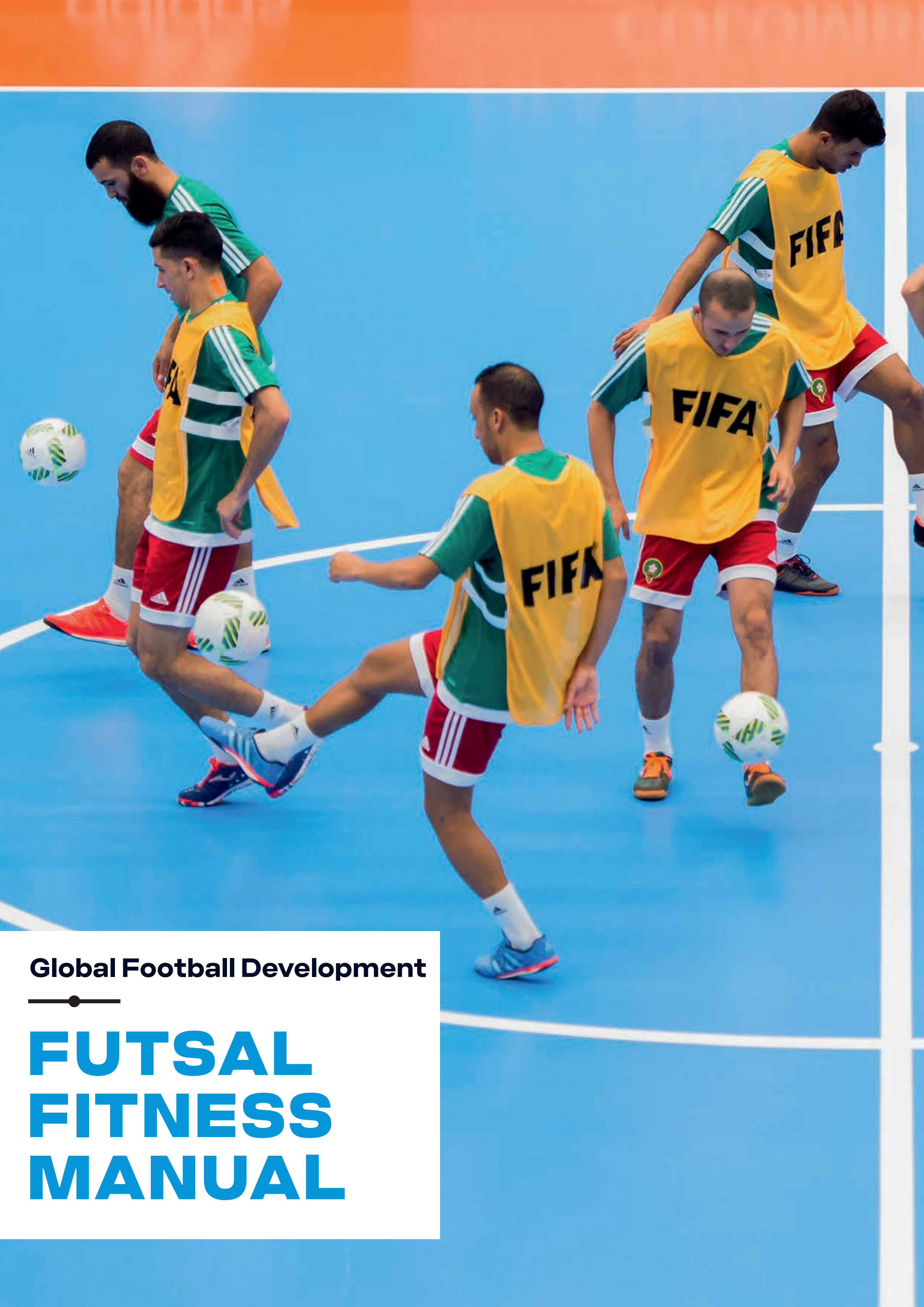

Global Football Development

FUTSAL FITNESS MANUAL

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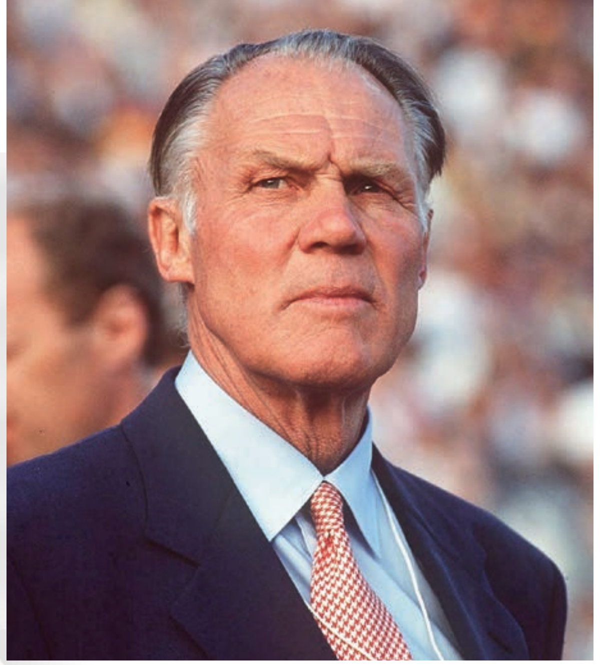
INTRODUCTION



Futsal is explained well in this adapted quote from famous Dutch football coach Rinus Michels:

"There is enormous complexity in the sport of futsal for the coach to comprehend. The complexity of different sports depends on such factors as the size of the teams, the roles of each individual, the level of contact allowed, the size of the pitch and the continuous nature of the game. Futsal demands [the] complete versatility of all its players. It is unpredictable, with endless unique situations and constant change between attack and defence."

To prepare players, Michels suggests:

"You must translate what has occurred in the match into training activities which are linked to these guidelines. There are often training activities that keep the players busy, but when training is over, the players cannot make the translation to the match reality. This is a waste of time and energy. Most coaches do not reach the final step. They do not reach further than creating general training exercises, which hardly have any relation to problems that occurred in the match."

The modern approach to player preparation is to "play as you train, train as you play" (TSG, Youth Olympic Futsal Tournament Buenos Aires 2018). Understanding the position-specific match demands and the physical requirements of elite futsal players is the foundation for planning and developing effective periodisation and training programmes (Spyrou et al., 2020; Serrano Luengo et al., 2020; Gabbett et al., 2020) which can optimise performance, reduce the risk of injury and increase player availability for training and matches (Spyrou et al., 2020; Illa et al., 2021).

Futsal is a dynamic, high-intensity, intermittent, multiple-sprint sport. The game requires players to develop optimal body composition, aerobic and anaerobic capacities, speed, strength, power, agility, balance, coordination, mobility and flexibility to cope with the physical demands of both training and competition over a long competitive season (Esteves et al., 2022). A typical competitive season for an elite player consists of approximately 50 matches including national (i.e. league and cup) and international (i.e. European club tournaments and national team) competitions over a 7.5-month period, with a frequency of one to three games per week (Spyrou et al., 2022). Training involves sessions once or twice a day in preparation for matches, covering an average of 10km at high and very high intensities during a typical weekly microcycle (Illa et al., 2020; Spyrou et al., 2022).

A professional futsal season imposes significant physiological, psychological and mechanical stress on players (Rabelo et al., 2016; Spyrou et al., 2020; Spyrou et al., 2022). Consequently, the planning and design of training, match situations and recovery is critical in optimising performance. The goal is to create an environment where training is process-driven and sessions result in multiple outcomes concurrently developing fitness, technical skills and tactical understanding.

The Portuguese national-team coach, Jorge Braz, explained:

"The game is becoming very physical. If you have powerful players, very strong physically, and you do individual marking, then for you to have an advantage you have to create a positional and numerical advantage against your direct opponent with and without the ball. Let's play a lot without the ball, let's not stop, let's be dynamic so it's very difficult for them to run after everybody. Because if they run after my players, I will take them to the places that I want. They will do what I want defensively."

The importance of fitness in modern futsal was highlighted in a report following the Youth Olympic Futsal Tournament in Argentina in 2018. The TSG reported:

"The physicality of better conditioned teams such as Spain, Brazil, Russia, Portugal and Japan resulted in positive outcomes as they were all notably the fittest teams from the outset… This indicates the importance of physiological preparation to maintain [high] performance [levels] across the competition phase… The contribution of appropriate physical conditioning at this level, as at senior level, will also influence technical execution and tactical deployment as fatigue starts to take hold."

By developing a detailed understanding of the physical and physiological loads during training and matches in elite futsal, this information can be used to great effect in the optimisation of elite performance, while simultaneously driving both coach education and player development.

GAME DESCRIPTION

Futsal is a five-a-side team sport played on a 40×20m pitch with 3×2m goals (Spyrou et al., 2020). Organisationally, the five players are distributed over four different playing positions: goalkeeper, defender, wingers and pivot (Caetano et al., 2015; Illa et al., 2021; Serrano Luengo et al., 2020). The maximum number of players in a matchday squad is 14 (up to nine substitutes per team). An unlimited number of rolling substitutions are permitted during games (Illa et al., 2021; Ayarra et al., 2018; González et al., 2022) which contributes to maintaining high match intensity and increasing the physical demands during the match (Castagna et al., 2009; Ribeiro et al., 2021). Teams may request a one-minute timeout in each half. As the match clock is stopped for in-game events that occur such as when the ball goes out of play, fouls, injuries, timeouts and pitch cleaning (Barbero Álvarez et al., 2008; Ayarra et al., 2018 Serrano Luengo et al., 2020; Illa et al., 2021), the actual match length can be 75-85% longer than 40 minutes (Ohmuro et al., 2020; Wilke et al., 2020), which means that the total match length can be as much as 75-90 minutes (Barbero Álvarez et al., 2008; Rodrigues et al., 2011; Serrano Luengo et al., 2020).

2.1 Match demands

Futsal is an intermittent, high-intensity, multiple-sprint sport involving short high-intensity actions (HIA) (such as accelerations, decelerations, high-intensity runs, repeated sprints, braking and changes of direction) interspersed by short recovery periods between efforts (Serrano Luengo et al., 2020; Spyrou et al., 2020; Ribeiro et al., 2020; Illa et al., 2021; Miloski et al., 2016; Riberio et al., 2022; Caetano et al., 2015).

Due to the pitch size and player density, which result in time and spatial restrictions, there are constant turnovers in play (Méndez et al., 2019). With a work-to-rest ratio of 1:1 and activity changes every three seconds (Nemčić and Calleja-González, 2021), players are exposed to high physical, psychological, technical and tactical demands during matches (Ribeiro et al., 2020; Illa et al., 2020; Barbero Álvarez et al., 2008; Caetano et al., 2015; Castagna et al., 2009; Miloski et al., 2014). These physical demands, combined with the execution of futsal skills and techniques (e.g. shooting, dribbling, passing, tackling and jumping), heavily tax both the aerobic and anaerobic pathways (Ayarra et al., 2018; Barbero Álvarez et al., 2008; Miloski et al., 2014; Wilke et al., 2020; Ribeiro et al., 2020; Spyrou et al., 2020; Esteves et al., 2022), which means that players need to have well-developed cardiovascular, neuromuscular and metabolic systems with high aerobic and anaerobic capacities (Nogueira et al., 2016; De Freitas et al., 2019; De Oliveira et al., 2021), repeated sprint ability (RSA), well-developed leg strength/power, agility and coordination (Miloski et al., 2016; Naser et al., 2017; Serrano Luengo et al., 2020; Soares et al., 2023).

Both training and matches create significant physiological, neuromuscular and biochemical stress (Spyrou et al., 2020; Spyrou et al., 2022; Wilke et al., 2020; Rodrigues et al., 2011), resulting in inflammation and muscle damage (De Moura et al., 2013; Wilke et al., 2020). Prolonged intermittent sprint exercise provokes disturbances in skeletal muscle structure and function, associated with reduced contractile function, perceived soreness and a delayed return to optimal physical performance (Nemčić and Calleja-González, 2021). Consequently, the sport combines characteristics that carry a high risk of injury (López-Segovia et al., 2019).

2.2 Match time

Studies have reported that the total playing time for futsal players during matches is approximately 50% of the whole game time, while the remaining 50% is spent on the bench (Barbera Álvarez et al., 2008; Dogramaci et al., 2015; Ohmuro et al., 2020), but this may be affected by contextual factors.

During the 2019-2020 season, ten competitive matches from the Spanish Professional Futsal League (LNFS) were analysed, the findings of which reported a player time of 37.10 ± 13.60 minutes (Serrano Luengo et al., 2020). In Brazil (Rodrigues et al., 2011) and Japan (Ohmura et al., 2020) national league matches, players remained on the pitch for 34 and 36 minutes, respectively (Dos Santos et al., 2020).

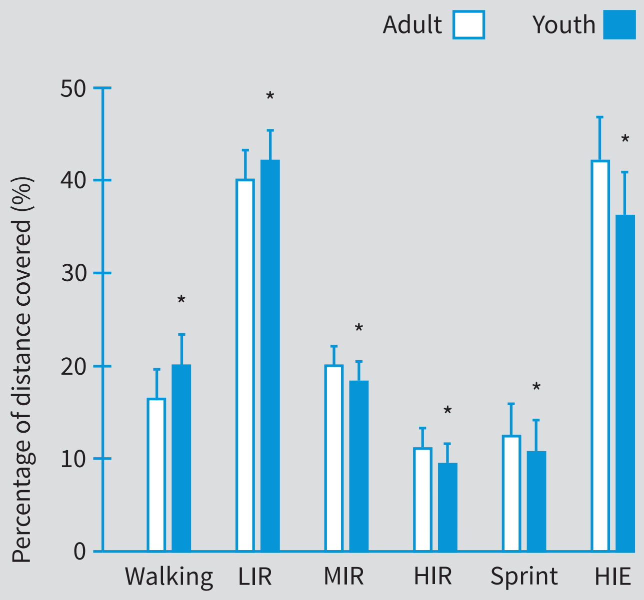
Substitution characteristics during official futsal matches in both categories.

	Total playing time (min)	In-play time (min)	Number of substitutions	Total playing time per substitution (min)	In-play time per substitution (min)	Bench time (min)
Adult	35.9 ± 9	18.7 ± 4.8	8.2 ± 3.4	4.6 ± 0.9	2.4 ± 0.5	5.4 ± 1.9
Youth	39.7 ± 11	22.3 ± 6.1*	6.5 ± 3.4*	6.2 ± 2.1*	3.8 ± 1.1*	5.5 ± 2.1

Note: *p ‹ 0.05 v. adults.

2.3 Distance covered

Match data indicates that professional players in different international leagues cover approximately 3,000-4,500m in a match (Naser et al., 2017; Ribeiro et al., 2020; Sekulic et al., 2021; Barbero Álvarez et al., 2008; Dogramaci et al., 2011; Ribeiro et al., 2022; Serrano Luengo et al., 2020; De Oliveira Bueno et al., 2014; Ohmuro et al., 2020; Rinaldo et al., 2022), approximately 675m of which are spent running (12-18km/h) and 135 ± 54m are spent sprinting (>18km/h), perform around 70-90 high-intensity accelerations and decelerations >2m/s (5 ± 2 high accelerations and decelerations per minute relative to "playing time") and complete around 170-200 changes of direction as part of 1,165 ± 188 explosive movements (Spyrou et al., 2021).



The percentage of velocity in play during matches across different categories.

The total distance covered is influenced by the overall game duration as well as by the total time each player spends participating in the match (Serrano Luengo et al., 2020; Barbero Álvarez et al., 2008; De Oliveira Bueno et al., 2014; Ayarra et al., 2018; Ohmura et al., 2020) due to the impact of unlimited substitutions, player position, tactics (Naser et al., 2017) and contextual factors. As such, the total distance covered should not be taken as an indicator of running performance (Barbero Álvarez et al., 2008; Ribeiro et al., 2020; Nemčić and Calleja-González, 2021). It is better to convert/relativise distance data to minutes of play (m/min) to allow comparisons between individual performance in training sessions and matches to be made (De Oliveira Bueno et al., 2014; Ribeiro et al., 2020).

Professional futsal players cover around 20-25% of their distance at high speed or maximum speed/sprinting (Rinaldo et al., 2022; Barbero Álvarez, 2008; Castagna et al., 2009; Serrano Luengo et al., 2020; De Oliveira Bueno et al., 2014; Naser et al., 2017; Ribeiro et al., 2020) with a work-to-rest ratio of 1:1, where rest means the player is stationary, walking or jogging, and work means the distance is covered at medium, high or maximum speed (Naser et al., 2017; De Oliveira Bueno, 2014; Serrano Luengo et al., 2020). The speed metrics and methodologies applied can differ, so relative distances can vary depending on the speed threshold selected, which makes comparisons difficult. As such, the total distance per minute covered during a game can vary between 113m and 232m (Naser et al., 2017; Ribeiro et al., 2020).

The high-speed distance covered by players in the Portuguese league (Ribeiro et al., 2020), when compared to players from Brazil and Spain (Barbero Álvarez et al., 2008; De Oliveira Bueno et al., 2014; Dogramaci et al., 2015), was approximately twice the distance covered per minute with a higher number of sprints performed. This data appears to indicate an increase in the demands and dynamics of the game over time. The development of attacking and defensive tactics has increased the demands required by competition, a fact reflected in the greater distance covered per minute (Naser et al., 2017). An unlimited number of substitutions can enable players to cover more distance at high

intensity and perform a high number of sprint and high-intensity actions (HIA) (Sekulic et al., 2019; Naser et al., 2017).

Any analysis must also ensure that external loading comparisons are made considering actual playing time rather than the length of the match. Futsal is played in a small environment with tight areas, so the ability to run at high speeds, accelerate, decelerate and change direction while performing the correct technique under pressure are key physical performance factors essential for elite performance during matches (Ribeiro et al., 2020; Rinaldo et al., 2022; Naser et al., 2017; Borges et al., 2021; Spyrou et al., 2020).

