 2020	Amateur male football player n=18 (age: 21.8±02.5)	The games were played in the form of Gk+3vs3+Gk in a 36x27m area for 12 minutes without interruption.	On the first day, participants were given information about the study and tests. On day 2, called the control condition, all participants watched a 30-minute video documentary about social networking sites and the history of a technology company. Then they played SSG. On day 3, referred to as the "MF" condition, all participants performed the Stroop task and played the SSG immediately afterwards.	TD(m) SD (< 0.7 km/h-1) WD (0.8 to 7.1 km/h-1) JD (7.2 to 14.3 km/h-1) RD (14.4 to 19.7 km/h-1) HSD (19.8 to 25.1 km/h-1) Sprinting (> 25.1 km/h-1) Maximal speed (km/h) Average speed (km/h)- Stroop -VAS -PP -FUT-SAT	In the MF condition, players' environmental perception was reduced, forcing them to perform penetration, depth mobility, and defensive unit actions more frequently, and less frequently to perform defensive coverage and balance actions. When players were mentally fatigued, they were less efficient while performing actions related to tactical principles. Players covered longer distances at moderate speed in the MF condition.

Table 2. A detailed overview of the works (Continued).

Study	Participants	Study design	Intervention Protocol	Measure	Results
Canton et al., 2021	Male football player n=24 (age: 11.3±0.8)	Participants are divided into 4 separate teams according to the coach's criteria. The games were played in 31x37m area as Gk+5vs5+Gk and 6x5'/3'.	Each team played SSG six times in three different scenarios; 1) CTR 2) RGT 3) LFT	-TD -WD (0-3.5 km/h) -JD (3.6-14.3 km/h) -RD (14.4-19.8 km/h) -CV -Length/width in attack and defense	It was observed that the teams' TD levels were similar, but they performed differently in terms of team behavior. It showed that in the RGT and LFT scenarios, teams were wider in the defensive phase than in the attack, and width in the defensive phase had large effects in both crossover scenarios.
Folgado et al., 2019	Young male football player n=20 (age: 6.4 ± 1.8)	Players are divided into four balanced teams of 4 field players and 1 goalkeeper according to the coaches' perception. Each team played SSG 18 times in total, with SSGs as 3x6'/3'.	The players participated in Gk+4vs4+Gk SSG a total of 18 times, including (1) 40x30m and (2) 30x40m, in two different field conditions during six training sessions. Each team participated in SSG with the same pitch characteristics three times per training session.	-TD -WD (0-7.1 km/h) -JD (7.2-14.3 km/h) -RD (14.4-19.7 km/h) -HSD (>19.8 km/h) - Technical-tactical performance	It was observed that the players exhibited more distance, more passing and dribbling at higher intensities in the 40x30m area, and were more synchronized in the longitudinal axis. It has been observed that on the 30x40m field, there is less distance, more shots, more lateral passes and a wider team position. It has been observed that there is a more constant distance between the attacker and defender on the 40x30m field.
Asian-Clemente et al., 2021	Young professional football player n=17 (age: 18.7±0.5)	Two SSG designs were applied in the study. SSG _{NC} was played as 5vs5+5+2 joker players in a 35x35m field. SSG _{CA} was played as 5vs5+1 joker/5vs5+1 joker on a 28.5x57m field.	SSG _{NC} is a game format with 5 defenders and 10 attackers +2 joker players without changing the field, while SSG _{CA} is in the game format with 5vs5+1 joker players in 2 fields of 28.5m. When the attacking team makes 7 passes or the defensive team saves the ball, they throw the ball to the other field and send the opponent to the other field. SSGs were played in 4x4' format with 2 touches. In addition, data from nineteen official matches were collected in the study.	-TD -HSD -VHSD -TAcc and TDec	SSG _{CA} performed more TD, HSD, VHSD, and more TAcc and TDec than SSG _{NC} . Both SSGs showed higher HSD, TAcc and TDec compared to official matches.
Giménez et al., 2018a	Professional male football player n=14 (age: 23.2±2.7)	SSG was played as Gk+4vs4+Gk in a 30x30m area, and LSG was played as Gk+8vs8+Gk in a 42.4x42.4m area. Games were played in 8x4'/2' format. Additionally, the first 32 minutes of a friendly match were watched.	All SSGs were played one week apart. All SSGs were conducted outdoors on an artificial grass field with regular targets. Participants were encouraged to work competitively and score the highest number of goals during each game. Goalkeepers' only duty was limited to saving goals. Immediately after each game, participants individually rated their perception of effort using a visual analog scale from 1 to 10.	-TD -WD (≤2.2 m/s) -JD (>2.2≤3.3 m/s) -LSD (>3.3≤4.2 m/s) -MSD (>4.2≤5.0 m/s) -HSD (>5.0≤6.9 m/s) -SSD (>6.9 m/s) -TAcc and TDec -RPE	A significant difference was observed in the movement patterns of SSG and LSG, such as more RPE, less TD at various speeds, lower running speed, more walking distance, more TAcc and TDec, compared to the friendly match. SSG resulted in less RPE across different movement patterns compared to LSG. However, one of the key results was that during the Friendly match, TD was significantly larger compared to both SSG and LSG. Higher TAcc and TDec and RPE produced during SSG were defined as SSG>LSG>FM.

Table 2. A detailed overview of the works (Continued).

Study	Participants	Study design	Intervention Protocol	Measure	Results
Randers et al., 2020	Recreational active young men n=11 (age:28.4±4.2)	Participants are in a 20x13m area 1)WB 2)WOB Two different games were played as 3vs3.	SSGs were applied twice in two different ways, with and without wood around the areas, for a total of 4 times. One session of the game was played in 4x12'/4' format.	-TD -LSD (0-2/2-5/5-9 km/h) -MSD (9-13 km/h) -HSD (13-16/16-20/>20 km/h) -TAcc -HR -BLa -RPE	Although TD, MSD and HSD, and maximum speed data were higher in the WOB condition, average heart rate, blood lactate, player load, TAcc and RPE were observed to be higher in the WB condition.
Lozano et al., 2020	Young male football player n=26 (age:15.7±0.3)	There are two different designs in the study. 1) To analyze the physical demands of football players in the joker player's role in different SSG formats (4vs4+2 and 8vs8+1). 2) To analyze differences in physical demands faced by regular and joker players between SSG formats and official matches.	The physical demands faced by SSG 4vs4+2 joker and LSG 8vs8+1 joker football players were recorded and normal and wild card players were distinguished. Games were played in 2x6'/3'. During the match, data was collected only from players who completed the entire match (80 minutes).	-TD (min) -LSD (<14.4 km/h) -HSD (>14.4 km/h) -VHSD(>21 km/h) -TAcc and TDec -Vpeak	It shows that the use of jokers reduces the physical demands compared to the demands faced by regular players in the 4vs4+2 SSG and 8vs8+1 LSG formats. Normal players in 8vs8+1 LSG have increased physical demands compared to regular players in 4vs4+2 SSG. It was observed that SSG and LSGs were lower in HSD and VHSD compared to the match play order.
Nunes et al., 2021	Semi-professional male football player n=20 (age:22.3±2.0)	Participants performed in a series of 4vX (4v3, 4vs4 and 4vs5) SSGs aiming to gain possession of the ball on different playing field sizes. Small playground (S: 20x15m), medium playground (M: 25x20m) and large playground (L: 30x25m) were held on artificial grass field.	In opponent-based protocols, variables were analyzed by fixing the same four players and comparing them with (4vs3), (4vs4) and (4vs5) players. SSGs (day 1 M; day 2 S and day 3 L) were played in 4x4'/4' format.	-WD (≤9 km/h) -RD (9-18 km/h) -SSD (>18 km/h) -Sprint sayısı -Vpeak - Number of passes with dominant and non-dominant foot - Maximum passing speed	Larger playing areas with a larger number of players encouraged higher intensity running, while the same area with a smaller number of players encouraged tactical individual actions. Smaller fields have allowed for lowering the pace of play, especially in formats with fewer players.
Lemes et al., 2020	Young male football player n=48 (U13-U14)	SSGs were played in two different areas: 36x27m (normal) and 40x29 m (large). The teams were played as 4x4'/4', with Gk+3vs3+Gk+1 as the joker players.	To form the teams, they were first played in a narrow field once and according to the technical answers, all team players were divided into 4 different teams: 1 defender, 1 midfielder and 1 forward player. Additionally, 1 joker player is given per match.	-TD (0-6,9/ 6,9-14,3/ 14,3-21,4 km/h) -HR	Total distance at the highest intensity was higher in the larger field. Other variables (both physical and physiological) did not differ between field sizes.

Table 2. A detailed overview of the works (Continued).