Typically, elite male players perform:

- a low-intensity effort every 14s;
- a medium-intensity effort every 37s;
- a high-intensity effort every 43s;
- a maximum-intensity effort every 56s;
- 8.6 actions per minute of match play; and
- a change in locomotor activity every 3.3s.

(Serrano Luengo et al., 2020; Naser et al., 2017)

Ribeiro et al. (2020) reported an average peak sprinting speed of 20.3km/h, with maximum speeds of 22.6km/h in elite Portuguese players from eight futsal teams that reached the quarter-finals of the *Taça de Portugal de Futsal* (Portuguese Futsal Cup).

Nine male professional players competing in the LNFS and finalists of the UEFA Futsal Champions League were monitored using a GPS accelerometer device during all 20 matches of the 2019-2020 season (Spyrou et al., 2021).

In a match, on average, players completed:

- 73.3 ± 13.8 high-intensity accelerations (>3.5m/s^2);
- 68.6 ± 18.8 decelerations (<-3.5m/s^2);
- 1,165 ± 188 explosive movements (ACC, DEC and COD in the medium and high bands >2.5m/s^2); and
- 173 ± 29.1 changes of direction (right/left lateral shift within the high band >3.5m/s^2).

Metabolic rate is known to have a strong positive correlation with running speed (Margaria et al., 1963; Helgerud, Storen and Hoff, 2010) and, as such, high-speed running (HSR) and sprint performance indicates physically demanding efforts during match situations. Accelerations (ACC) have a higher metabolic cost and decelerations (DEC) have a higher mechanical load (Dalen et al., 2016). The frequency of high-speed running actions and high-intensity accelerations/decelerations completed during matches often result in reductions in neuromuscular performance due to fatigue or muscle damage (Harper et al., 2019; Verheul et al., 2021; Ribeiro et al., 2022; Spyrou et al., 2020).

Travassos (personal communication) noted that, during matches, ACC and HSR are completed when a player enters open spaces to advance or recover (e.g. when dribbling, finding space, tracking back, zonal marking or closing down opponents). On the other hand, accelerations (ACC) and decelerations (DEC) can be seen when players want to close the space to prevent an opponent from progressing up the pitch through actions such as marking, closing down opponents, individual duels and interceptions.

Variables	Description
With the ball	
Dribble	Player moves with the ball in order to progress in some direction.
Interception	Player intercepts a pass by the opposition.
Dynamic ball control	Player receives a pass and moves the ball with intention.
Ball protection	Player uses their body to protect the ball from opponents.
Pass	Player passes the ball towards a team-mate.
Shot	Player intends to direct the ball towards the opposition goal.
Regain possession	Player intervenes and attempts to take the ball away from a direct rival.
Static ball control	Player receives a pass and retains control of the ball in the same place.
Without the ball	
Defensive return/loss reaction	Player runs back towards their own goal, immediately following the loss of possession.
Support movements – Away	Player moves to receive a pass from a team-mate or to create/explore space (usually in behind).
Support movements – Break	Player moves to receive a pass from a team-mate or to create/explore space (usually comes short to receive ball).
Support movements – Strategy	Player moves to receive a pass from a team-mate in strategic situations (e.g. corner kick and free kick).
Marking – Ball trajectory	Player runs following the movement of the ball towards the opponent.
Marking – Opponent trajectory	Player runs following the direction of their opponent‘s movement.
Marking – Individual duel	Player in a basic defensive position preventing opponent from advancing.
Help coverage	Player moves to provide defensive corner for team-mate.

High-speed running (HSR), accelerations and decelerations, changes of direction (COD) and jumps greatly contribute to the external load in futsal (Spyrou et al., 2021; Spyrou et al., 2020; Vanrenterghem et al., 2017). The ability to accelerate or decelerate over short distances is considered decisive during critical match actions (i.e. changing direction in response to opponents' movement, movements to create or reduce space, and pressing the opposition in transition to regain possession) and is the most direct and reliable predictor of futsal performance (Ribeiro et al., 2020), more so than HSR due to the size of the playing area (Yiannaki et al., 2020; Beato et al., 2017). Consequently, futsal requires players to develop good aerobic and anaerobic conditioning, power, strength, agility, balance and coordination (Naser et al., 2017) to undertake the large volume of HIA (Taylor et al., 2017; Serrano Luengo et al., 2020).

In terms of acceleration ability, Loturco et al. (2018) reported values of 4.64 ± 0.50m/s^2 for 0-5m, 1.22 ± 0.22m/s^2 for 5-10m, and 0.74 ± 0.09m/s^2 for 10-20m in futsal players from the team that won the Brazilian *Liga Nacional de Futsal* with running speeds of 4.81 ± 0.25m/s (5m) 5.68 ± 0.19m/s (10m) and 6.61 ± 0.22m/s (20m) (Spyrou et al., 2021).

Serrano Luengo et al. (2020) highlighted that elite Spanish futsal players complete between 0.58 and 0.88 sprints per minute and perform between seven and nine accelerations over 2m/s^2 per minute and seven to nine decelerations (<-2m/s^2) per minute (Unanue et al., 2020).

First v. second half

Research has shown that distance covered per minute, peak velocity, initial velocity, recovery time between sprints, sprints per minute, explosive distance per minute or number of accelerations and decelerations per minute do not decrease in the second half of a match (Caetano et al., 2015; Serrano Luengo et al., 2020; Unanue et al., 2020).

There were no differences in sprint distances between the first and second halves reported when comparing five official matches in the Brazilian *Liga Nacional de Futsal* (Caetano et al., 2015), while no significant differences were noted in distances covered in the first and second halves at different intensities or as a proportion of the high-intensity running in 28 players from eight futsal teams that reached the quarter-finals of the *Taça de Portugal de Futsal* in 2018. This suggests that performance levels remain constant regardless of the length or stage of the match. High-intensity actions (HIA) did not decrease significantly between halves (Serrano Luengo et al., 2020; Ribeiro et al., 2020).

	Full match M ± SD	First half MD (IR)	Second half MD (IR)
Kinematics			
Distance covered per minute	232 ± 71	216 (55)	229 (86)
Walking per minute (0-6km/h)	108.3 ± 51.5	92.5 (30.5)	110.8 (54.8)
Jogging per minute (6-12km/h)	76.5 ± 24.3	79.5 (16.5)	77.9 (17.9)
Running per minute (12-18km/h)	30.0 ± 19.2	15.7 (26.4)	38.6 (12.3)
Sprinting per minute (>18km/h)	8.5 ± 7.9	7.4 (3.8)	7.3 (5.4)
Sprints (n/min)	2 ± 1	2 (2)	2 (2)
Mechanical			
ACC (n/min)	5 ± 2	5.2 (2)	5.1 (2)
DEC (n/min)	5 ± 2	5 (2)	5 (2)
Jumps (n/min)	0.8 ± 1.1	0.4 (0.5)	0.5 (0.9)
Total impact (n/min)	35 ± 35.2	29 (22.4)	30 (28.1)
Player load (a.u./min)	4.5 ± 2.3	4.1 (1.3)	4.3 (1.8)
DSL (a.u./min)	15.0 ± 8.5	11.2 (13.4)	15.1 (13)
Metabolic			
Metabolic power per minute	6.9 ± 1.7	0.9 (0.6)	0.9 (0.8)
HMLD per minute	22.8 ± 10.6	22.2 (18.3)	23.7 (7.2)

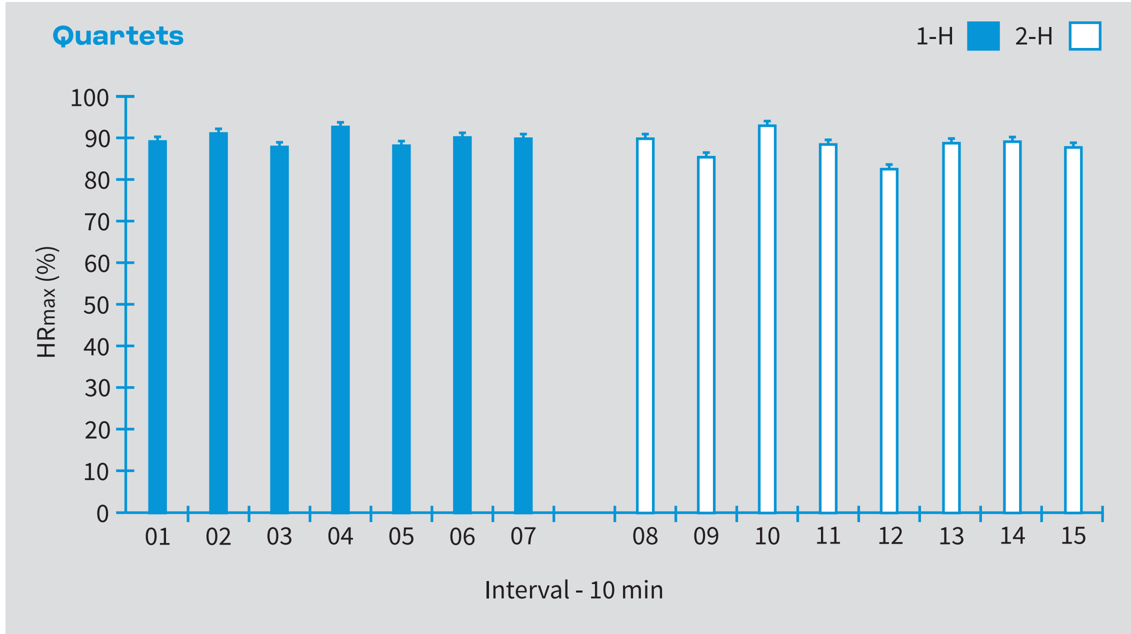
*p < 0.005 significant difference; M, mean; SD, standard deviation; MD, median; and IR, interquartile range.

Ribeiro et al. (2020) found that kinematic (i.e. distance covered per minute and sprints), mechanical (i.e. accelerations and decelerations) and metabolic variables (i.e. metabolic power per minute) were not affected by time periods, which was explained by different factors related to an unlimited number of substitutions or tactical decisions (e.g. "fly goalkeeper"). Players who have less playing time tend to have higher physical performance outputs per minute compared to the players with more playing time (Ribeiro et al., 2022). Thanks to regular substitutions, players can maintain a higher intensity and tolerate a greater workload because of the shorter work periods. Consequently, the use of tactical substitutions requires all players in the squad to have the physical and tactical ability to adopt multiple positions and maintain match intensity whilst playing. Performance analysis should identify the time that each player has per rotation to accurately describe the actual physical load during matches. It is essential to calculate the match effort per minute and to consider the work-to-rest ratio to understand the impact that matches have on players.

Professional futsal players from a team competing in the *Liga Paulista de Futsal* in Brazil were monitored during a friendly match. Their opponents were one of the best teams in Brazil, which had already won the *Liga Nacional de Futsal* and the *Copa Libertadores de Futsal* and boasted three players from Brazil's national team (Dos Santos et al., 2020). There were no differences identified in the physical responses between the first and second halves.

The cardiovascular and metabolic loads did not differ between the first and second halves. The %HRmean (89.61 ± 2.31 v. 88.03 ± 4.98 %HRmax) and [La−] mean (8.46 ± 3.01 v. 8.17 ± 2.91 mmol/l) were consistent, which can be explained by the high physical demand during the match (89% HRmax) and limited recovery between efforts (Dos Santos et al., 2020). The players remained in the high-intensity zone (>90% HRmax) for most of the match.

The similar HR and [La−] values between the first and second halves can be explained by the use of substitutions and players' playing time. There were 12 substitutions, players participated twice in each half, with no difference in time on the pitch between the first and second halves as well as in the ratio between time spent on and off the pitch, which influenced how players maintained the level of intensity in the second half. The 24 substitutions created 15 different formations from four outfield players.



The above graph shows the percentage of maximum heart rate (%HRmax), considering the mean of quartets (four outfield players on the pitch) in the first (1-H) and second (2-H) halves. In addition, the higher level of the opponents may have also influenced the demand placed on the Brazilian team analysed and the low level of aerobic conditioning, considering the game was played during preseason (Dos Santos et al., 2020).

	Match (95% CI)	1-H (95% CI)	2-H (95% CI)
Match duration (min)	67.00	30.28	36.72
Total time on the pitch (min)	31.71 ± 9.02 (23.37 - 40.05)	13.44 ± 5.72 (8.15 - 18.73)	18.19 ± 6.04 (12.60 - 23.77)
Each participation (min)	8.19 ± 2.27 (6.09 - 10.28)	7.15 ± 2.39 (4.94 - 9.35)	9.49 ± 3.80 (5.98 - 13.01)
HR_{mean} (bpm)	179 ± 6 (173 - 185)	181 ± 5 (176 - 186)	178 ± 9 (169 - 186)
HR_{max} (bpm)	200 ± 7 (194 - 206)	195 ± 9 (187 - 203)	198 ± 7 (192 - 204)
$\%HR_{max}$ (%)	88.79 ± 3.35 (85.69 - 91.88)	89.61 ± 2.31 (87.48 - 91.75)	88.03 ± 4.98 (83.42 - 92.63)
$(La\text{-})_{mean}$ (mmol·L-1)	8.32 ± 2.88 (5.65 - 10.98)	8.46 ± 3.01 (5.67 - 11.24)	8.17 ± 2.91 (5.48 - 10.86)
$(La\text{-})_{max}$ (mmol·L-1)	9.71 ± 3.00 (6.94 - 12.49)	9.16 ± 3.16 (6.23 - 12.08)	9.20 ± 3.14 (6.30 - 12.10)

This table shows the results of the first half (1-H), the second half (2-H) and the match (1-H and 2-H).

Earlier researchers reported a significant decrease in relative distance covered and variations in total distance covered in the second half of games. Various pieces of research reported that match activity decreased from the first to the second half (Barbero Álvarez et al., 2008; Castagna et al., 2009; Milioni et al., 2016). For example, professional futsal players had a lower mean heart rate (HRmean) in the second half (2-H) compared to the first half (1-H) (88.1 v. 91.1% of HRmax, respectively) and a lower percentage of time spent in high-intensity HR zones (Barbero Álvarez et al., 2008; De Oliveira Bueno et al., 2014). However, players in one study covered distances of 2,496m and 2,596m, corresponding to 118m and 111m per minute in the first and second half, respectively. Barbero Álvarez et al. (2008) observed a 4% increase in the total distance covered in the second half, but there was a 7% reduction in the distance covered per minute as a result of the 12% increase in the total time played in the second half. The reduction in the distance covered per minute in the second half may be related to the decline in intensity or work rate due to fatigue. Players covered a greater distance because they had more playing time, but distances were covered at lower speeds.

Milioni et al. (2016) identified that the total distance (first half: 1,986 ± 74.4m; second half: 1,856 ± 129.7m) and the distance covered per minute (first half: 103.2 ± 4.4m per minute; second half: 96.4 ± 7.5m per minute) decreased from the first half to the second half, but found no differences regarding the number of sprints or total sprint time. These findings could potentially have been due to contextual factors rather than any loss of performance or physical capacity (Dos Santos et al., 2020).

Similar contradictory results have been reported. Nine male professional players – competing in the LNFS and finalists of the UEFA Futsal Champions League – were monitored using a GPS accelerometer device during all 20 games of the 2019-2020 season (Spyrou et al., 2021).

On average, players participated twice in each half, playing an average of eight minutes each, while the ratio between players' time spent on and off the pitch over the course of the match presented an average of 1:1.18 ± 1:0.51min. This may have enabled the players to maintain similar intensity levels between the first and second halves.

Substitutions are used during futsal matches for a number of reasons (e.g. fatigue, being cautioned, poor performance, tactical changes or other strategic reasons).

Elite futsal players can maintain physical performance between the first and second halves (Ribeiro et al., 2020; Serrano Luengo et al., 2020; Yianniki et al., 2020) through the use of substitutions following periods of high-intensity work to avoid accumulating high levels of fatigue (Serrano Luengo et al., 2020; Caetano et al., 2015; Barbero Álvarez 2008; De Oliveira Bueno et al., 2014; Dos Santos et al., 2020) and maintain the frequency of HIA – accelerations, decelerations and HSR (Ribeiro et al., 2022).

Milanez et al. (2020) found that players were substituted twice on average in each half and had similar lactate concentrations (8.46 ± 3.01 v. 8.17 ± 2.91 mmol/l) and heart rates (89.61 ± 2.31 v. 88.03 ± 4.98 %HRmax) in the first and second halves, which suggests comparable physical demands.

Variables		Full game	First half	Second half
Total PL	a.u	3,868 ± 594	1,990 ± 299	1,868 ± 34*
PL·min^{-1}	a.u	10.8 ± 0.8	11.2 ± 0.9	10.4 ± 1.0*
ACC_{HI}	nº	79.3 ± 13.8	36 ± 7.3	37.3 ± 9.9*
DEC_{HI}	nº	68.6 ± 18.8	38 ± 9.4	30.6 ± 11.3*
EXPL-MOV	nº	1,165 ± 188	611 ± 97	559 ± 108*
COD_{HI}	nº	173 ± 29.1	89.5 ± 19.6	85 ± 16.4

Match demands and comparison between the first and second halves.

Using accelerometry, a decrease in the load per player, load per minute, decelerations and explosive movements was found in the second half compared to the first half (Spyrou et al., 2021). However, high-intensity accelerations (HIA) and changes of direction (COD) appeared not to decline significantly.

2.4 Contextual factors

Contextual or situational factors such as the location (playing home or away), tactical system, style of play, positional demands, use of a fly keeper, level of physical fitness, quality of the opponents, stage of the match and scoreline can influence the physical performance of players (Aquino et al., 2017, 2020; Naser et al., 2017; Novak et al., 2021; Méndez et al., 2019; Castagna et al., 2009; Illa et al., 2021).

Whether the game is official (OFF) or non-official (non-OFF) can possibly induce bias in the interpretation of the physical demands as competitiveness can influence player movement characteristics (Dogramaci et al., 2011; Spyrou et al., 2021; Lopes et al., 2023). Recovery times between sprints were found to be higher in non-OFF matches (around 40s) when compared to OFF matches (around 15s) (Castagna et al., 2009; Caetano et al., 2015; Spyrou et al., 2021).

Professional players have been reported to spend between approximately 12% and 5% of the whole match in high-intensity running and sprinting actions in a simulated match (i.e. 4 x 10min), values lower than the approximate 14% and 9% values found during OFF competition (Barbero Álvarez et al., 2008; Castagna et al., 2009). Considering physiological parameters, a study conducted by Barbero Álvarez et al. (2008) found that players spent 83% of playing time above 85% of HRmax in OFF games as opposed to another investigation that reported that only 36% of the total time was spent at >80% of the maximum heart rate in non-OFF matches (Bekris et al., 2020; Spyrou et al., 2021).

Elite players perform more high-energy metabolic and mechanical actions during competition with shorter recovery times covering a greater total distance with higher intensity and perform a greater number of sprints or high-intensity actions during matches when compared to sub-elite players (Spyrou et al., 2020; Sekulic et al., 2020). Dogramaci et al. (2011) compared international and national-level futsal competitions and noted that elite teams covered a 42% greater total distance than sub-elite teams (4,277 ± 1,030m v. 3,011 ± 999m, respectively).

Contrary to this, the external match loads of the nine aforementioned male professional players that were monitored during all 20 games of the 2019-2020 season were not influenced by contextual factors (i.e. the opponents' level, the scoreline and the match location) (Spyrou et al., 2021).

Futsal match demands according to the opposing team's ranking position.

Variables		High (n = 6)	Medium (n = 8)	Low (n = 6)	*p* value
Total PL	a.u	4,021 ± 653	3,802 ± 703	3,804 ± 522	0.795
$PL{\cdot}min^{-1}$	a.u	10.3 ± 0.9	11.0 ± 0.9	11.0 ± 0.6	0.328
ACC_{HI}	nº	81 ± 5.5	71.7 ± 14.1	68.8 ± 16.6	0.625
DEC_{HI}	nº	73 ± 18.9	69.7 ± 19.5	64.5 ± 19.9	0.732
EXPL-MOV	nº	1,217 ± 163	1,171 ± 233	1,122 ± 182	0.131
COD_{HI}	nº	185 ± 24.1	166 ± 39.5	170 ± 24.5	0.477

Values expressed as mean ± SD. ACC_{HI}: acceleration; a.u: arbitrary units; COD_{HI}: change of direction; DEC_{HI}: deceleration; EXPL-MOV: explosive moments; nº: number; PL: player load; $PL{\cdot}min^{-1}$: player load per minute; SD: standard deviation.

External load according to match result and location.

		Match result				Match location			
Variables		**Win (n = 13)**	**Loss (n = 5)**	***p* value**	**ES**	**Home (n = 12)**	**Away (n = 8)**	***p* value**	**ES**
Total PL	a.u	3,846 ± 623	3,990 ± 689	0.675	0.22	3,757 ± 646	4,036 ± 498	0.315	0.47
$PL{\cdot}min^{-1}$	a.u	11.0 ± 0.7	10.2 ± 1.0	0.082	0.97	11.0 ± 0.5	10.5 ± 1.0	0.174	0.64
ACC_{HI}	nº	72.1 ± 16	79.4 ± 4.3	0.337	0.52	72.6 ± 15.9	74.4 ± 10.7	0.784	0.12
DEC_{HI}	nº	67.2 ± 20.8	70.4 ± 19	0.766	0.15	67.4 ± 20.7	70.4 ± 16.7	0.741	0.15
EXPL-MOV	nº	1,157 ± 203	1,210 ± 179	0.621	0.26	1,134 ± 206	1,212 ± 157	0.376	0.41
COD_{HI}	nº	171 ± 31.1	182 ± 26.2	0.491	0.37	169 ± 33.6	180 ± 21	0.405	0.38

Values expressed as mean ± SD. ACC_{HI}: high-intensity acceleration; a.u: arbitrary units; COD_{HI}: high-intensity change of direction; DEC_{HI}: high-intensity deceleration; ES: effect size; EXPL-MOV: explosive movements; nº: number; PL: player load; $PL{\cdot}min^{-1}$: player load per minute; SD: standard deviation.

The external match load and movement profile were similar whether the match took place at home or away. There were no differences in external load metrics, suggesting that players are exposed to high mechanical and kinematic loads regardless of the opponents' level. A decrease in players' physical performance throughout the match may have been the result of the coaching strategy/tactics (e.g. each player's playing style, match tempo, tactics) used or other situational and contextual factors (e.g. the scoreline, run of play, number of fouls) that slow the match tempo or influence the players' tactical roles.

2.5 Ball in and out of play

Analysing the profiles of 93 players over five official matches in the 2012 *Liga Nacional de Futsal*, Bueno et al. (2014) demonstrated that considering the match as a whole without taking into account the time when the ball is out of play underestimates the match intensity. Even when the ball is not in play, futsal matches can require physical efforts from players.

Condition	First half	Second half
In play	136.6 (17.2)	129.2 (16.7)*
Out of play	58.8 (10.4)	56.8 (14.8)
Whole game	97.9 (16.2)	90.3 (12.0)*

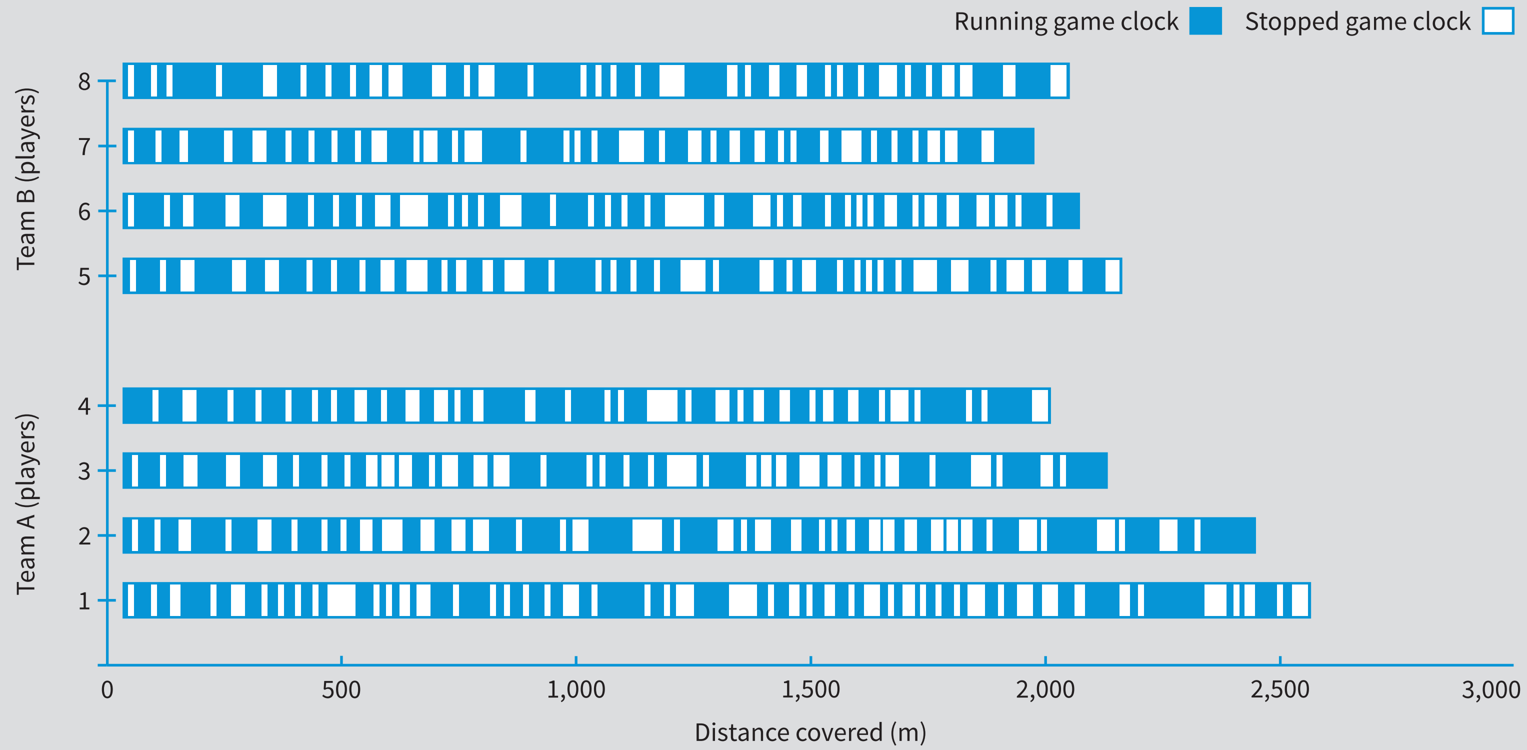
Total distance covered (m/min)

The total distance covered was 3,133.2m for the entire match and 2,133.9m and 1,028.5m for the in-play and out-of-play phases, respectively. There was an increase in the percentage of high-intensity running during the out-of-play periods from the first half to the second half, which may have been due to the number of attacking set pieces (corner kicks, kick-ins or free kicks) with high-velocity running immediately before when the moment the ball is in play.

During these periods (which consisted of more than 50% of the total match duration), players perform actions that should be considered when planning training sessions. Determining players' movement (distance covered) when the ball is both in and out of play can help coaches better estimate the physical profile of futsal match situations and design training drills to replicate actual match demands (Bueno et al., 2014).

Condition	Velocity ranges	First half	Second half	*p*
In play	Standing and walking	16.2 (5.7)	19.3 (8.3)*	<0.01
	Low-intensity running	41.9 (5.3)	42.1 (5.4)	0.69
	Medium-intensity running	20.1 (4.2)	17.8 (5.1)*	<0.01
	High-intensity running	10.3 (3.5)	9.6 (3.4)*	<0.01
	Sprinting	10.1 (6.1)	9.9 (5.0)	0.49
Out of play	Standing and walking	52.4 (11.9)	55.4 (15.2)*	0.72
	Low-intensity running	33.1 (8.0)	32.9 (11.1)	0.44
	Medium-intensity running	8.1 (5.9)	8.7 (5.5)	0.55
	High-intensity running	2.1 (2.4)	3.1 (3.2)*	<0.01
	Sprinting	1.5 (2.8)	1.7 (3.0)	0.29
Whole game	Standing and walking	28.0 (6.1)	30.8 (6.7)*	<0.01
	Low-intensity running	39.0 (5.0)	38.7 (4.0)	0.92
	Medium-intensity running	16.4 (3.4)	15.4 (3.4)*	<0.01
	High-intensity running	8.0 (2.4)	7.5 (2.0)*	<0.01
	Sprinting	7.6 (4.3)	7.2 (2.7)	0.32

The distance covered during the first half (1,710.6m) was not significantly different from that in the second half (1,635.9m).
Players reduced their physical performance during the second half. However, the reduction in the distance covered per minute between the two halves when only the in-play time was considered was from 136.6m per minute to 129.2m per minute.



Accumulated distance covered by professional futsal players during the first half of a match differentiated by in-play and out-of-play periods.

There was an increase in low-intensity actions (standing/walking) in the second half compared to the first half considering the match as a whole (30.8% v. 28.0%, respectively) and during the in-play time (19.3% v. 16.2%, respectively).

2.6 Most demanding/worst-case scenarios

Average values have traditionally been used to assess the physical demands of training and matches, but this approach may underestimate the most demanding scenarios (MDS) in matches and not reflect the true physical load (Serrano Luengo et al., 2020; Ila et al., 2021).

To optimally prepare players by understanding the demands of competition and the most intense periods, training drills can be designed to ensure that players are exposed to worst-case scenarios (WCS), particularly in technical-tactical training (García et al., 2022; Illa et al., 2021).

Spyrou et al. (2021) analysed match data from 26 matches (13 official matches (OFF) and 13 friendlies (non-OFF)) throughout the 2019-2020 and 2020-2021 seasons. OFF matches consisted of national (e.g. *Liga Nacional de Fútbol Sala* [LNFS] – Spain's top tier) or international (e.g. UEFA Futsal Champions League) matches, and non-OFF consisted of only friendly matches.

Researchers described the worst-case scenario during matches using either a fixed time period or rolling average using four time periods (i.e. 30-second, one-minute, three-minute and five-minute) and found that the use of rolling averages with short time intervals (30-60s) accurately described the intermittent high-intensity nature of the game, whereas using fixed periods underestimated the player load during WCS in 30-second, one-minute and three-minute intervals but not five-minute.

The differences in intensity calculated by rolling averages and fixed time periods:

Time window	PL · min⁻¹ (a.u.)	
	Rolling	Fixed
30-s	26.1 ± 2.84	24.2 ± 2.93
1-min	21.2 ± 2.21	19.6 ± 2.39
3-min	16.2 ± 1.68	15.9 ± 2.08
5-min	14.6 ± 1.69	14.9 ± 2.00

Match intensity during OFF matches (e.g. LNFS and UEFA Futsal Champions League) was found to be higher than during non-OFF matches when considering the 30-second and one-minute time windows. This could be explained by the importance of the OFF matches, in which winning is the priority, and players are more likely to undertake maximal intensity efforts as opposed to friendly matches, which are mainly focused on developing tactical, technical and physical abilities (Spyrou et al., 2021). Non-OFF games usually take place during preseason when players are completing high training loads, carrying residual fatigue and not at peak performance.

No difference in WCS was found between the matches as time windows increased (e.g. three- and five-minute intervals). Durations longer than three minutes may obscure the "actual intensity" of these matches because players are on the pitch for less than five minutes due to unlimited substitutions.

García et al. (2022) analysed 65 players in LFNS matches for FC Barcelona for two consecutive seasons (2018-2019 and 2019-2020). The peak physical demands and most demanding scenarios were only analysed when players were on the pitch.

This information can be used to establish the upper limit threshold to optimise the intensity of drills of different durations. The peak physical demands of elite futsal competitions are very high, therefore training programme should be designed to prepare players for such high-intensity periods. Coaches must consider individual variability when thinking about positional requirements and adapting these scenarios to the duration of the training drills.

An accurate understanding of the physical demands that players have to face during competition is important to consider in training prescription (Gabbett et al., 2012) and periodisation, with the aim of reducing the risk of burnout and injury (Bourdon et al., 2017; Vanrenterghem et al., 2017).

Descriptive results in selected physical demands for a professional futsal team (García et al., 2022)

Training duration (s)	Dist (m)	Dist > 18km/h (m)	Dist > 18km/h (n)	Acc > 2ms (m)	Dec > 2m/s (m)	Acc > 2m/s (n)	Dec > 2m/s (n)
30s	92.3 ± 8.1	25.4 ± 8.2	2.3 ± 0.7	37.6 ± 6.8	33.8 ± 6.2	6.8 ± 1.2	6.7 ± 1.2
60s	152.5 ± 13.5	29.3 ± 9.8	2.9 ± 0.9	50.7 ± 8.9	46.1 ± 8.2	9.7 ± 2.0	9.4 ± 1.9
120s	262.3 ± 21.6	36.2 ± 13.6	3.6 ± 1.3	74.7 ± 14.6	66.2 ± 11.8	14.5 ± 3.0	14.1 ± 3.0
180s	363.9 ± 29.1	41.1 ± 15.9	4.2 ± 1.5	96.1 ± 19.1	83.0 ± 15.4	18.8 ± 3.8	18.3 ± 3.9
300s	556.6 ± 45.3	49.6 ± 21.2	5.2 ± 1.9	131.8 ± 27.0	113.8 ± 22.3	26.3 ± 5.1	25.2 ± 5.4

		Time window (s)				
		30	60	120	180	300
(m.min⁻¹)	Defenders	186 ± 14	155 ± 10	133 ± 8	123 ± 7	112 ± 9
	Pivots	175 ± 15	143 ± 12	124 ± 11	115 ± 10	105 ± 9
	Wingers	187 ± 17	154 ± 14	132 ± 11	122 ± 10	113 ± 8
Distance HSR (m.min⁻¹)	Defenders	47 ± 14	27 ± 8	16 ± 5	12 ± 4	8 ± 3
	Pivots	43 ± 14	24 ± 7	15 ± 6	10 ± 4	7 ± 3
	Wingers	54 ± 17	32 ± 11	20 ± 7	15 ± 5	11 ± 4
HSR effort (n.min⁻¹)	Defenders	4.5 ± 1.4	2.8 ± 0.8	1.7 ± 0.5	1.4 ± 0.4	1.0 ±0.3
	Pivots	3.9 ± 1.4	2.4 ± 0.8	1.4 ± 0.5	1.1 ± 0.4	0.8 ± 0.3
	Wingers	4.8 ± 1.4	3.0 ± 0.9	1.9 ± 0.7	1.5 ± 0.5	1.1 ± 0.4
High acceleration distance (m.min⁻¹)	Defenders	75 ± 13	52 ± 8	39 ± 6	34 ± 5	28 ± 4
	Pivots	65 ± 9	44 ± 5	31 ± 5	27 ± 4	22 ± 3
	Wingers	78 ± 14	52 ± 9	39 ± 8	33 ± 7	27 ± 6
High acceleration effort (n.min⁻¹)	Defenders	13.9 ± 2.0	10.5 ± 1.8	7.8 ± 1.3	6.7 ± 1.2	5.7 ± 1.0
	Pivots	11.8 ± 1.9	8.1 ± 1.2	5.9 ± 0.7	5.1 ± 0.6	4.3 ± 0.5
	Wingers	13.9 ± 2.3	9.9 ± 2.0	7.5 ± 1.5	6.5 ± 1.2	5.4 ± 0.9
High deceleration distance (m.min⁻¹)	Defenders	66 ± 12	45 ± 7	33 ± 4	28 ± 4	23 ± 4
	Pivots	63 ± 13	42 ± 7	30 ± 5	24 ± 4	20 ± 3
	Wingers	69 ± 13	47 ± 9	34 ± 7	28 ± 6	24 ± 5
High deceleration effort (n.min⁻¹)	Defenders	14.4 ± 2.4	10.1 ± 2.1	7.5 ± 1.7	6.5 ± 1.4	5.4 ± 1.1
	Pivots	11.6 ± 2.0	8.0 ± 1.1	6.0 ± 0.7	5.0 ± 0.5	4.2 ± 0.5
	Wingers	13.7 ± 2.4	9.6 ± 1.7	7.2 ± 1.4	6.3 ± 1.2	5.2 ± 1.0

Illa et al. (2021) analysed the peak physical demands in elite futsal players from an elite Spanish team that competes in the LNFS and the UEFA Futsal Champions League using a local positioning system during 15 official matches in the LNFS (2018-2019 season), quantifying the most demanding scenarios of matches (external load from distance, HSR, acceleration and deceleration) and the differences between playing positions (defenders, wingers and pivots) over a season.