Study	Participants	Study design	Intervention Protocol	Measure	Results
Giménez et al, 2018b	Professional male football player n=14 (age: 23.2±2.7)	The games were played in 3x4'/3' format, 4vs4 on a 30x24m area. These games were repeated on 3 different days for a total of 9 games (36 minutes).	The games were played with 4 miniature goals as one touch [T1] on the first day, two touches [T2] on the second day and free touches [FT] on the third day.	-TD -WD and time (>1.67 m/s, ≤ 2.22 m/s) -JD and time (>2.22 m/s, ≤ 3.33 m/s) -LSD and time (>3.33 m/s, ≤ 4.17 m/s) -MSD and time (>4.17 m/s, ≤ 5 m/s) -HSD and time (>5 m/s, ≤ 6.94 m/s) -TAcc and TDec	In SSGs played with T1, players were observed to perform the highest exercise intensity and walks. SSGs played with T2 or FT have been shown to spend less action at high intensities and more time at low or medium intensities.
Clemente et al., 2019	Amateur male football player n=10 (age: 19.8±1.6)	Participants played 2 different 5vs5. 1) 6x3'/2' 2) 3x6'/2'	5vs5 games were played in a 30x30m area with and without a small goal. On the first day, the 6x3'/2' format was implemented, followed two days later by the 3x6'/2' format. The second week, the opposite was done. Borg's CR-10 scale was used immediately after each set.	-TD -RD (14-19.9 km/h) -SD (>20 km/h) -HR -RPE	No differences were found in HR and SD. It has been demonstrated that the 3x6' format is significantly more intense in terms of RPE than the 6x3' format. Shorter sets of the 6x3' format were found to be significantly higher in TD and RD.
Mohr et al., 2022	Male and Female football player n=213 (U9 men's team, U11 women's team, U14 men's team, competitive young men's team (YM) and recreational women's team (RF))	Participants were exposed to game performance in 3 different training sessions; 1) CMT 2) SSG 3) SMP	CMT consisted of technical drills such as passing and dribbling, where players were instructed to maintain a minimum distance of 2m and the field size was adjusted accordingly. SSG consists of 10 minutes of legal and goalless possession drills, followed by 10 minutes of 3vs3-5vs5, depending on the total number of participants, and the field size is set at 32 m ² per player. SMP consisted of a 20-minute football match with Normal rules. Field size is arranged according to age groups.	-TD -HIR (children: 12-16 km/h; for women playing fun: 13-16 km/h; for young men: 13-20 km/h) -SD (children and women playing fun>16 km/h; young men: >20 km/h) -TAcc -HR	CMT revealed lower exercise intensity and physiological load compared to SSG and SMP. A greater TD and HIR was seen during SMP compared to CMT. While all groups performed 2-4 times more HIR during SMP compared to SSG, a higher SD was observed in SMP than in CMT and SSG. Compared to CMT and SSG during SMP, 8–11% higher HRs were observed in U9, YM, and RF than in CMT, whereas higher HRs were seen only in YM and RF (6 and 10%, respectively).
Aquino et al., 2019	Young male football player n=51 U11 (n = 16) U13 (n = 10) U15 (n = 9) U17 (n = 8) U20 (n = 8)	This study applied three different formats. (1) Comparing external and internal load by age group during 6vs6-SSG (2) Relating these parameters between 6vs6-SSG and official matches (3) Testing the reliability of 6vs6-SSG.	Experiment A: 51 players aged 11 to 20 were sent to 6vs6-SSGs (n=10). Experiment B: thirty-two players were randomly selected to also play official matches (n=6 matches). Experiment C: Thirty-five young players played the SSG twice for test-retest reliability analysis. 6vs6 games were played in 6x6'/1.5' format in a 49x25m area, including goalkeepers.	-TD -HIR -TAcc and TDec -HR (HR _{mean})	Experiment A: Gradual increases were observed in all parameters according to categories during the 6vs6-SSGs protocol in age groups (U11<U13<U15<U17<U20). Experiment B: All values except HR _{mean} increased gradually with age. HR _{mean} was highest in the U17 group. Experiment C: In general, the reliability of 6vs6-SSG is high.

Table 2. A detailed overview of the works (Continued).

Study	Participants	Study design	Intervention Protocol	Measure	Results
Alcântara et al., 2022	Young male football player n=53 (age: 14.8±0.2)	Participants were assigned to one of three levels by 3 different coaches for short and long term success rankings; (1) Promising (PL;n=15) (2) moderately promising (IL; n=23) (3) Least promising (LPL; n=15).	PL players played exclusively against their LPL teammates during two SSGs held in the same session, interspersed with 15 minutes of rest. SSG for short-term ranking was played before SSG for long-term ranking. SSGs was played in 2x10'5' format as Gk+5vs5+Gk on a 48x21m field.	-TD -LSD (0-11 km/h) -MSD (11-14 km/h) -HSD (14.1-19 km/h) -SD (>19.1 km/h) -HIR (≥14.1 km/h) -RPE -Antropometrik -PHV -Sprint (10-30m) -RSA -SLJ -Football specific skill tests -Technical and tactical actions	There were no differences between the groups in terms of anthropometric, maturation and physical results, but PL players in both rankings covered more distance in the sprint and displayed more offensive technical and tactical actions than their LPL peers during SSG. PL and IL received more minutes than the LPL short-term rankings played in competitive seasons.
VT: Video-based tactical; TD:Total Distance; SSD: Sprint Speed Distance; WD: Walking Distance; LSD: Low Speed Distance; HSD:High Speed Distance; VHSD: Very High Speed Distance; TAcc: Total Accelerations; TDec: Total Decelerations; VLSD: Very Low Speed Distance; MSD: Moderate Speed Distance; VAS: Visual Analogue Scale; PP: Peripheral perception; FUT-SAT: The System of Tactical Assessment in Soccer; CTR: Goals placed directly opposite each other; RGT: goals placed in the right-hand corner of the offensive half-pitch; LFT: goals placed in the left-hand corner of the offensive half-pitch; CV: Game Pace; JD: Jogging Distance; RD: Running Distance; RPE: Rating of perceived exertion; HR: Heart Rate; HR _{mean} : Mean Heart Rate; SmO ₂ : Muscle oxygen saturation; THb: total muscle haemoglobin; PP-SSG: the possession play rule; MG-SSG: the mini-goals rule; WB: With Boards; WOB: Without Boards; Vpeak: Peak velocity; AS _i : Average duration of sprints; AS _d : Average distance of sprints; D-MP: Metabolic Power Distance; SD: Sprint Distance; BLA: Blood Lactate; HIR: High-intensity running; PHV: Biological maturation; RSA: Repeated-Sprint Ability; SLJ: Standing Long Jump; CMT: COVID-19-modified training; SMP: Simulated match-play; SSG: Small-Sided Games; LSD: Large-Sided Games; CT: Circuit Training; MG: Mini Goal Games; MF: Mental Fatigue; CMJ: Countermovement jump; Gk: Goalkeeper					