Peak physical demands are position-dependent with differences in the MDS being "higher" for wingers and defenders than for pivots due to the technical and tactical (attacking and defensive phases) demands of each position and the actions that each position performs during games (Caetano et al., 2015; Serrano Luengo et al., 2020).

Descriptive statistics for the most demanding scenarios of each dependent variable assessed across five time windows (Illa et al., 2021).

These findings have important practical implications for training design, as they reflect the importance of knowing the extent to which the different physical output targets must be adjusted in relation to the duration of a training drill. For example, for a given drill performed either as ten 30-second repetitions or one whole 300-second exercise, the target for relative distance for the defenders would need to be around 930m in each 30-second repetition and around 560m for the 300-second drill. In contrast, the total HSR distance target would decrease from around 235m to 40m.

Illa et al. (2020) demonstrated that MDSs (very highly demanding passages and highly demanding passages) were not isolated demands during matches but multiple occurrences.

PLAYING POSITIONS

A player's physical performance is influenced by their position, tactical role and the characteristics of the match itself (i.e. match stage) (Naser et al., 2017; Travassos et al. (personal communication)). All three playing positions (e.g. defenders, wingers, pivots) must be flexible and able to effectively change/rotate their positions during the match (Sekulic et al., 2019) so there is a tendency for match demands to be uniform and not position-specific with players all requiring a similar level of physical fitness (Dos Santos et al., 2022).

Individual tactical actions, with or without the ball, tend to present a similar external load regardless of playing position (Travassos, personal communication), so the frequency and type of the technical and tactical actions required in different playing positions may be what distinguishes the physical demands that players experience during a match or training session (Caetano et al., 2015; Illa et al., 2021; Ohmuro et al., 2020; Serrano Luengo et al., 2020; Ribeiro et al., 2022; Spyrou et al., 2020).

It is therefore essential that training is tailored to develop the specific technical-physical requirements for a given playing position. Pivots perform brief actions and, during the attacking phase, act as target players taking up positions in the attacking third with their back to goal, to link play, assist or shoot (Serrano Luengo et al., 2020). Pivots have the lowest frequency of HIA (Ohmuro et al., 2020; Ribeiro, Gonçalves et al., 2022).

Defenders completed less HIE out of possession (36.7 ± 6.1%) when compared to wingers (41.9 ± 6.1%). During defensive plays, the defender marks the opponents' pivot in the defensive third and the pivot or winger marks the opponents' defender or winger in the attacking third or midfield. If the opponents' pivot receives the ball, the pivot or winger drops to carry out a defensive role (Ohmuro et al., 2022).

The most physically demanding position is that of the wingers, who have a higher frequency of HIA (Ribeiro, Gonçalves et al., 2022; Travassos et al., (personal communication); Illa et al., 2021). Wingers usually play at a fast pace with continuous explosive actions (such as dribbling) and move around the pitch a lot. Wingers complete supporting runs during both the attacking and defensive phases of the game (Ohmuro et al., 2020).

The winger position is more physiologically demanding than the pivot position with the ball and the defender position without the ball. Wingers and defenders have the most similar profiles, which is probably because they commonly swap positions during matches (Serrano Luengo et al., 2020; Caetano et al., 2015).

Wingers complete greater HIA and HSR distances compared to the pivots (Serrano Luengo et al., 2020) due to the technical and tactical requirements of each position in the attacking role.

When wingers have the ball, they increase the number of 1v1 situations by boosting dribbling actions, dynamic receptions and, as a result, ball protections. Tactical actions without the ball include running deep to create space or goalscoring opportunities (Ohmuro et al., 2020). Wingers are also required to take up defensive coverage actions, due to the players' wide position on the pitch (Serrano Luengo et al., 2021), as well as engaging in individual duels.

Research has revealed little to no difference in physical performance between playing positions (Naser et al., 2017; Caetano et al., 2015).

In a recent study conducted by Serrano Luengo et al. (2020), the influence of playing positions and match stage on physical requirements in the LNFS was analysed. The external load from distance, speed, acceleration and deceleration variables were obtained from 14 elite futsal players during ten official matches in the 2019-2020 season.

Physical actions during the first and second half of a futsal match according to playing position:

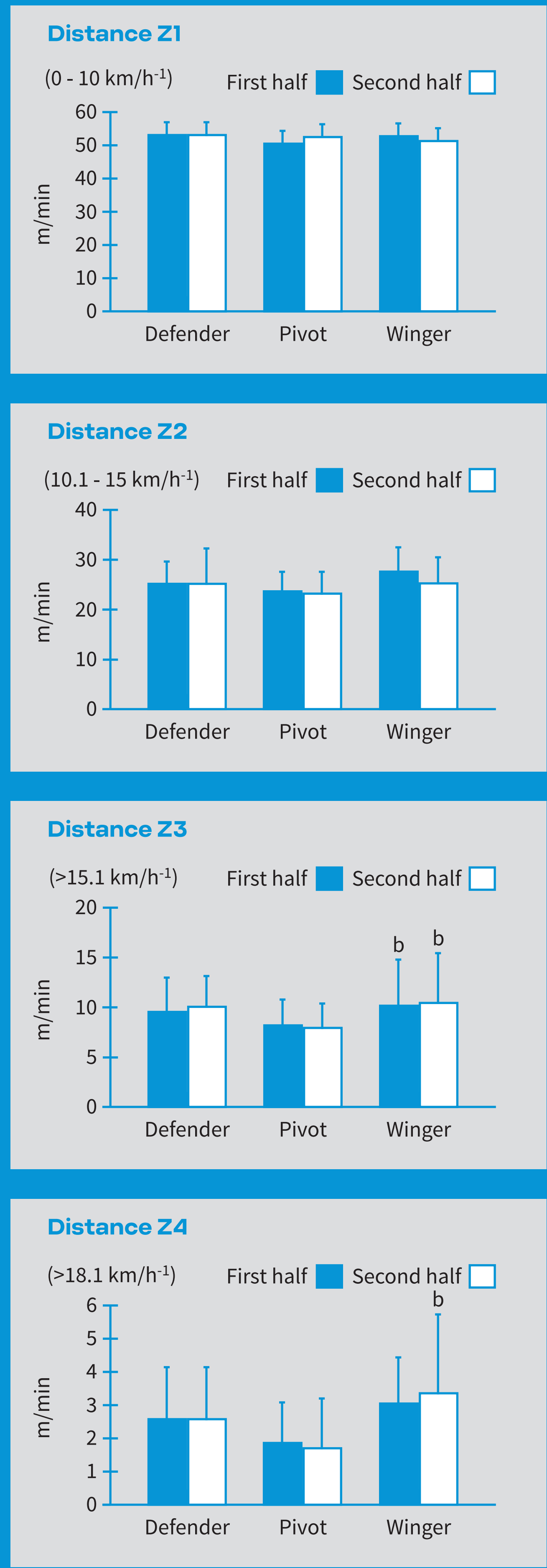
Half	Variable	Defender (1)	Pivot (2)	Winger (3)
First	Relative distance ($m \cdot min^{-1}$)	91.93 ± 9.41	85.58 ± 6.41	94.69 ± 9.66[b]
	Explosive distance ($m \cdot min^{-1}$)	14.53 ± 2.57	13.40 ± 2.04	15.72 ± 2.25[b]
	HIBD ($m \cdot min^{-1}$)	5.04 ± 1.56	4.45 ± 0.94	5.61 ± 1.11[b]
	HSR ($m \cdot min^{-1}$)	15.44 ± 5.10	12.99 ± 4.37	17.03 ± 4.86[b]
	Accelerations ($n \cdot min^{-1}$)	9.41 ± 9.73	7.42 ± 8.18	8.04 ± 8.09
	Decelerations ($n \cdot min^{-1}$)	9.12 ± 9.75	7.37 ± 8.14	7.77 ± 8.15
	ACC_{MAX} ($m \cdot s^{-2}$)	4.95 ± 0.63	5.00 ± 0.45	5.19 ± 0.48
	DEC_{MAX} ($m \cdot s^{-2}$)	-5.25 ± 0.63	-5.43 ± 0.56	-5.70 ± 0.59[a]
	ACC_{MEAN} ($m \cdot s^{-2}$)	2.46 ± 0.69	2.61 ± 0.68	2.63 ± 0.66
	DEC_{MEAN} ($m \cdot s^{-2}$)	-2.53 ± 0.73	-2.64 ± 0.70	-2.72 ± 0.70
	V_{MAX} ($km \cdot h^{-1}$)	20.60 ± 0.80	20.14 ± 0.98	21.03 ± 0.83
	V_{MEAN} ($km \cdot h^{-1}$)	6.26 ± 0.39	6.03 ± 0.40	6.46 ± 0.45*
	Number of sprints ($n \cdot min^{-1}$)	0.74 ± 0.33	0.59 ± 0.26	0.81 ± 0.24
Second	Relative distance ($m \cdot min^{-1}$)	91.80 ± 12.00	85.58 ± 9.01	91.50 ± 9.39
	Explosive distance ($m \cdot min^{-1}$)	14.67 ± 3.30	13.44 ± 2.13	14.94 ± 2.73
	HIBD ($m \cdot min^{-1}$)	5.17 ± 1.61	4.46 ± 1.14	5.32 ± 1.59
	HSR ($m \cdot min^{-1}$)	16.17 ± 5.43	12.30 ± 3.98	17.54 ± 6.35
	Accelerations ($n \cdot min^{-1}$)	9.05 ± 9.42	8.63 ± 9.07	7.26 ± 7.91
	Decelerations ($n \cdot min^{-1}$)	8.87 ± 9.42	8.28 ± 9.14	6.94 ± 7.87
	ACC_{MAX} ($m \cdot s^{-2}$)	5.00 ± 0.59	5.04 ± 0.46	5.12 ± 0.57
	DEC_{MAX} ($m \cdot s^{-2}$)	-5.29 ± 0.69	-5.41 ± 0.57	-5.71 ± 0.62
	ACC_{MEAN} ($m \cdot s^{-2}$)	2.50 ± 0.68	2.50 ± 0.66	2.67 ± 0.59
	DEC_{MEAN} ($m \cdot s^{-2}$)	-2.56 ± 0.70	-2.62 ± 0.72	-2.80 ± 0.65
	V_{MAX} ($km \cdot h^{-1}$)	20.46 ± 0.96	20.18 ± 1.02	20.68 ± 2.96
	V_{MEAN} ($km \cdot h^{-1}$)	6.24 ± 0.58	5.95 ± 0.51	6.15 ± 1.00
	Number of sprints ($n \cdot min^{-1}$)	0.73 ± 0.27	0.58 ± 0.21	0.88 ± 0.46[b]

The distances covered were similar between defenders, pivots and wingers, who averaged a relative distance covered per minute of 91 ± 9m per minute, 86 ± 6m per minute, and 95 ± 10m per minute, respectively, during the first half, and 92 ± 12m per minute, 86 ± 9m per minute, and 92 ± 9m per minute, respectively, during the second half.

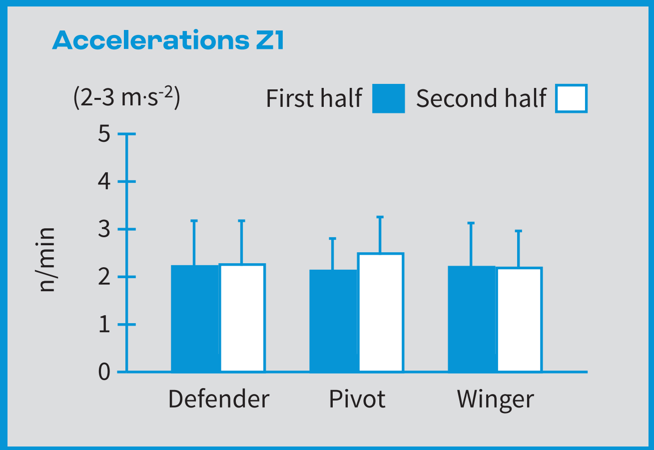
ZONE 1: walking and low-intensity running (0-10km/h); ZONE 2: medium-intensity running (10.1-15km/h); ZONE 3: high-intensity running (>15.1km/h); ZONE 4: sprinting (>18.1km/h).

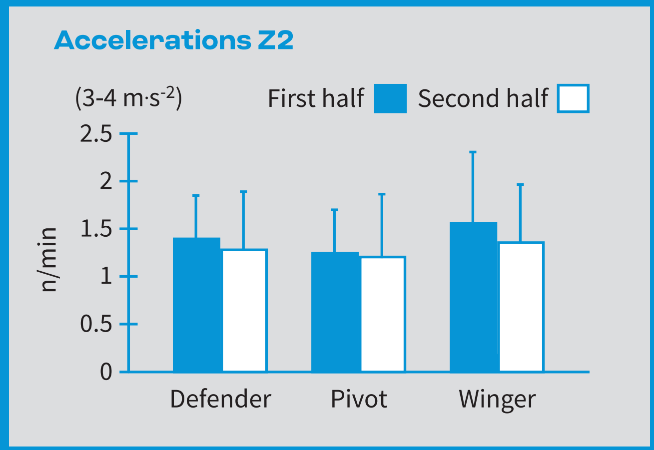
Wingers covered a greater HSR distance (HSR: >15.1km/h) than pivots throughout both the first half and the second half and sprint distance (>18.1km/h) during the second half, potentially due to a greater number of attacks completed. Possession play requires more HIA in comparison with play out of possession. The attacking player must perform fast powerful movements away from defending players to lose opponents and find space before receiving the ball or creating goalscoring opportunities.

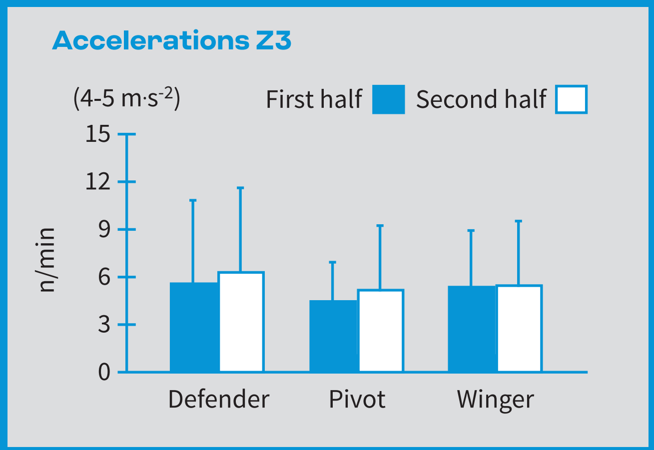
There were no differences in the acceleration/deceleration profile between positions. However, there was a suggestion that, due to the need to react and mirror opponents' movements/actions, defenders completed marginally more accelerations (9.41 ± 9.73m/s^2) and decelerations (9.12 ± 9.75m/s^2).

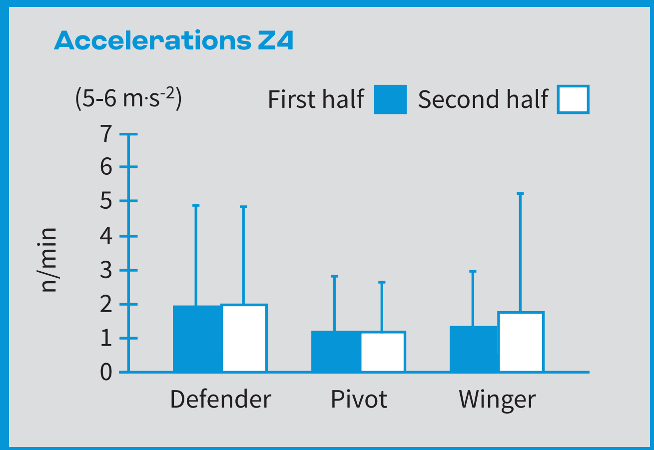


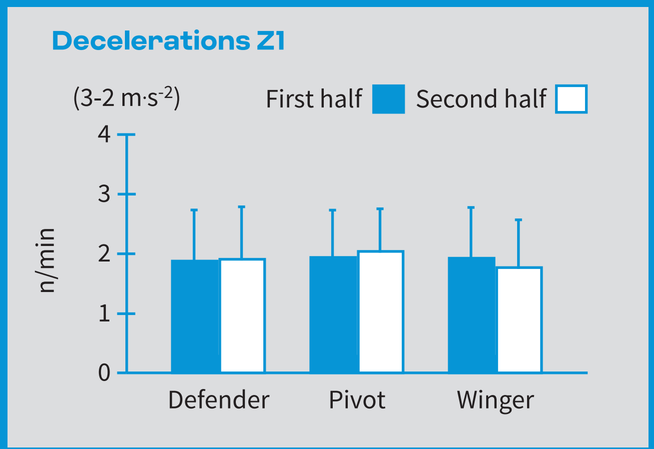
Relative distance covered in different speed ranges. [b] significant differences with respect to pivot ($p < 0.05$). Abbreviations: Z1, zone 1; Z2, zone 2; Z3, zone 3; Z4, zone 4.