Bujalance-Moreno et al. (2022) conducted Small-Sided Game (SSG) sessions played in different formats. In the first format, where mini-goals were included in the game, there was no difference in internal load compared to possession games. However, in terms of external load, it led to lower values in time-motion characteristics. In another study where the perimeter of the playing area was covered with boards, Randers et al. (2020) found that in games played without boards, non-board games resulted in higher values for total distance, distance at moderate and high speeds, number of intense runs, average length of each run, and maximum speed. However, in board conditions, the average heart rate, blood lactate, player load, Total Acceleration (TAcc), and Rating of Perceived Exertion (RPE) were higher. Papanikolaou et al. (2021) conducted a study measuring fatigue in which they observed that Delayed Onset Muscle Soreness (DOMS) and Creatine Kinase values increased for 72 hours in 4vs4 games and for 24 hours in 8vs8 games. They also noted that power and sprint values decreased for 48 hours in 4vs4 games and for 72 hours in 8vs8 games. Jump values decreased for 24 hours in 4vs4 games and for 48 hours in 8vs8 games. Additionally, they reported that neuromuscular fatigue increased for 2 hours in 4vs4 games and for 3 hours in 8vs8 games.

In studies examining different age groups, the internal and external loads of 51 players aged between 11 and 20 years were compared based on age groups in 6vs6 games. As a result, it was noted that the average heart rate (KAH) was highest in the U17 group, with other values showing a gradual increase according to age groups (Aquino et al., 2019). In three different training sessions conducted by female and male football players from different age groups, the game performances were examined. It was noted that the COVID-19 modified training (CMT), consisting of 3vs3 and 5vs5 Small-Sided Games (SSG) and simulated match play (SMP) with normal rules, resulted in lower exercise intensity and physiological load compared to SMP. In all age groups, during simulated match play (SMP), 2-4 times more high-intensity running was observed compared to Small-Sided Games (SSG), and a higher sprint distance was observed both in COVID-19 modified training (CMT) and SSG compared to SMP (Mohr et al., 2022).

Discussion

The widespread adoption of player monitoring methods plays a crucial role in training planning. Therefore, analyzing the use of GPS in small-sided games frequently employed in soccer training is essential to understand game performance. Examining which parameters are preferred in

these practices helps in comprehending game performance. However, there is limited research aimed at measuring and assessing training loads systematically, providing a foundational knowledge base for individuals entering or already working in this field. The purpose of the current systematic review is to examine the GPS technology used in soccer training and investigate the kinematic, cognitive, technical-tactical, and psychophysiological responses in various small-sided games.

Kinematic Responses

The total distance covered is one of the most commonly used external load measurements for evaluating the workload undertaken by players in training and matches. Considering the results of this study, it has been identified as a parameter most frequently evaluated by researchers in a similar fashion. Total distance covered, high-speed running distance, acceleration, deceleration, and sprint distance are common external load metrics used by sports scientists in locomotor activities (Miguel et al., 2021). However, a meta-analysis study conducted by McLaren et al. (2018) reveals that total distance covered has the strongest correlations with internal load and intensity indicators. These data indicate a strong association between the internal responses to training and match play and the total amount of completed running, more so than numerous other external load measurements typically monitored in team sport athletes.

Eight of the studies included in this review have just focused on kinematic responses. Lemes et al. (2020) observed that games played in different field dimensions, such as goalkeeper-included and joker player 3vs3, resulted in greater distances covered in larger fields. Two studies involving games without goalkeepers but with joker player presented conflicting findings (Asian-Clemente et al., 2021; Lozano et al., 2020). Studies involving touch manipulation have yielded contradictory results regarding exercise intensity, but these studies differ in terms of the number of players involved (Gimenez et al., 2018b; Younes et al., 2021).

In games played on different surfaces and field dimensions, it has been observed that the total distance covered is lower on grass fields compared to other surfaces, and games played on the smallest field size have the lowest values compared to other games (Lopez-Fernandez et al., 2019). Additionally, it has been suggested that Small-Sided Games (SSGs) with areas of 115, 150, 225, and 280 m² are needed for strength, endurance, power, and sprint development, respectively, in various field dimensions (Sangnier et al., 2019). When comparing game performance to official matches, it has been observed that

Small-Sided Games (SSGs) result in higher speeds, acceleration, and deceleration distances. However, another study found that running distances in SSGs were lower when compared to official matches (Asian-Clemente et al., 2021; Lozano et al., 2020). In their study examining five different games, Gimenez et al. (2020) discussed which game might be more effective based on players' physical outputs. According to the research findings, different game designs lead to diversity in kinematic responses in studies.

Kinematic and Cognitive Responses

Mental fatigue is defined as a psychobiological state that can arise during or after prolonged cognitive activities, characterized by tiredness, decreased alertness, and increased unwillingness to persist in the ongoing activity (Boksem & Tops, 2008). When examining the impact of mental fatigue on game performance, in one study, it was found that mental fatigue applied before 5vs5 Small-Sided Games (SSGs) did not impair physiological and technical performance (Ciocca et al., 2022), in another study, it was reported that there was a decrease in cognitive processes such as environmental perception during goalkeeper-included 3vs3 Small-Sided Games (SSGs), and players performed tactical actions with less efficiency (Kunrath et al., 2020). Mental fatigue leads to an increase in sympathetic activity and a decrease in parasympathetic activity (Filipas et al., 2019). Therefore, some physiological changes occur and as a result, fatigue occurs (Coutts, 2016). Fatigue, on the other hand, decreases the work production performance in the central nervous system as a result of the decrease in muscle activation, reducing the players' desire to exert effort (Enoka and Duchateau, 2016). Literature review reveals that studies examining the impact of mental fatigue on cognitive responses in small-sided games have shown that mental fatigue affects cognitive responses and increases mental effort (Soylu and Arslan, 2021; Soylu et al., 2021). According to the study's results, Small-Sided Games (SSGs), which are used as time-efficient, effective, and enjoyable training strategies to mitigate the negative effects of mental fatigue, can be preferred in training programs.