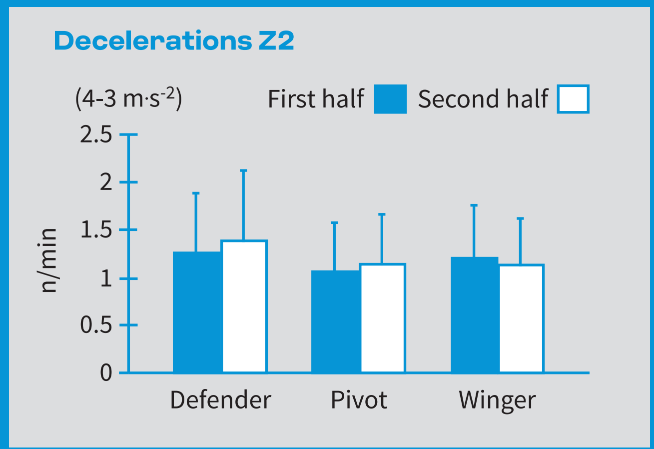


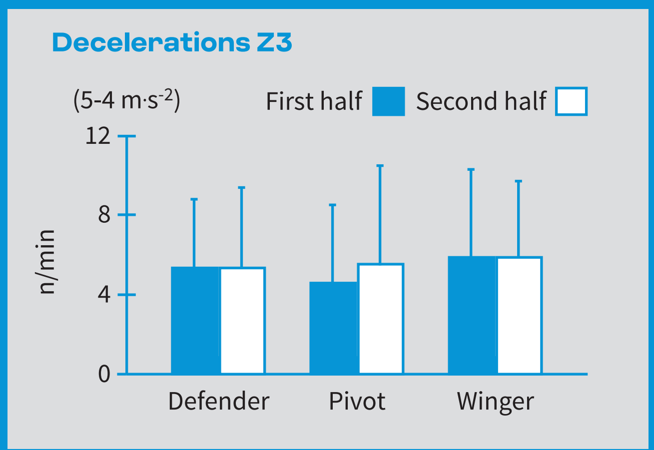


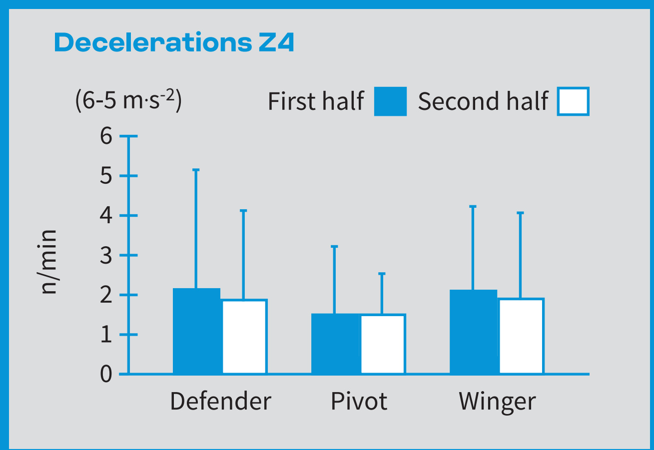












Number of acceleration and deceleration per minute in different speed ranges. Abbreviations: Z1, zone 1; Z2, zone 2; Z3, zone 3; Z4, zone 4.

Ohmuro et al. (2020) analysed six Japanese top-tier matches in the 2017-2018 season and reported no significant difference in the total distance covered according to the playing positions of 79 elite Japanese futsal players, which was consistent with the findings of previous studies on Spanish and Brazilian players (Barbero Álvarez et al., 2008; Caetano et al., 2015).

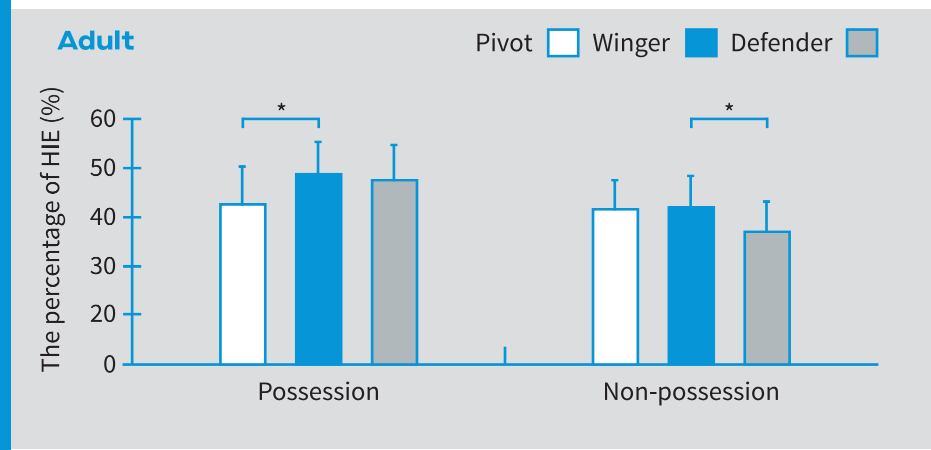
Total distance covered between different playing positions in both categories.

			Total playing time (min)	Total distance (m)	Total distance (m/min)	In-play (m/min)	Possession (m/min)	Non-possession (m/min)
Adult	Pivot	(n=17)	35.5 ± 10.6	4,050 ± 1,038	116 ± 6	140 ± 11	140 ± 15*	139 ± 12
	Winger	(n=38)	35.6 ± 9.2	4,226 ± 1,011	118 ± 8	144 ± 12	151 ± 15#	139 ± 13
	Defender	(n=24)	35.9 ± 6.6	4,105 ± 774	115 ± 9	139 ± 10	151 ± 15#	130 ± 11*
Youth	Pivot	(n=15)	36.6 ± 11.0	4,382 ± 1,200	121 ± 5	132 ± 5	135 ± 10	131 ± 9
	Winger	(n=23)	41.1 ± 11.1	4,859 ± 1,198	119 ± 8	134 ± 9	137 ± 9#	131 ± 10
	Defender	(n=21)	40.4 ± 10.6	4,667 ± 1,226	116 ± 6	128 ± 12	131 ± 15#	125 ± 9

Note: * $p < 0.05$ v. Winger; * $p < 0.05$ v. non-possession.

In elite Japanese futsal, the average total distance covered per minute during ball possession was significantly greater than that without ball possession (Ohmuro et al., 2020). The futsal pitch is narrow, and the attacking player must lose the opposition defender before receiving the ball. Consequently, gaining and retaining possession requires more HIA in comparison with when out of possession. Analysis of ball possession demonstrated significant differences between playing positions. The average total distance covered with ball possession in the pivot position (140 ± 15m per minute) was significantly lower than that in the winger and defender positions (151 ± 15m per minute; p<0.05) in adult players.

The proportion of high-intensity exercise (HIE) during matches in different playing positions.



The amount of HIE across all positions during adult matches was 43.2 ± 5.2%. The pivot is the target player during the attacking phase while the winger supports the pivot. Consequently, the intensity in the pivot position may be low during attacking phases. Futsal players are involved in both the attacking and defensive phases, so tailored technical training must be designed and carried out in order to develop position-specific physical requirements (Illa et al., 2021).

TACTICS IN AND OUT OF POSSESSION

Individual tactical actions require a combination of HIA efforts to be performed. Travassos (personal communication) identified 3,497 individual tactical actions without the ball compared to 737 when in possession in 19 elite Spanish futsal players playing in the LNFS (2018-2021).

In terms of the positional tactical action demands, the three most common tactical actions with the ball for:

- wingers are dribbling (43%), passing (16%) and dynamic ball control (11%);
- defenders are dribbling (22%), regaining possession (17%) and shooting (15%); and
- pivots are dribbling (32%), static ball control (18%) and dynamic ball control (16%).

In terms of movement patterns, the frequency of decelerations (DEC) is greatest, followed by accelerations (ACC) and high-speed running (HSR) in individual tactical actions in possession (static ball control, winning the ball back, shooting and passing).

Other actions in possession, such as dynamic ball control and intercepting, require both DEC and ACC actions, with much greater frequencies of DEC compared to ACC actions. When dribbling, all three HIA measures (ACC, DEC and HSR) are required with a significantly higher frequency of ACC regarding individual tactical actions without the ball. The three key tactical actions for:

- wingers are support movement – away (29%), marking – ball trajectory (27%) and marking – opponent trajectory (19%);
- defenders are marking – ball trajectory (28%), support movement – away (25%) and marking – opponent trajectory (20%); and
- pivots are support movement – away (29%), marking – ball trajectory (26%) and marking – opponent trajectory (19%).

The frequency of ACC is significantly greater than DEC and HSR in specific tactical actions out of possession, including “Help coverage”, “Marking – Opponent trajectory”, “Support movements – Break”, “Support movements – Away” and “Defensive return”.

The frequency of DEC is significantly greater than both ACC and HSR in “Marking – Individual duel”, as well as in “Marking – Ball trajectory”.

Frequency of HIA actions (ACC, DEC, HSR) according to action in and out of possession

	Action	ACC	DEC	HSR
Actions: With the ball	Static ball control	-	64	-
	Regain possession	-	60	-
	Shots	-	72	-
	Pass	-	111	-
	Ball protection	13	10	-
	Dynamic ball control	5	$75^{\pm\pm}\dagger$	-
	Interception	5	$49^{\pm\pm}\dagger$	-
	Dribble	169	$64^{++}\alpha$	$40^{++}\beta^{\#}\alpha$
Actions: Without the ball	Help coverage	142	$91^{++}\alpha$	$5^{++}\dagger^{\#\#}\dagger$
	Marking - Individual duel	19	$74^{\pm\pm}\beta$	$5^{++}\beta^{\#\#}\dagger$
	Marking - Opponent trajectory	341	272^{++}	$55^{++}\dagger^{\#\#}\beta$
	Marking - Ball trajectory	417	$504^{\pm\pm}$	$30^{++}\dagger^{\#\#}\dagger$
	Support movements - Strategy	21	20	$5^{++}\beta^{\#\#}\beta$
	Support movements - Break	120	$74^{++}\alpha$	$13^{++}\dagger^{\#\#}\beta$
	Support movements - Away	479	$321^{++}\alpha$	$186^{++}\alpha^{\#\#}\alpha$
	Defensive return	152	$84^{++}\alpha$	$67^{++}\alpha$

Individual tactical actions in and out of possession differed by playing positions.

Frequency of HIA actions (ACC, DEC, HSR) related to action in possession according to playing position (WG, DF and PV)

	Position	Action	ACC	DEC	HSR
Actions: With the ball	WG	Static ball control	-	38	-
		Regain possession	-	24	-
		Shots	-	37	-
		Pass	-	75	-
		Ball protection	11	5	-
		Dynamic ball control	-	53	-
		Interception	-	24	-
		Dribble	127	$47^{++}\alpha$	$29^{++}\beta$
Actions: With the ball	DF	Static ball control	-	9	-
		Regain possession	-	30	-
		Shots	-	26	-
		Pass	-	25	-
		Ball protection	5	5	-
		Dynamic ball control	-	12	-
		Interception	5	$18^{+}\beta$	-
		Dribble	23	$9^{+}\alpha$	$7^{++}\beta$
Actions: With the ball	PV	Static ball control	-	17	-
		Disarm	-	6	-
		Shots	-	9	-
		Pass	-	11	-
		Ball protection	-	-	-
		Dynamic ball control	5	10	-
		Interception	-	7	-
		Dribble	18	7	$6^{++}\beta$

Frequency of HIA actions (ACC, DEC, HSR) related to actions out of possession according to playing position (WG, DF and PV)

	Position	Action	ACC	DEC	HSR
Actions: Without the ball	WG	Help coverage	104	$65^{++}\alpha$	$5^{++}\dagger^{\#\#}\dagger$
		Marking – Individual duel	13	$45^{++}\beta$	$5^{++}\alpha^{\#\#}\dagger$
		Marking – Opponent trajectory	207	166	$41^{++}\beta^{\#\#}\beta$
		Marking – Ball trajectory	252	334^{++}	$19^{++}\dagger^{\#\#}\dagger$
		Support movements – Strategy	12	8	-
		Support movements – Break	56	$37^{++}\alpha$	$8^{++}\dagger^{\#\#}\beta$
		Support movements – Away	306	218^{++}	$128^{++}\alpha^{\#\#}\alpha$
		Defensive return	99	$50^{++}\alpha$	$40^{++}\alpha$
Actions: Without the ball	DF	Help coverage	33	21	-
		Marking – Individual duel	5	$24^{++}\beta$	-
		Marking – Opponent trajectory	97	82	$6^{++}\dagger^{\#\#}\dagger$
		Marking – Ball trajectory	126	120	$6^{++}\dagger^{\#\#}\dagger$
		Support movements – Strategy	5	7	-
		Support movements – Break	33	28	$5^{++}\dagger^{\#\#}\beta$
		Support movements – Away	118	$78^{++}\alpha$	$33^{++}\beta^{\#\#}\alpha$
		Defensive return	43	$22^{++}\alpha$	$20^{++}\alpha$
Actions: Without the ball	PV	Help coverage	5	5	-
		Marking – Individual duel	-	6	-
		Marking – Opponent trajectory	37	24	$8^{++}\beta^{\#\#}\beta$
		Marking – Ball trajectory	39	50	$5^{++}\dagger^{\#\#}\dagger$
		Support movements – Strategy	7	7	-
		Support movements – Break	31	$9^{++}\beta$	-
		Support movements – Away	55	$25^{++}\alpha$	$25^{++}\alpha$
		Defensive return	10	12	7

Only one player can be in possession at any given time, so a large percentage of HIA in futsal occurs without the ball. Creating tactical options requires movement from team-mates to support and provide passing angles based on the position of the player in possession and their distance from the opponent (Vilar et al., 2012), which can increase the number of HIA performed. When the team lose possession, they often attempt to press to recover the ball or drop into defensive positions, requiring the implementation of a number of HIA actions.

CONGESTED PERIODS OF COMPETITION

Weeks with two or more matches (congested weeks) may require different recovery and training strategies to minimise the effects of high loads in players, aiming to maintain performance and competitive levels (Clemente et al., 2019). Most international futsal competitions and play-offs of the main leagues around the world are played in congested periods, with matches played between very short recovery times (Ribeiro et al., 2021). When teams play two to three matches per week, there is a corresponding increase in stress levels, fatigue and injury risk (Nedelec et al., 2014; Bengtsson et al., 2013; Spyrou et al., 2020; Ribeiro et al., 2021). Performance and muscle function are also affected due to the increased levels of inflammation and muscle damage (Moreira et al., 2016; Ribeiro et al., 2021).

Physical performance was measured in 12 elite male futsal players to determine the match-to-match variation of physical performance over a short, congested period during two four-day FIFA Futsal World Cup™ qualifiers. Two periods with three matches within four days were analysed (Ribeiro et al., 2021). From MD1 to MD2, there was a 24-hour recovery time, whereas from MD2 and MD3 onwards, recovery time was 48 hours. The external load was measured to identify the capacity of players to maintain HIA during matches.

The external load assessment included kinematic (total distance covered, high-speed running (HSR, 12.1-18km/h) and sprinting (>18km/h)) and mechanical variables (number of accelerations (>3m/s²) and decelerations (>−3m/s²)) to identify the capacity of players to maintain HIA during matches. (Ribeiro et al., 2020; Serrano Luengo et al., 2020; Ribeiro et al., 2021).

Ribeiro et al. (2021) observed that congested periods did not affect the players' physical performance during match situations. However, this can differ in sub-elite players who are not conditioned as well (Dogramaci et al., 2015; Charlot et al., 2016). Charlot et al. (2016) analysed the intensity of matches on a four-day FIFA futsal tournament and reported no differences in heart rate, recovery kinetics or well-being, but a decrease in sprinting activity between matches. Dogramaci et al. (2015) reported a small reduction in sprinting and an increase in walking after a futsal tournament that lasted for more than one day.

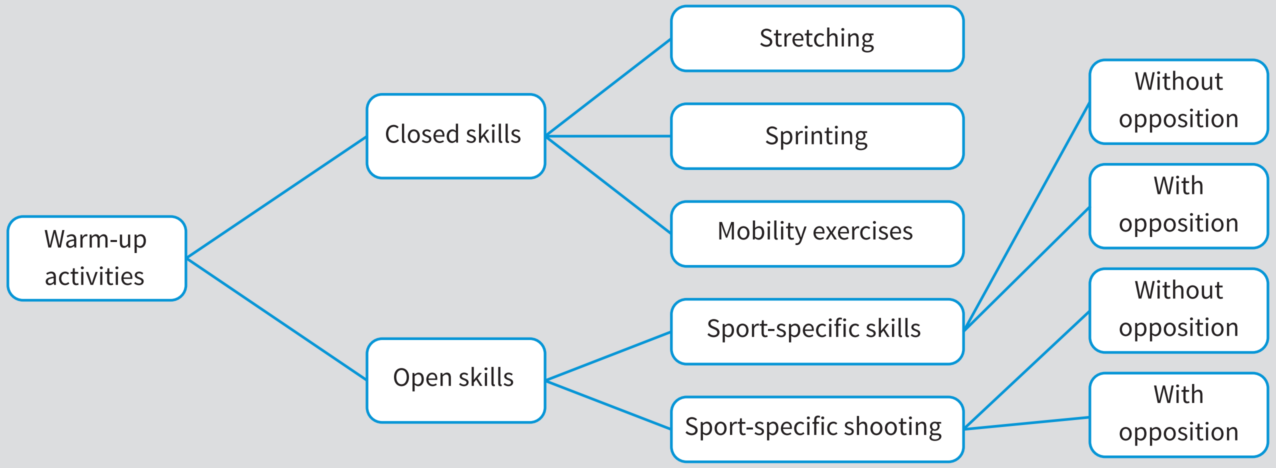
Ribeiro et al. (2021) noted that physical performance did not decrease during the short, congested period, but actually improved over the congested periods from MD1 to MD3. The players with more playing time reported a lower intensity per minute in each game and increased performance (high TDC and HSR) from MD1 to MD3, and therefore reported a higher internal load (perception) than players with less playing time. Players who played for longer revealed smaller increases in ACCs and DECs than players who played less from MD1 to MD3.

The high internal load and associated fatigue did not decrease players' running capacity, but may have limited the mechanical capability of players to perform ACCs and DECs, probably due to increased neuromuscular fatigue (Ribeiro et al., 2021). Playing time had a significant effect on physical performance with notable interindividual and intraindividual variability from MD1 to MD3. Despite players having different recovery profiles (Wilke et al., 2020), they all seemed to maintain their levels of performance between matches.

Fixture congestion is a multi-faceted problem where physical, technical, tactical and psychological issues combine and interact to impact player performance (Ribeiro et al., 2021).

5.1 Warm-up

Warm-ups are used in futsal prior to training and competition to increase muscle temperature, to optimise metabolic, psychological and neuromuscular mechanisms, and to increase player readiness (Nuno et al., 2020). Warm-ups utilise a variety of closed and open skills, such as sprinting and static/dynamic stretching to facilitate key performance abilities such as speed, change of direction, vertical jumping and reactive agility (Gabbett et al., 2008; Ayala et al., 2012). Small-sided games (SSG) and shooting exercises designed to achieve technical/tactical objectives are also included to enhance performance capacity.



Classification of exercises under specific categories according to their characteristics.

A piece of analysis was conducted on the pre-match warm-up practices of 43 elite players from eight teams competing in the *Taca de Portugal de Futsal* final across multiple seasons.

Descriptive analysis of each activity.

Variables	Total distance covered (m)			Distance covered (m/min)			Running (m/min)			Sprinting (m/min)			Accelerations (n/min)			Decelerations (n/min)		
	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max
$Skill_{WithoutOPP}$	231	8.4	431	61.4	10.2	92.8	0.7	0	21	0	0	6.1	0.9	0	4.1	0.6	0	3.1
Stretching	13.4	1.1	68.4	12.3	1.1	64.1	0	0	0	0	0	0	0	0	3	0	0	2.2
$Skill_{WithOPP}$	166	26.8	283	57.5	7.7	80.7	0.9	0	11.5	0	0	1.1	1.1	0	4	1.2	0	2.8
$Shoot_{WithoutOPP}$	215	19.4	517	65	23.4	104	8.5	0	27.6	0	0	10.3	0.8	0	3.1	0.7	0	3.3
$Shoot_{WithOPP}$	129	61	283	63.9	40.7	113	6.7	0	37	0	0	5.4	1.3	0	4.5	1.2	0	3.8
Sprinting	56.7	9.2	147	54.6	27.9	89.2	7.6	0	23.6	0	0	6.3	0,9	0	10	1	0	9.1
Mobility exercises	166	71.3	427	83	35.6	105	2.2	0	15	0	0	1.6	2.3	0	4.2	1.1	0	3

Warm-ups generally lasted for around 27.5 ± 9.2 minutes (ranging from 18 to 50 minutes) and included up to 11 drills (9.3 ± 1.8), mostly consisting of open-skill tasks (80% of total exercises). Some 20% of warm-up routines lasted for only 15 to 20 minutes.

Warm-up model design (Nuno et al., 2020)

- Includes around ten exercises grouped under different categories with a special emphasis on open skills important for match performance
- Mobility (closed skill) exercises – drills of sub-maximal aerobic intensity in order to increase muscle temperature (e.g. jogging, running, skipping back and forth and plyometric exercises) (roughly five minutes)
- Sport-specific (open) skills without opposition – individual shooting, two-player combinations, shooting from set pieces and tactical combinations plus static stretching exercises (around 7.5 minutes + two minutes)
- Sport-specific (open) skill exercises with opposition such as SSG or rondos with a different area/space and distances and a number of players followed by sport-specific shooting exercises – individual or two-player combinations for shooting and tactical combinations with three or four players in a progressive pattern ending with target practice (around five minutes)
- Sessions typically progress from drills without opposition (e.g. tactical combinations, individual shooting and set pieces) (around 8.5 minutes) to match-like situations (e.g. SSG, counter-attacks/attacking-defensive drills with different overloads between attackers and defenders (i.e. with gradually increasing numbers of players – 2v1 + GK; 3v1 + GK; 3v2 + GK) (for around four minutes)
- Repeated sprinting exercises such as ten-metre linear accelerations and with changes of direction (one to two minutes)
- Duration: around 27.5 to 36 minutes

The intensity of work progressively increases during warm-ups, mainly due to the higher number of accelerations and decelerations performed per minute. Open-skill drills (with/without opposition) were included in 90% of the total warm-up routines, with a higher focus on non-competitive tasks (68% of total time).

The warm-up period creates a significant load and players must be capable of coping with the demand in both training and competition alike. The warm-up/preparation aspects of the game, which contribute to overall levels of fatigue, should not be overlooked or underestimated.

5.2 Anthropometry/body composition

Research has shown that somatotype characteristics play a key role in achieving success in team sports (Figueiredo, Gonçalves, Coelho Silva and Malina, 2009). A player's anthropometrical profile is one of the key criteria associated with optimal performance in futsal (Lago Fuentes et al., 2020; Soares et al., 2023).

Numerous studies have identified the stature of elite players (domestic/international) in Europe:

- Unanue et al. (2020) reviewed 33 players from three teams which play in the Spanish National Futsal League (LNFS) (two elite teams and one amateur team were analysed) (stature: 175.48 ± 5.73cm; body mass: 73.43 ± 5.93kg; fat mass: 13.25 ± 3.57%).
- Travassos et al. (2023) assessed the stature of the Portuguese national futsal team (13 players aged 27.4 ± 4.7 years; height: 176.3 ± 5.5cm; weight: 70.3 ± 7.6kg).
- Lopes et al. (2023) described nine teams' elite/international-level male futsal players competing in the top-tier league in Portugal (*Liga Placard*) during the 2019-2020 season who had a mean age of 27.8 ± 5.4 years and mean body mass and height of 73.7 ± 9.5kg and 174.8 ± 7.6cm, respectively.
- Serrano Luengo et al. (2020) reported the stature of 14 elite futsal players (age 30.21 ± 3.98 years; height 1.77 ± 0.07m; weight 74.85 ± 6.40kg) from a professional club which plays in the LNFS.
- Ribeiro et al. (2022) reviewed 17 professional futsal players (age: 28.8 ± 2.4 years, weight: 73.7 ± 6.2kg, height: 175.9 ± 5.9cm) from an elite Spanish team that competes in the LNFS as well as the UEFA Futsal Champions League.
- Clemente et al. (2019) analysed 20 male professional futsal players (age: 27.8 ± 5.7 years old; height: 173.8 ± 5.6cm; weight: 71.5 ± 7.9kg) who participated in Portugal's *Liga Placard*.

Giro et al. (2022) characterised the body composition of Portuguese professional and semiprofessional male futsal players. A total of 78 futsal players were included in the study, 54 of whom were professional players competing in the *Liga Placard*. The training load of the professional players consisted of five 150-minute training sessions and one official game per week. The remaining 24 players were semi-professional athletes competing in the second- and third-tier competitions, with three 150-minute training sessions and one official game per week.

Variables	Total sample	Range
Anthropometry		
Age	23 [20 - 30]	18 - 37
Body mass (kg)	72.8 ± 1.0	55.7 - 99.1
Stature (cm)	176.0 ± 0.8	164.0 - 192.0
BMI (kg/m²)	23.5 ± 0.2	19.1 - 29.5
Triceps (mm)	8.2 ± 0.3	3.7 - 17.0
Subscapular (mm)	9.8 ± 0.3	6.0 - 18.0
Bicipital (mm)	4.0 ± 0.2	2.3 - 10.0
Iliac crest (mm)	11.7 ± 0.6	4.0 - 27.5
Supraspinal (mm)	9.1 ± 0.5	3.8 - 23.0
Abdominal (mm)	13.1 ± 0.7	5.9 - 29.0
Front thigh (mm)	11.3 ± 0.5	4.8 - 25.0
Medial calf (mm)	5.8 ± 0.3	2.5 - 15.0
Sum of 3SKF (mm)	32.6 ± 1.4	15.7 - 68.0
Sum of 4SKF (mm)	44.3 ± 1.9	22.5 - 95.5
Sum of 8SKF (mm)	73.0 ± 2.9	40.1 - 147.0
Arm-girth relaxed (cm)	29.9 ± 0.2	25.0 - 35.0
Arm-girth flexed and tensed (cm)	32.5 ± 0.2	28.5 - 37.1
Waist girth (cm)	78.2 ± 0.5	67.4 - 92.3
Gluteal girth (cm)	95.7 ± 0.5	84.5 - 109.3
Calf girth (cm)	37.1 ± 0.3	32.1 - 44.4
DXA		
Bone mineral content (kg)	3.2 ± 0.1	2.4 - 4.5
Fat-free mass (kg)	60.0 ± 0.7	45.6 - 73.8
Lean soft tissue (kg)	56.8 ± 0.7	43.2 - 70.1
Fat mass (kg)	11.4 ± 0.4	6.3 - 25.0
Fat mass (%)	15.8 ± 0.4	10.5 - 25.6
Visceral adipose tissue (cm²)	54.5 ± 1.6	29.7 - 105.8

Anthropometric and body composition characteristics (n = 78)

Data from southern European futsal players with similar training loads are similar to these findings of a mean body mass of about 72-75kg and a fat mass of around 12-16% (Barbero Álvarez et al., 2008; Spyrou et al., 2020; Ramos Campo et al., 2014; Rodrigues et al., 2011) assessed the body composition of players from a top-six team in the Brazilian *Liga Nacional de Futsal* (players' height 172.8 ± 5.5cm, weight 69-70kg, and body fat 9.6-10 ± 2.4%).

Anthropometric characteristics (i.e. height, body mass and body composition (fat percentage and muscle mass)) are important components of physical fitness. High levels of body fat can impair performance (Spyrou et al., 2020). Increased fat mass has been shown to negatively influence FSRAG (futsal-specific random agility) involving dribbling, and RSI (reactive strength) (Sekulic et al., 2021). Excess body weight may be associated with an increased risk of fatigue and injury, while a lower body fat percentage can be seen as protective in injury prevention in futsal players by improving mobility and agility (Soares et al., 2023). Range of motion is important to reduce the injury risk in futsal considering the volume of HIA completed (Lago Fuentes et al., 2020). A greater percentage of muscle mass can improve futsal performance as it contributes to energy production during high-intensity actions and enhances players' force production capabilities (Vila Suárez et al., 2008; Spyrou et al., 2020). The fat percentage and efficiency in SJ and CMJ are inversely correlated, indicating that a reduced fat percentage can increase the efficiency in explosive actions, a key factor in futsal (Lago Fuentes et al., 2020). Reducing body fat mass and increasing muscle mass is directly linked to gains in power, agility, speed and strength (Milanese et al., 2015; Santos et al., 2021) and enable players to move more efficiently (e.g. accelerate and decelerate at a higher rate).

Soares et al. (2023) assessed 186 players who participated in the 2022 Brazilian *Liga Nacional de Futsal* over the course of a season. When comparing positions, significant differences were found in total body weight, lean mass and fat mass.

Descriptive measurements of total body weight by assessment and tactical position, in the respective assessments carried out on athletes from the National Futsal League, 2022 edition.

Positions	Assessments				P
	First	Second	Third	Overall average	
Goalkeeper	79.78 ± 6.54	79.45 ± 7.21	77.94 ± 7.87	79.07 ± 7.20	0.496
Defender	77.50 ± 5.96	77.80 ± 5.99	77.47 ± 5.98	77.60 ± 5.94	0.958
Ala	70.15 ± 6.05	70.36 ± 6.02	69.73 ± 5.98	70.11 ± 6.00	0.801
Pivot	78.80 ± 7.17	79.15 ± 7.05	79.58 ± 6.85	79.15 ± 6.98	0.899
Overall average	**75.11 ± 7.58**	**75.15 ± 7.65**	**74.86 ± 7.76**	-	-

(Ala = winger; Fixed = defender; Pivot = forward)

Descriptive measurements of lean weight by assessment and tactical position.

Positions	Assessments				P
	First	Second	Third	Overall average	
Goalkeeper	70.06 ± 5.32	69.88 ± 5.83	68.71 ± 6.30	69.56 ± 5.80	0.564
Defender	68.33 ± 4.75	68.57 ± 4.72	66.87 ± 7.45	67.94 ± 5.77	0.338
Ala	62.29 ± 4.79	62.55 ± 4.93	61.71 ± 5.65	62.22 ± 5.10	0.536
Pivot	69.11 ± 5.43	69.59 ± 5.39	69.73 ± 5.15	69.46 ± 5.30	0.877
Overall average	**66.29 ± 6.03**	**66.42 ± 6.12**	**65.69 ± 6.99**	-	-

Descriptive measurements of fat percentage by assessment and tactical position.

Positions	Assessments				P
	First	Second	Third	Overall average	
Goalkeeper	12.11 ± 2.15	11.99 ± 2.03	11.17 ± 2.65	11.76 ± 2.31	0.173
Defender	11.74 ± 2.27	11.78 ± 2.21	11.71 ± 2.10	11.75 ± 2.18	0.982
Ala	11.12 ± 1.64	11.02 ± 1.50	10.92 ± 1.43	11.03 ± 1.53	0.696
Pivot	12.17 ± 2.28	11.96 ± 2.08	12.27 ± 2.08	12.13 ± 2.14	0.818
Overall average	**11.63 ± 2.05**	**11.53 ± 1.92**	**11.38 ± 2.05**	-	-

Descriptive measurements of body mass by assessment and tactical position.

Positions	Assessments				P
	First	Second	Third	Overall average	
Goalkeeper	9.71 ± 2.21	9.55 ± 2.14	8.83 ± 2.72	9.37 ± 2.39	0.243
Defender	9.16 ± 2.21	9.23 ± 2.21	9.12 ± 2.08	9.18 ± 2.16	0.966
Ala	7.85 ± 1.67	7.80 ± 1.52	7.67 ± 1.49	7.79 ± 1.57	0.721
Pivot	9.68 ± 2.45	9.55 ± 2.29	9.84 ± 2.32	9.69 ± 2.34	0.864
Overall average	**8.82 ± 2.21**	**8.74 ± 2.11**	**8.61 ± 2.22**	-	-

In terms of positional differences, De Moura et al. (2013) conducted a survey of 29 elite Brazilian players playing in the *Liga Paulista de Futsal* and the *Campeonato Metropolitano Paulista de Futsal* and noted that goalkeepers were slightly taller and heavier and had a higher percentage of body fat (1.78 ± 3.2cm, 74 ± 2.5kg, 13 ± 2%, respectively) than defenders (1.74 ± 1cm, 69 ± 2kg, 10 ± 2%), wingers (1.69 ± 3cm, 68 ± 2kg, 11 ± 2%) and pivots (1.73 ± 2cm, 71 ± 2kg, 10 ± 2%).

In a study of 186 elite professional players from the Brazilian league, goalkeepers were significantly heavier (85.95 ± 10.23kg v. 74.48 ± 8.11kg) and taller (180 ± 5.47cm v. 176.36 ± 5.75cm) than their outfield counterparts (Baroni and Leal Junior, 2010).

López Fernández et al. (2020) found similar body mass between elite and sub-elite players when comparing 16 male futsal players from three elite clubs belonging to the LNFS (25.8 ± 5.8 years; 176.2 ± 5.3cm; 74.85 ± 5.17kg) and 13 sub-elite male futsal players from two clubs playing in the third tier (23.2 ± 4.62 years; 173 ± 6cm; 71.25 ± 6.33kg). Elite players were found to have a higher lean mass in the dominant and non-dominant legs when compared to sub-elite players, while the latter showed higher bilateral asymmetry in body mass percentage.

PHYSIOLOGICAL DEMANDS

6.1 Cardiovascular load

During matches, players spend more than 80% of their playing time performing at above 85% of HRmax (Barbero Álvarez et al., 2008; Makaje et al., 2012; Clemente et al., 2019; Rodrigues et al., 2011; Dogramaci et al., 2011; Miloski et al., 2014), which reflects the high-intensity nature of the sport. During international tournaments, across the three matches, cardiovascular load during games equated to an average of 87.7% HRmax with peak values exceeding 98.3% based on playing time (Yiannaki et al., 2020).