Kinematic and Technical-Tactical Responses

Team sports like soccer are open dynamic environments where players need to adjust their individual actions based on the constantly emerging spatial-temporal relationships with teammates and opponents (Coito et al., 2022). Technical-tactical performance in small-sided games has been a frequently researched topic. For instance, previous research has emphasized the analysis of the effects on players' physical and technical actions when manipulating fundamental task constraints in Small-Sided Games (SSGs), such as altering the dimensions of the playing area, the

number of involved players, the type and number of goals, or the allowed touches while in possession of the ball (Clemente et al., 2020; Sarmiento et al., 2018). There are various parameters that affect technical-tactical performance. For example, in addition to studies investigating the effects of mental fatigue on technical responses (Ciocca et al., 2022; Kunrath et al., 2020), there are studies including the effects of different tactical tasks (Coutinho et al., 2019). In the 8vs8 game with a goalkeeper, midfielders not only offer higher total distance traveled and effort index values, but also the duos formed by midfielders are less synchronized in their longitudinal displacements than the duos of defenders and attackers (Folgado et al., 2018). Additionally, various studies have revealed how technical-tactical performance is influenced in small-sided games through the use of diverse manipulations. Canton et al. (2021) noted that in goalkeeper-included 5vs5 games where goals were placed diagonally, individual behaviors such as the distance covered were similar, but the defensive width increased in scenarios where the goals were positioned diagonally. Nunes et al. (2021) found that in Small-Sided Games (SSGs) played in different field dimensions and with varying numbers of players, larger game areas with more players encourage high-intensity running, while reducing the number of players enhances tactical individual actions. Similarly, they indicated that games played with goalkeepers in different field areas affect technical performance (Folgado et al., 2019). Additionally, Alcantara et al. (2022) categorized male youth soccer players into three groups based on their future prospects: promising players (PL), moderately promising players (IL), and least promising players (LPL). They noted that PL players exhibited more offensive technical and tactical actions compared to the LPL group. According to the study's results, there has been an increasing interest in using positional data to understand the effects of Small-Sided Game (SSG) manipulations on the technical-tactical behaviors of players and teams, as well as examining the coordinated actions of players with and without the ball.

Kinematic and Psychophysiological Responses

Technological advancements have increased research on dose-response relationships between load, fatigue, and training prescription to better understand various internal and external training load measurements (e.g., total distance covered, high-speed running, and player load) (Salter et al., 2021). Therefore, measuring training workload using various biological, hormonal, and psychological stress markers is recommended as a necessary research area (Filaire et al., 2003). Internal training load refers to the measurement of responses that occur as a result of the

impact of physical training elements, including exercise type, intensity, duration, and frequency. These responses can be measured with markers such as the Rating of Perceived Exertion (RPE), mood states, salivary testosterone (T) levels, cortisol concentrations (C), blood creatine kinase concentration (CK), and heart rate (Lazarim et al., 2009; Maya et al., 2016). For example, cardiac autonomic nervous system activity, indirectly assessed through heart rate variability, serves as a tool not only for measuring physiological adaptations but also for monitoring training load and fatigue (Botelho et al., 2022). In a study measuring fatigue, it was found that in Small-Sided Games (SSGs), Delayed Onset Muscle Soreness (DOMS) and Creatine Kinase (CK) values varied according to the number of players (Papanikolaou et al., 2021). Additionally, in 5vs5 SSGs structured as 6x3'/2' (6 sets/3 minutes/2 minutes rest) and 3x6'/2' (3 sets/6 minutes/2 minutes rest), no difference was observed in heart rate (KAH) and sprint distance. However, the 3x6' program was found to be more intense in terms of Rating of Perceived Exertion (RPE) compared to the 6x3' program. In terms of running distance and total distance covered, the 6x3' program was higher than the other (Clemente et al., 2019).

In soccer Small-Sided Games (SSGs), the game can be manipulated by altering parameters such as field size, number of players, game duration, rule changes, and the inclusion of goalkeepers. Results from Small-Sided Games (SSGs) implemented with different game manipulations show diversity. For instance, games played as goalkeeper-included and wildcard 3vs3 on fields of 36x27m and 40x29m resulted in greater distances covered on the larger field, while other variables (both physical and physiological) did not show differences between field sizes (Lemes et al., 2020). Different studies on Small-Sided Games (SSGs) played in various formats have shown varied results. For example, in a study by Bujalance-Moreno et al. (2022), there was no difference in internal load when comparing possession games played with mini goals to other game formats. In another study where the perimeter of the playing area was covered with boards, it was observed that, despite providing higher results in total distance, distance covered in medium and high-speed running, the number of intense runs, average length of each run, and maximum speed in games played without boards, average heart rate, blood lactate, player load, Total Acceleration (TAcc), and Rating of Perceived Exertion (RPE) were higher in the board condition (Randers et al., 2020). Gimenez et al. (2018a) analyzed goalkeeper-included 4vs4 Small-Sided Games (SSG), goalkeeper-included 8vs8 Large-Sided Games (LSG), and the first 32 minutes of a preparation match. In their study, they found