Internal workload measurements in a futsal team used as a point of reference during international tournament match play (mean ± SD)

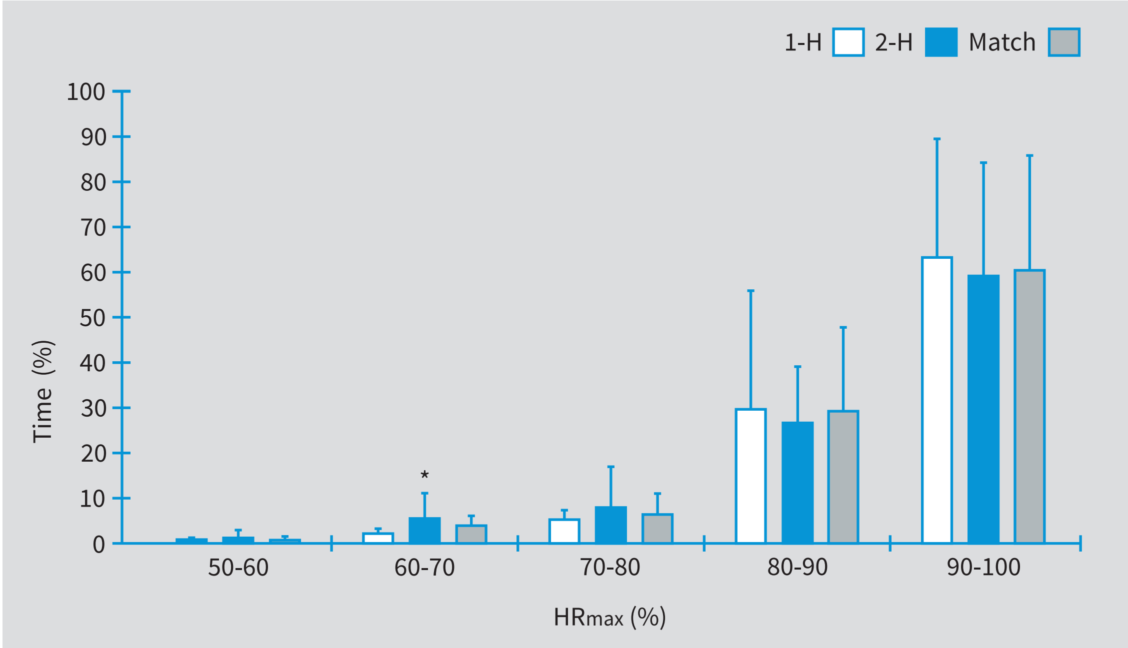
Variables	Match 1	Match 2	Match 3	Total
Total chronological game time	01:21:43 mins	01:15:40 mins	01:25:13 mins	01:20:52 mins
Heart rate *during pitch time *** (beats min^{-1})**	167.9 ± 21.3	168.5 ± 18.7	158.1 ± 25.1	164.8 ± 22.3
Heart rate *during pitch time *** (% maximum heart rate)**	88.7% ± 3.8%	88.3% ± 4.0%	85.0% ± 7.1%	87.7% ± 4.4%
Peak heart rate *during pitch time *** (% maximum heart rate)**	99.3% ± 2.2%	97.9% ± 2.7%	97.3% ± 2.9%	98.3% ± 2.5%

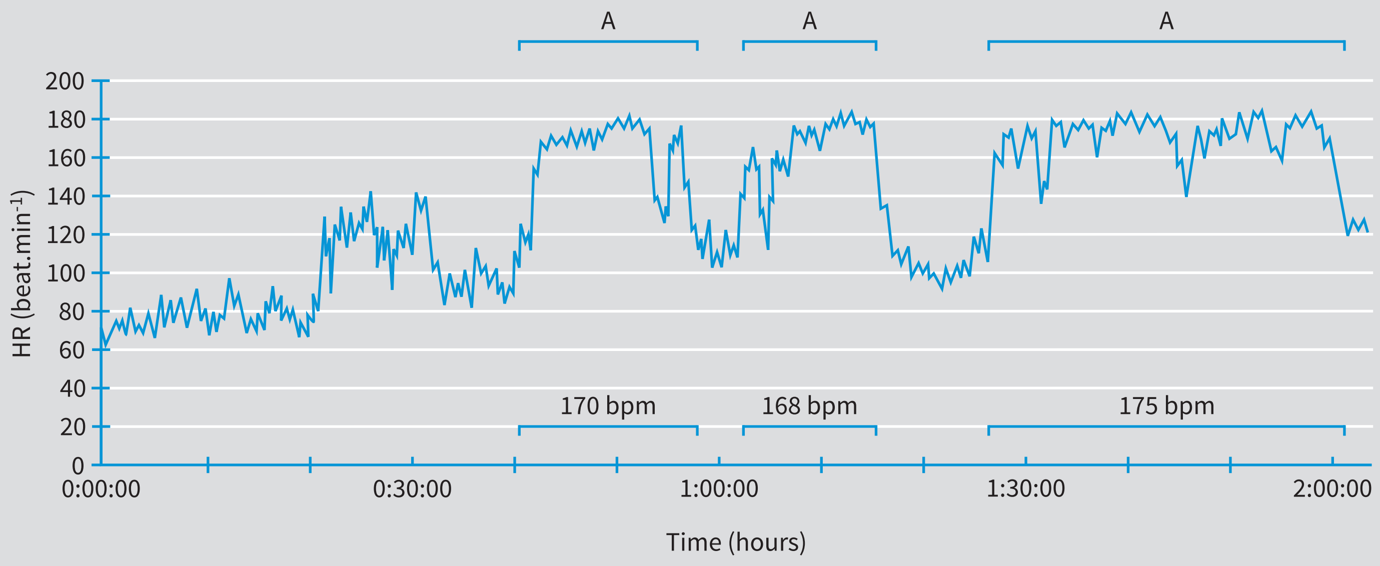
*Data collected per minute of pitch time filtered to exclude half-time, bench time and timeouts.

Dos Santos et al. (2020) reported the percentage of time for which the players remained in each of the five % HRmax zones did not differ between the first and second halves either, except 60-70% HRmax. For most of the match, the players remained in the high-intensity zone (>90% HRmax).

Percentage of time in five zones of % HRmax (1-H = first half; 2-H = second half)

During matches, players' heart rates rarely fall below 150bpm, possibly due to short and incomplete rest periods (Naser et al., 2017). Such demands are also required during training sessions, in particular, in small-sided games and simulated games, which are often used by coaches to simulate the characteristics of official matches (Miloski et al., 2014).





Example of a player's heart rate (HR) measurement during a match. Line A shows the HR recorded when the athlete was on the pitch playing (walking, jogging and running).

Changes in heart rate may be caused by fatigue or reduced work rate, or influenced by changes in game situations and tactical demands.

6.2 Aerobic capacity

The aerobic energy system has a crucial role in futsal (Barbero Álvarez et al., 2008; Ribeiro et al., 2020; Naser et al., 2017) as the match intensity and tempo require players to develop a high level of aerobic conditioning for energy production to resist fatigue and optimise recovery from HIA and repeated sprints (Nunes et al., 2012; Wilke et al., 2020; Castagna et al., 2009; Miloski et al., 2014; Oliveira et al., 2012; Spyrou et al., 2020).

With match demands in excess of 75-85% of maximal aerobic power and lactate concentrations of >5mmol/l having been recorded in matches (Castagna et al., 2009; Makaje et al., 2012; Dos Santos et al., 2022; Barbero Álvarez et al., 2008; Makaje et al., 2012; Rinaldo et al., 2022; Ayarra et al., 2018; Naser et al., 2017; Spyrou et al., 2020; Ribeiro et al., 2020; Dos Santos et al., 2020; Yiannaki et al., 2020), players must have well-developed aerobic and anaerobic capacities (Nogueira et al., 2016; Naser et al., 2017; Castagna et al., 2010; Serrano Luengo et al., 2020; De Freitas et al., 2019; Beato et al., 2016).

To optimise performance, it is suggested that players should have maximal oxygen uptake ($\dot{V}O_2max$) values > 60ml/kg per minute (Barbero Álvarez et al., 2008; Pedro et al., 2012; Ayarra et al., 2018, Spyrou et al., 2020) to ensure greater recovery capacity and lower subjective perception of the training load (Pedro et al., 2013).

6.3 Anaerobic capacity

The intermittent nature of futsal places significant reliance upon the anaerobic system for energy production (Castagna and Barbero Álvarez, 2010; Miloski et al., 2016). Most key HIA in futsal matches (sprints, stops, accelerations, decelerations and changes of direction) occur following efforts of <5s in duration (performed at high speeds and intensities), the energy for which is primarily supplied through the alactic anaerobic pathway (ATP and creatine phosphate) (Wilke et al., 2020). Anaerobic glycolysis increases when HIA are more frequent and/or longer in duration as the delivery and metabolism of oxygen in the blood and muscles is insufficient to cope with demands (Baker, McCormick and Robergs, 2010).

The extent to which a sport is considered "demanding" can be identified by the circulating blood lactate concentrations, which have been recorded as >4.0mmol/l during futsal matches (Milioni et al., 2016; Dos Santos, 2020). In a simulated match with four ten-minute periods and five-minute pauses, the [La−] remained unchanged, with a mean of 5.3mmol/l (Castagna et al., 2009; Dos Santos et al., 2020). Confounding issues of different sampling periods and methods of analysis results in a loss of accuracy in evaluating the metabolic demand. In studies where blood samples are only collected at half-time or full time, it can result in the loss of information (Stolen et al., 2005; Dos Santos et al., 2020).

Since substitutions are unlimited in futsal, verifying players' [La−] after each substitution during the match provides accurate information and insight to understand the anaerobic demand.

When blood lactate samples were collected throughout the match for analysis, each substitution reported high [La−] values with a mean of 8.3mmol/l and no reduction between the first and second halves was observed (Dos Santos et al., 2020). Using similar sampling techniques, Bekris et al., (2020), reported incredibly high mean blood lactate values (first half: 14.9 ± 4.9mM; second half: 15.0 ± 4.7mM).

Similar HR and [La−] values between the first and second halves can be explained through the use of substitutions and the time spent on the pitch. The level of the players/competition, tactics, match intensity, the absence of substitutions during the match and analysed players' low aerobic capacity may explain the variation in [La−] in the match and reductions seen in the second half. Low levels of aerobic fitness can explain the high values of [La−], since the [La−] response is a result of the production-removal ratio (Stolen et al., 2005).

6.4 High-intensity actions (HIA)

During matches and training, players frequently complete high-intensity actions (HIA) to change their speed or direction and perform high-braking events (Spyrou et al., 2020; Travassos (personal communication)). HIA describe both mechanical (acceleration and deceleration) and kinematic (speed and distance covered) aspects. The analysis of HIA (Ribeiro et al., 2022; Spyrou et al., 2020) allows for a more holistic understanding of the physical requirements of the game and the physical impact of individual tactical (attacking/defensive) actions (Serrano Luengo et al., 2020).

There is significant variation in the HIA between elite futsal players (Ribeiro et al., 2022). An analysis of 19 male players for an elite futsal team in seven competitive matches from the LNFS (2018-2021) identified 4,234 HIA and tactical actions. These passes, dribbles, marking actions or defensive returns – corresponding to the specific actions that players perform individually to contribute to teamwork – were similar between playing positions. However, the frequency and type varied according to playing position (Travassos et al., personal communication).

A variety of situational factors can influence a number of HIA during a match, including the number of minutes already played, the number of substitutions, the time spent on the pitch, the accumulated load in the period immediately preceding the HIA, the strength of the opposition, and the current score. (Novak et al., 2021). A high-frequency substitution strategy predisposes players to be available for both attacking and defensive actions. After each substitution, futsal players see an increase in the distance covered and the ability to sprint.

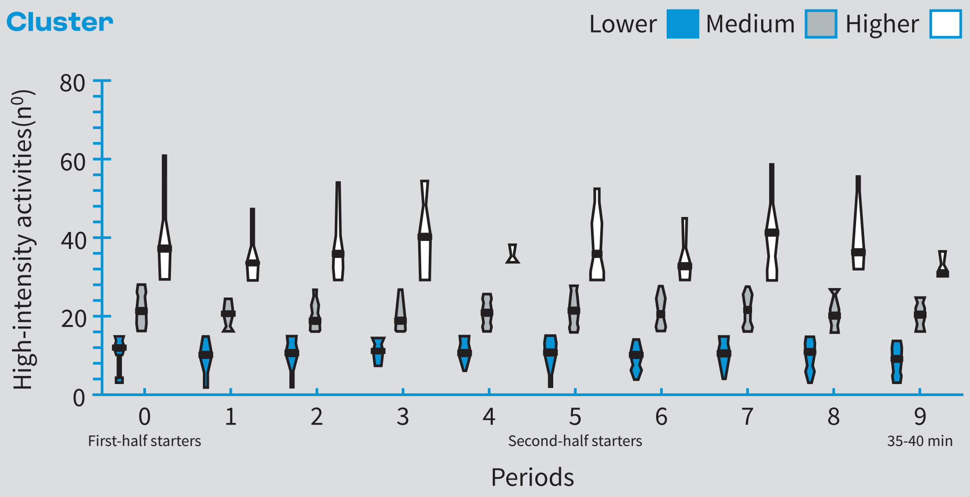
An analysis of 12 matches involving 17 elite professional futsal players (from an elite Spanish team that competes in the LNFS and the UEFA Futsal Champions League) identified that players performed an average of two to three substitutions per half with an average of 20 HIA per substitution. With an average of 3.9 minutes per substitution and a work-to-rest ratio of 1:1, players spent equal time on the pitch and on the bench with the same "ball in-play time". Players averaged between four and five substitutions per match, resulting in a team total of 450 substitutions (Ribeiro et al., 2022).

Mean time on the pitch and bench durations per player rotation and counting different HIA.

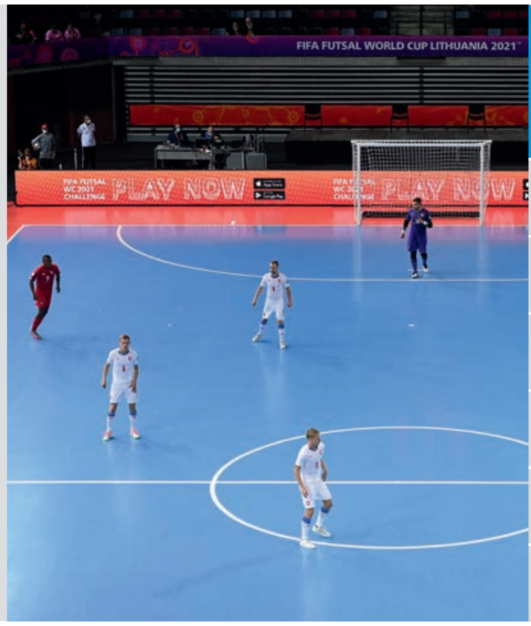
Time variables					External load variables			
Playing time		Rest time						
Effective time	Total time	Effective time	Total time	Work-to-rest ratio	ACC	DEC	HSR	HIA
3.9 ± 1.1	7.6 ± 2.3	3.9 ± 2.9	7.6 ± 5.4	1.0 ± 0.4	8.0 ± 5.3	8.0 ± 5.1	4.0 ± 2.4	20.0 ± 11.2

ACC, high-intensity accelerations; DEC high-intensity decelerations; HIA, high-intensity activities; HSR, high-speed running (sum of ACC, DEC, and HSR).

The phosphagen energy system plays an important role in futsal and is essential for HIA. The ATP-CP replenishment time is close to 20 seconds of rest, and the intramuscular reserve restoration time (three to four minutes) is approximately within the average time (3.9 minutes) that elite futsal players are on the bench (Ulupınar et al., 2021). This period allows players to recover and undertake high work rates and HIA when substituted back on (Ribeiro et al., 2022).



The mean and distribution of HIA for the three clusters between match periods.



Variables	Cluster (mean ± SD)		
	Lower	Medium	Higher
Playing time	3.4 ± 1.2	4.0 ± 0.9	4.6 ± 1
Work-to-rest ratio	0.8 ± 0.4	1.0 ± 0.4	1.1 ± 0.6
Accumulated work-to-rest ratio	1.0 ± 0.5	1.2 ± 0.6	1.4 ± 0.8
Accumulated rest time	10.8 ± 6.2	9.4 ± 5.9	7.8 ± 5.9
Rest time	4.3 ± 2.8	3.9 ± 2.9	3.4 ± 2.7
Accumulated playing time	10.2 ± 4.7	10.8 ± 5.5	10.6 ± 6

The findings highlight the importance of developing a training programme that emphasises the work-to-rest ratio (energy system) required to play futsal (Santos et al., 2020; Ribeiro et al., 2022). Players with more playing time and with a work-to-rest ratio equal to or greater than 1 are the ones with the higher capacity to repeat HIA (Ribeiro et al., 2022), which could be related to a decrease in body temperature when resting on the bench (García et al., 2020; Silva et al., 2018). To minimise this cooling effect, it is suggested that players prepare to come on the pitch and warm up again to maximise readiness.

Depending on the player activity profile, elite futsal players can be categorised into three groups: lower HIA (10 HIA), medium HIA (28 HIA) and higher HIA (38 HIA) per substitution. This reflects the players' recovery capacity (Ribeiro et al., 2022).

Classification of cluster physical profiles of futsal players.

Variables	Higher M ± SD	Medium M ± SD	Lower M ± SD
Kinematics			
Distance covered per minute	364 ± 180	231 ± 46	185 ± 102
Walking per minute (0–6km/h)	249.2 ± 120.3	100 ± 29.5	114.7 ± 64.2
Jogging per minute (6–12km/h)	82.2 ± 67.3	80.5 ± 13.2	43.9 ± 37.8
Running per minute (12–18km/h)	49.8 ± 53.5	30.8 ± 15.3	16.1 ± 17.6
Sprinting per minute (> 18km/h)	26.7 ± 31.5	8.2 ± 3.18	3.9 ± 3.3
Sprints (n/min)	3.0 ± 1.0	2.0 ± 1.0	2.0 ± 1.0
Mechanical			
ACC (n/min)	5 ± 1	6 ± 2	3 ± 2
DEC (n/min)	10 ± 4	5 ± 1	2 ± 2
No. of jumps (n/min)	1 ± 1.3	0.6 ± 0.6	0.5 ± 0.46
Total impact (n/min)	42 ± 27	29 ± 16	75 ± 86
Player load (a.u./min)	4.3 ± 0.7	4.3 ± 1.3	6.2 ± 5.7
DSL (a.u./min)	20.7 ± 11	14.4 ± 7.9	17.2 ± 11.2
Metabolic			
Metabolic power per minute	16.9 ± 32.5	1.4 ± 2.6	1 ±0.6
HMLD per minute	24.8 ± 2.3	22.9 ± 11.2	21.3 ±7.6

M, mean; SD, standard deviation; PI, predictor importance; *p < 0.05 higher with medium; **p < 0.001 higher with medium; higher with lower; #p < 0.05 medium with lower; and ##p < 0.001 medium with lower.