that although SSG and LSG had higher Ratings of Perceived Exertion (RPE) compared to the preparation match, there were significant differences in movement patterns, such as less running distance, lower running speed, lower work-to-rest ratio, more walking distance, and more deceleration and acceleration. In studies examining different age groups, it has been reported that the average heart rate (KAH) was highest in the U17 group, with other values showing a gradual increase in comparison to the other age groups (Aquino et al., 2019). In a study that included different age groups as well as male and female soccer players, game performances were analyzed in three different training sessions. They have indicated that COVID-19 Modified Training (CMT) resulted in lower exercise intensity and physiological load compared to 3vs3 and 5vs5 Small-Sided Games (SSG) and simulated match play (SMP) with normal rules (Mohr et al., 2022). The research results indicate that in studies focusing on psychophysiological responses, the most commonly investigated marker is heart rate.

As a result, it is emphasized that understanding the needs of the specific sports discipline and designing training programs accordingly are crucial, underscoring the importance of player monitoring systems. Thus, the data obtained from monitoring technology can be crucial for practitioners by providing vital information about an athlete's training load, making it key for the process. Considering this research on monitoring training load in football, certain limitations have been addressed. In this regard, our results encompass different levels of expertise, various age groups, and studies involving both genders. As a result of the study, research on small-field games in football reveals diversity in terms of kinematics, cognitive, psychophysiological, technical-tactical, ground, gender and player positions. Based on this systematic review, kinematic, psychological, and technical-tactical factors can be integrated with positional data using player movement speed, spatial movement, playing areas, intra-team and inter-team synchronization pairs.

Conflict of Interest

The authors hereby declare that there was no conflict of interest in conducting this research.

References

- Alcântara, C. H., Machado, J. C., Teixeira, R. M., Rossato, M., Teixeira, A. S., & Fernandes da Silva, J. (2022). What Factors Discriminate Young Soccer Players Perceived as Promising and Less Promising by Their Coaches?. *Research Quarterly for Exercise and Sport*, 1-9.

- Aquino, R., Melli-Neto, B., Ferrari, J. V. S., Bedo, B. L., Vieira, L. H. P., Santiago, P. R. P., ... & Puggina, E. F. (2019). Validity and reliability of a 6-a-side small-sided game as an indicator of match-related physical performance in elite youth Brazilian soccer players. *Journal of sports sciences*, 37(23), 2639-2644.
- Arsilan, E., Alemдарoglu, U., Koklu, Y., Hazir, T., Muniroglu, S., & Karakoc, B. (2017). Effects of passive and active rest on physiological responses and time motion characteristics in different small sided soccer games. *Journal of Human Kinetics*, 60, 123-132.
- Asian-Clemente, J., Rabano-Muñoz, A., Muñoz, B., Franco, J., & Suarez-Arrones, L. (2021). Can small-side games provide adequate high-speed training in professional soccer?. *International journal of sports medicine*, 42(06), 523-528.
- Bianchi, M., Anderson, L., Brownlee, T., Bossi, L., & Beato, M. (2022). The effect of two sessions of combined jump and sprint training per week on fitness parameters in soccer players. A randomized controlled trial. *Biology of Sport*, 40(3), 699-706.
- Boksem, M. A., & Tops, M. (2008). Mental fatigue: costs and benefits. *Brain research reviews*, 59(1), 125-139.
- Botelho, R., Abad, C. C., Spadari, R. C., Winckler, C., Garcia, M. C., & Guerra, R. L. (2022). Psychophysiological stress markers during preseason among elite female soccer players. *The Journal of Strength & Conditioning Research*, 36(6), 1648-1654.
- Buchheit, M., & Simpson, B. M. (2017). Player-tracking technology: half-full or half-empty glass. *Int J Sports Physiol Perform*, 12(Suppl 2), S2-S35.
- Buchheit, M., Allen, A., Poon, T. K., Modonutti, M., Gregson, W., & Di Salvo, V. (2014). Integrating different tracking systems in football: multiple camera semi-automatic system, local position measurement and GPS technologies. *Journal of sports sciences*, 32(20), 1844-1857.
- Bujalance-Moreno, P., Latorre-Román, P. Á., Martínez-Amat, A., & García-Pinillos, F. (2022). Small-sided games in amateur players: rule modification with mini-goals to induce lower external load responses. *Biology of Sport*, 39(2), 367-377.
- Canton, A., Torrents, C., Gonçalves, B., Ric, A., Salvioni, F., Exel, J., & Sampaio, J. (2022). The diagonal positioning of the goals modifies the external training load and the tactical behaviour of young football players. *Biology of Sport*, 39(1), 135-144.
- Cardinale, M., & Varley, M. C. (2017). Wearable training-monitoring technology: Applications, challenges, and opportunities. *International Journal of Sports Physiology & Performance*, 12.
- Ciocca, G., Tessitore, A., Mandorino, M., & Tschann, H. (2022). A video-based tactical task does not elicit mental fatigue and does not impair soccer performance in a subsequent small-sided game. *Sports*, 10(3), 31.
- Clemente, F. M., Afonso, J., Castillo, D., Los Arcos, A., Silva, A. F., & Sarmiento, H. (2020). The effects of small-sided soccer games on tactical behavior and collective dynamics: A systematic review. *Chaos, Solitons & Fractals*, 134, 109710.
- Clemente, F. M., Theodoros Nikolaidis, P., Rosemann, T., & Knechtle, B. (2019). Shorter small-sided game sets may increase the intensity of internal and external load measures: a study in amateur soccer players. *Sports*, 7(5), 107.
- Coito, N., Davids, K., Folgado, H., Bento, T., & Travassos, B. (2022). Capturing and quantifying tactical behaviors in small-sided and conditioned games in soccer: a systematic review. *Research quarterly for exercise and sport*, 93(1), 189-203.
- Coutinho, D., Gonçalves, B., Travassos, B., Abade, E., Wong, D. P., & Sampaio, J. (2019). Effects of pitch spatial references on players' positioning and physical performances during football small-sided games. *Journal of Sports Sciences*, 37(7), 741-747.
- Coutts, A. J. (2016). Fatigue in football: it's not a brainless task! *Journal of Sports Sciences*, 34(14), 1296-1296.
- Cummins, C., Orr, R., O'Connor, H., & West, C. (2013). Global positioning systems (GPS) and microtechnology sensors in team sports: a systematic review. *Sports medicine*, 43(10), 1025-1042.
- de Dios-Álvarez, V., Alkain, P., Castellano, J., & Rey, E. (2021). Accumulative weekly external and internal load relative to match load in elite male youth soccer players. *Pediatric Exercise Science*, 34(3), 119-124.
- Enoka, R. M., & Duchateau, J. (2016). Translating fatigue to human performance. *Medicine and science in sports and exercise*, 48(11), 2228.
- Filaire, E., Lac, G., & Pequignot, J. M. (2003). Biological, hormonal, and psychological parameters in professional soccer players throughout a competitive season. *Perceptual and Motor Skills*, 97(3_suppl), 1061-1072.
- Filipas, L., Gallo, G., Pollastri, L., & La Torre, A. (2019). Mental fatigue impairs time trial performance in sub-elite under 23 cyclists. *PLoS One*, 14(6), e0218405.
- Folgado, H., Bravo, J., Pereira, P., & Sampaio, J. (2019). Towards the use of multidimensional performance indicators in football small-sided games: the effects of pitch orientation. *Journal of Sports Sciences*, 37(9), 1064-1071.
- Folgado, H., Gonçalves, B., & Sampaio, J. (2018). Positional synchronization affects physical and physiological responses to preseason in professional football (soccer). *Research in Sports Medicine*, 26(1), 51-63.
- Giménez JV, Del-Coso J, Leicht AS, MÁ G. (2018a). Comparison of the movement patterns between small-and large-sided game training and competition in professional soccer players. *J Sports Med Phys Fitness*. 58(10):1383-1389.
- Giménez, J. V., Jiménez-Linares, L., Leicht, A. S., & Gómez, M. A. (2020). Predictive modelling of the physical demands during training and competition in professional soccer players. *Journal of Science and Medicine in Sport*, 23(6), 603-608.

- Giménez, J. V., Liu, H., Lipińska, P., Szwarc, A., Rompa, P., & Gómez, M. A. (2018b). Physical responses of professional soccer players during 4 vs. 4 small-sided games with mini-goals according to rule changes. *Biology of sport*, 35(1), 75-81.
- Hennessy, L., & Jeffreys, I. (2018). The current use of GPS, its potential, and limitations in soccer. *Strength & Conditioning Journal*, 40(3), 83-94.
- Huang, X., Lin, J., Demner-Fushman, D. (2006). Evaluation of PICO as a knowledge representation for clinical questions. AMIA ... Annual Symposium Proceedings. AMIA Symposium, 359-363.
- Ingebrigtsen, J., Dalen, T., Hjelde, G. H., Drust, B., & Wisløff, U. (2015). Acceleration and sprint profiles of a professional elite football team in match play. *European journal of sport science*, 15(2), 101-110.
- Kunrath, C. A., Nakamura, F. Y., Roca, A., Tessitore, A., & Teoldo Da Costa, I. (2020). How does mental fatigue affect soccer performance during small-sided games? A cognitive, tactical and physical approach. *Journal of Sports Sciences*, 38(15), 1818-1828.
- Lacome, M., Simpson, B. M., Cholley, Y., Lambert, P., & Buchheit, M. (2018). Small-sided games in elite soccer: Does one size fit all?. *International journal of sports physiology and performance*, 13(5), 568-576.
- Lazarim, F. L., Antunes-Neto, J. M., Da Silva, F. O., Nunes, L. A., Bassini-Cameron, A., Cameron, L. C., ... & de Macedo, D. V. (2009). The upper values of plasma creatine kinase of professional soccer players during the Brazilian National Championship. *Journal of Science and Medicine in Sport*, 12(1), 85-90.
- Lemes, J. C., Luchesi, M., Diniz, L. B. F., Brecht, S. D. G. T., Chagas, M. H., & Praça, G. M. (2020). Influence of pitch size and age category on the physical and physiological responses of young football players during small-sided games using GPS devices. *Research in Sports Medicine*, 28(2), 206-216.
- López-Fernández, J., Gallardo, L., Fernández-Luna, Á., Villacañas, V., García-Unanue, J., & Sánchez-Sánchez, J. (2019). Pitch size and game surface in different small-sided games. Global indicators, activity profile, and acceleration of female soccer players. *The Journal of Strength & Conditioning Research*, 33(3), 831-838.
- Lozano, D., Lampre, M., Díez, A., Gonzalo-Skok, O., Jaén-Carrillo, D., Castillo, D., & Arjol, J. L. (2020). Global positioning system analysis of physical demands in small and large-sided games with floaters and official matches in the process of return to play in high level soccer players. *Sensors*, 20(22), 6605.
- Maya, J., Marquez, P., Peñailillo, L., Contreras-Ferrat, A., Deldicque, L., & Zbinden-Foncea, H. (2016). Salivary biomarker responses to two final matches in women's professional football. *Journal of sports science & medicine*, 15(2), 365.
- McLaren, S. J., Macpherson, T. W., Coutts, A. J., Hurst, C., Spears, I. R., & Weston, M. (2018). The relationships between internal and external measures of training load and intensity in team sports: a meta-analysis. *Sports medicine*, 48, 641-658.
- Miguel, M., Oliveira, R., Loureiro, N., García-Rubio, J., & Ibáñez, S. J. (2021). Load measures in training/match monitoring in soccer: A systematic review. *International Journal of Environmental Research and Public Health*, 18(5), 2721.
- Mohr, M., Krstrup, P., & Bangsbo, J. (2005). Fatigue in soccer: a brief review. *Journal of sports sciences*, 23(6), 593-599.
- Mohr, M., Sjúrdarson, T., Leifsson, E. N., Randers, M. B., Knudsen, N. S., Thomasen, M. M. D., ... & Krstrup, P. (2022). The Faroe Islands COVID-19 Recreational Football Study: Player-to-Player Distance, Body-to-Body Contact, Body-to-Ball Contact and Exercise Intensity during Various Types of Football Training for Both Genders and Various Age Groups. *BioMed Research International*, 2022.
- Nunes, N. A., Goncalves, B., Coutinho, D., Nakamura, F. Y., & Travassos, B. (2021). How playing area dimension and number of players constrain football performance during unbalanced ball possession games. *International Journal of Sports Science & Coaching*, 16(2), 334-343.
- Papanikolaou, K., Tsimeas, P., Anagnostou, A., Varypatis, A., Mourikis, C., Tzatzakis, T., ... & Fatouros, I. G. (2021). Recovery kinetics following small-sided games in competitive soccer players: does player density size matter?. *International Journal of Sports Physiology and Performance*, 16(9), 1270-1280.
- Randers, M. B., Brix, J., Hagman, M., Nielsen, J. J., & Krstrup, P. (2020). Effect of boards in small-sided street soccer games on movement pattern and physiological response in recreationally active young men. *The Journal of Strength & Conditioning Research*, 34(12), 3530-3537.
- Salter, J., De Ste Croix, M. B., & Hughes, J. D. (2021). The moderating impact of maturation on acute neuromuscular and psycho-physiological responses to simulated soccer activity in academy soccer players. *European journal of sport science*, 21(12), 1637-1647.
- Sangnier, S., Cotte, T., Brachet, O., Coquart, J., & Tourny, C. (2019). Planning training workload in football using small-sided games' density. *The Journal of Strength & Conditioning Research*, 33(10), 2801-2811.
- Sannicandro, I., & Cofano, G. (2023). Large-Sided Games and Sport-Specific Training: Parameters of High Intensity in Professional Soccer Players. *Physical Education Theory and Methodology*, 23(1), 124-132.
- Sarmiento, H., Clemente, F. M., Harper, L. D., Costa, I. T. D., Owen, A., & Figueiredo, A. J. (2018). Small sided games in soccer—a systematic review. *International journal of performance analysis in sport*, 18(5), 693-749.
- Soylu, Y., Arslan, E. (2021). Effects of mental fatigue on psychophysiological, cognitive responses, and technical skills in small-sided soccer games in amateur players. *Baltic Journal of Health and Physical Activity*, Supp(2), 43-50.

- Soylu, Y., Ramazanoglu, F., Arslan, E., & Clemente, F. (2022). Effects of mental fatigue on the psychophysiological responses, kinematic profiles, and technical performance in different small-sided soccer games. *Biology of Sport*, 39(4), 965-972.
- Soylu, Y., Ramazanoglu, F., Arslan, E., Clemente, F. (2021). Effects of mental fatigue on the psychophysiological responses, kinematic profiles, and technical performance in different small-sided soccer games. *Biology of Sport*, 39(4), 965-972.
- Torres-Ronda, L., Beanland, E., Whitehead, S., Sweeting, A., & Clubb, J. (2022). Tracking Systems in Team Sports: A Narrative Review of Applications of the Data and Sport Specific Analysis. *Sports Medicine-Open*, 8(1), 1-22.
- Varley, M. C., Fairweather, I. H., & Aughey, R. J. (2012). Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *Journal of sports sciences*, 30(2), 121-127.
- Waqar, A., Ahmad, I., Habibi, D., & Phung, Q. V. (2021). Analysis of GPS and UWB positioning system for athlete tracking. *Measurement: Sensors*, 14, 100036.
- Younesi, S., Rabbani, A., Clemente, F., Sarmiento, H., & Figueiredo, A. J. (2021). Session-to-session variations in external load measures during small-sided games in professional soccer players. *Biology of sport*, 38(2), 185-193.