6.5 Sprinting – repeated sprint ability (RSA)

Repeated sprint ability and the associated anaerobic capacities are absolutely essential because of the numerous HIA such as sprints, changes of direction, accelerations and decelerations followed by short rest periods (Caetano et al., 2015; Naser et al., 2017; Ribeiro et al., 2020; Serrano Luengo et al., 2020). Consequently, the players' neuromuscular response and resistance to fatigue play a fundamental role in futsal performance (Loturco et al., 2015).

Researchers analysed 97 professional futsal players in the Brazilian *Liga Nacional de Futsal*. Irrespective of position, match analysis revealed a distinct movement profile. During a match, players complete around 26 ± 13.3 sprints (≥18.4km/h) with an average duration of 2-4s over 8-20m comprising sequences of two, three and four consecutive sprints, with 15-60-second rest intervals (Caetano et al., 2015; Spyrou et al., 2021; Ayarra et al., 2018). The repeated-sprint sequence was more predominantly two or three sprints with a recovery interval of up to 15 seconds between them (Caetano et al., 2015; Nuno et al., 2020).

Positions	Distance covered per sprint (m)		Duration (s)		Peak velocity (m*s-1)		Initial velocity (m*s-1)		Recovery time between sprints (s)		Sprints per minute	
	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Defender	13.5 (6.1)	13.6 (6.1)	3.1 (1.2)	3.2 (1.2)	5.9 (0.7)	5.9 (0.7)	1.5 (1.3)	1.4 (1.3)	57.3 (59.0)	62.4 (66.6)	0.9 (0.3)	0.8 (0.3)
Winger	13.3 (5.6)	14.3 (6.6)	3.1 (1.1)	3.3 (1.3)	5.9 (0.7)	6.0 (0.8)	1.4 (1.2)	1.3 (1.2)	55.7 (62.4)	61.2 (68.7)	0.9 (0.4)	0.9 (0.5)
Pivot	13.2 (5.7)	13.9 (6.5)	3.1 (1.2)	3.2 (1.3)	5.9 (0.7)	6.0 (0.8)	1.4 (1.3)	1.4 (1.2)	53.3 (58.0)	68.6 (82.5)	0.8 (0.4)	0.7 (0.2)
Total	**13.3 (5.7)**	**14.0 (6.5)**	**3.1 (1.2)**	**3.2* (1.3)**	**5.9 (0.7)**	**5.9 (0.7)**	**1.4 (1.2)**	**1.4 (1.2)**	**55.3 (60.5)**	**63.2 (71.6)**	**0.9 (0.4)**	**0.8 (0.4)**

These sprint metrics are higher than those of 10.5m for distance and 1.95s for the sprint duration reported by Castagna et al. (2009), with a sprint every 79s and a recovery of <40s. In another study, Dogramaci et al. (2011) recorded a value of 13m for the distance covered with a sprint duration of 1.9s. Results between analyses should be taken with a pinch of salt because the methods of analysis and speed thresholds may differ.

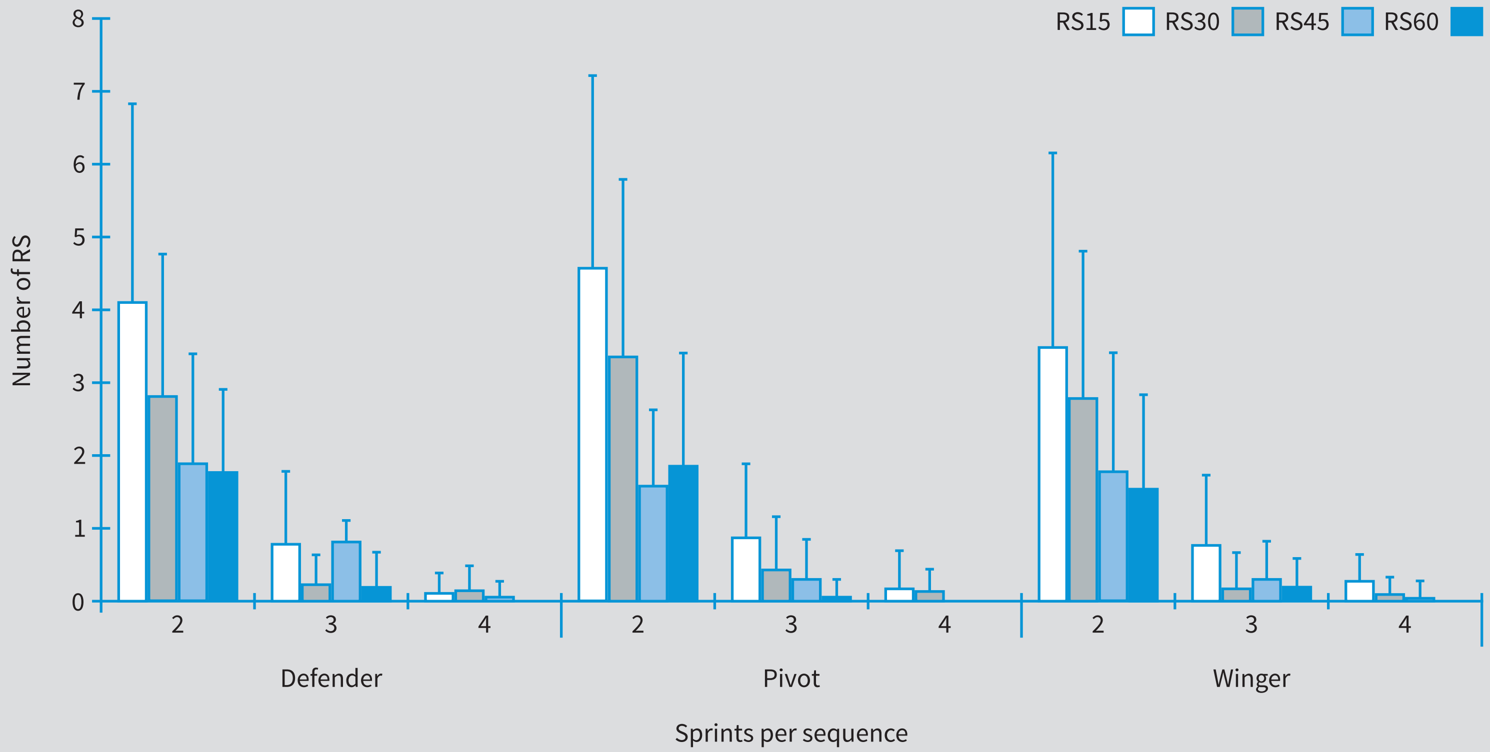
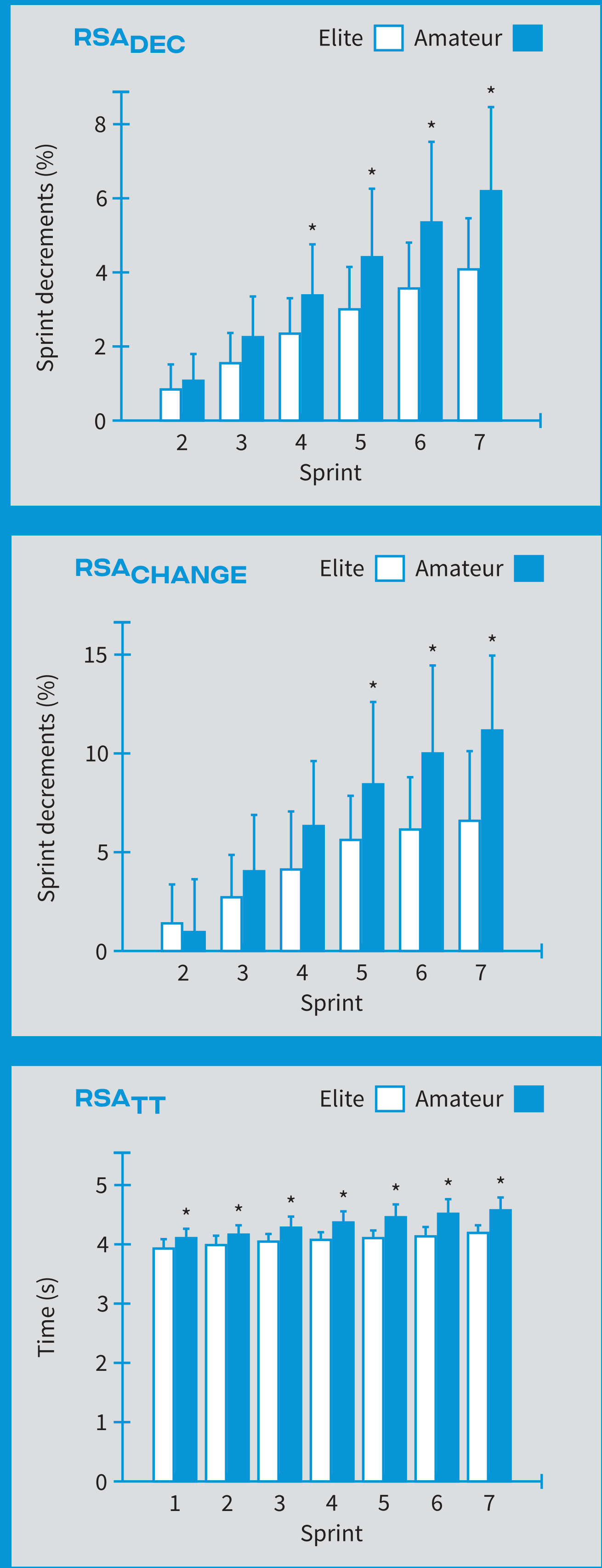


Figure: The mean and standard deviation of the number of repeated-sprint sequences per player. RS15 = repeated-sprint sequence with intervals of 15s between sprints; RS30 = repeated sprint sequence with intervals of 30s between them; RS45 = repeated-sprint sequence with intervals of 45s between them; RS60 = repeated-sprint sequence with intervals of 60s between them. (Caetano et al., 2015)

No differences were found for playing position or match stage with regard to the sprint distance covered, peak velocity, initial velocity, recovery time between consecutive sprints, and number of sprints per minute, which reflects the interchangeability of roles (attacking/defending) in futsal and the need for players to be tactically versatile (Caetano et al., 2015; Serrano Luengo et al., 2020).

The low frequency of repeated sprints in futsal may be related to the characteristics and constraints of futsal rather than player conditioning. A futsal pitch is small, so the players may not have enough space to reach the velocity threshold for rating some efforts as sprints.



Differences in the results of the RSA test between elite (n=20) and amateur (n=13) futsal players. *p <0.05.

To develop RSA capacity, players must possess strength, power, agility, balance and coordination (Naser et al., 2017) in addition to aerobic and anaerobic capacities. It is essential that players have well-developed neuromuscular capabilities that enable them to successfully perform actions that require high-power outputs (e.g. sprints, jumps and rapid changes of direction) and cope with the high-intensity demands of competition (Ayarra et al., 2018).

Analysis of three clubs (two elite LNFS teams and one amateur team) identified that elite players performed better in the RSA test than amateur players in a 30-metre test and in the agility test (Unanue et al., 2020).

The elite players obtained better results in the average time, total time and best sprint time variables. Elite players achieved better sprint times than amateur players from the first repetition while amateur players were more affected by fatigue from the fourth sprint onward, possibly due to low aerobic conditioning and poorer recovery skills. Elite futsal players run faster over 5m, 10m and 20m than sub-elite or amateur players (Naser and Ali, 2016; Sekulic et al., 2019; Spyrou et al., 2020).

Top-tier Spanish futsal players sprinted 5m in 1.36 ± 0.04s and 20m in 3.36 ± 0.09s, while second-tier players demonstrated lower sprint performances (5m: 1.40 ± 0.02s; and 20m: 3.46 ± 0.04s) (Jiménez Reyes et al., 2019).

Loturco et al. (2018) utilised photocells to examine sprint capabilities and found velocities of 4.81 ± 0.25m/s (5m), 5.68 ± 0.19m/s (10m), and 6.61 ± 0.22m/s (20m) in elite futsal players.

Gorostiaga et al. (2009) assessed the 5-metre and 15-metre sprint times of 15 players from a club playing in the LNFS using photocells and recorded times of 1.01 ± 0.02s and 2.41 ± 0.08s, respectively.

6.6 Neuromuscular capability

HIA (e.g. sprinting and changes of direction) are key movements in futsal. The stronger and more powerful players (i.e. with better-developed neuromuscular capabilities) accelerate faster, jump higher and change direction more rapidly (Loturco et al., 2016b; Freitas et al., 2019). Kicking or tackling are also influenced by an athlete's ability to generate force and power (Loturco et al., 2016a; Spyrou et al., 2020). Players competing at a higher level have been shown to have better agility, sprinting and jumping abilities (Ayarra et al., 2018; Jiménez Reyes et al., 2019; Sekulic et al., 2021; Spyrou et al., 2020).

An understanding of players' neuromuscular ability is important for identifying the profiles of players who are capable of coping with the physical demands of elite competition.

6.7 Agility

As futsal requires fast sprints, sudden changes of direction and rapid decision-making to obtain or maintain ball possession – agility is key for performance (Taylor et al., 2017; Milanović et al., 2020; Serrano Luengo et al., 2020). Ball size as well as the reduced pitch size puts players and technique under constant pressure (Sekulic et al., 2021).

Agility can be delineated into "non-reactive" or "pre-planned" agility involving an active change of direction (COD) speed while RAG (reactive agility) is referred to as "non-planned or random" agility (Sekulic et al., 2019). Agility/COD is dependent upon anthropometric (e.g. height, leg length), physical (e.g. lower-body and torso muscular strength, speed-power capabilities) and technical aspects (e.g. stride adjustments, foot placement) (Loturco et al., 2018; Spyrou et al., 2020). Agility requires explosive strength of the lower limbs to be successful (Naser et al., 2017; Spyrou et al., 2021). Higher eccentric leg strength helps to decelerate the body and facilitates changes of direction.

Sekulic et al. (2019) highlighted the importance of agility when identifying differences in the performance levels of professional futsal players, suggesting that enhanced reactive strength, the ability to rapidly change direction speed in response to external stimulus while executing futsal motor tasks (e.g. dribbling), along with players' ability to kick the ball quickly are essential qualities for elite performance in futsal. Research revealed that 75 professional futsal players (members of the national team and players who participated in elite team competition in Europe) outperformed high-level players in the reactive strength index (RSI), horizontal jumping, kicking speed and futsal-specific reactive agility (FSRAG) involving dribbling (Sekulic et al., 2021).

6.8 Strength – explosive power

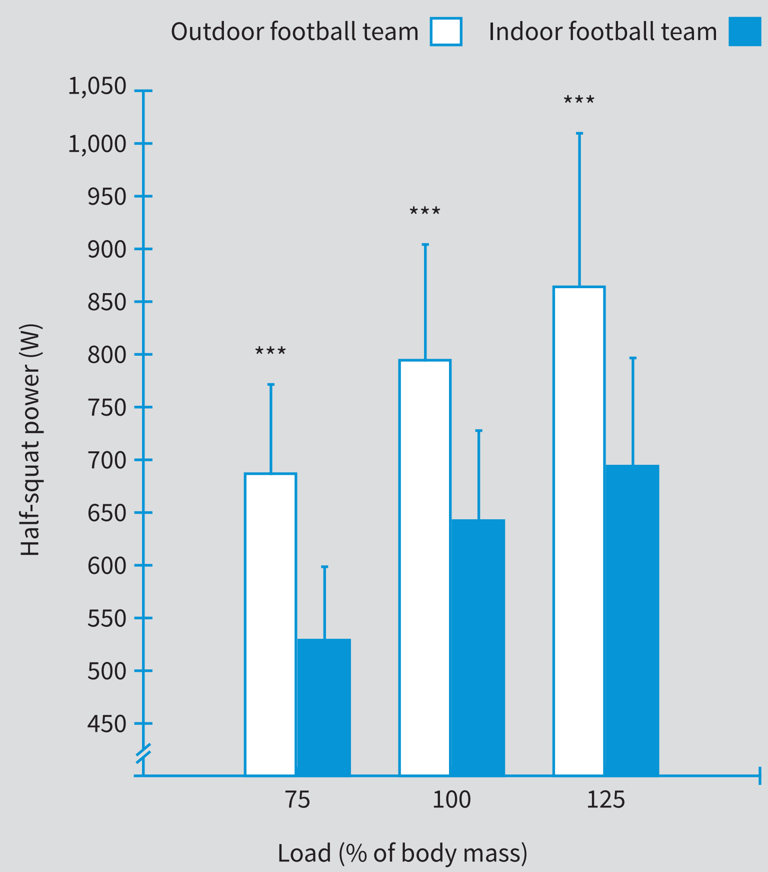
As futsal players perform multiple HIA (e.g. jumping, sprinting or COD), they require not only excellent anaerobic and aerobic endurance, but also a high level of speed, strength, explosive power and agility (Caetano et al., 2015; Ribeiro et al., 2020).

Strength and power capabilities play a key role in futsal performance (Loturco et al., 2018). Stronger and more powerful players have a high rate of force development and can accelerate faster, jump higher and change direction more rapidly. There is limited research detailing the strength profile and force production capacities of futsal players.

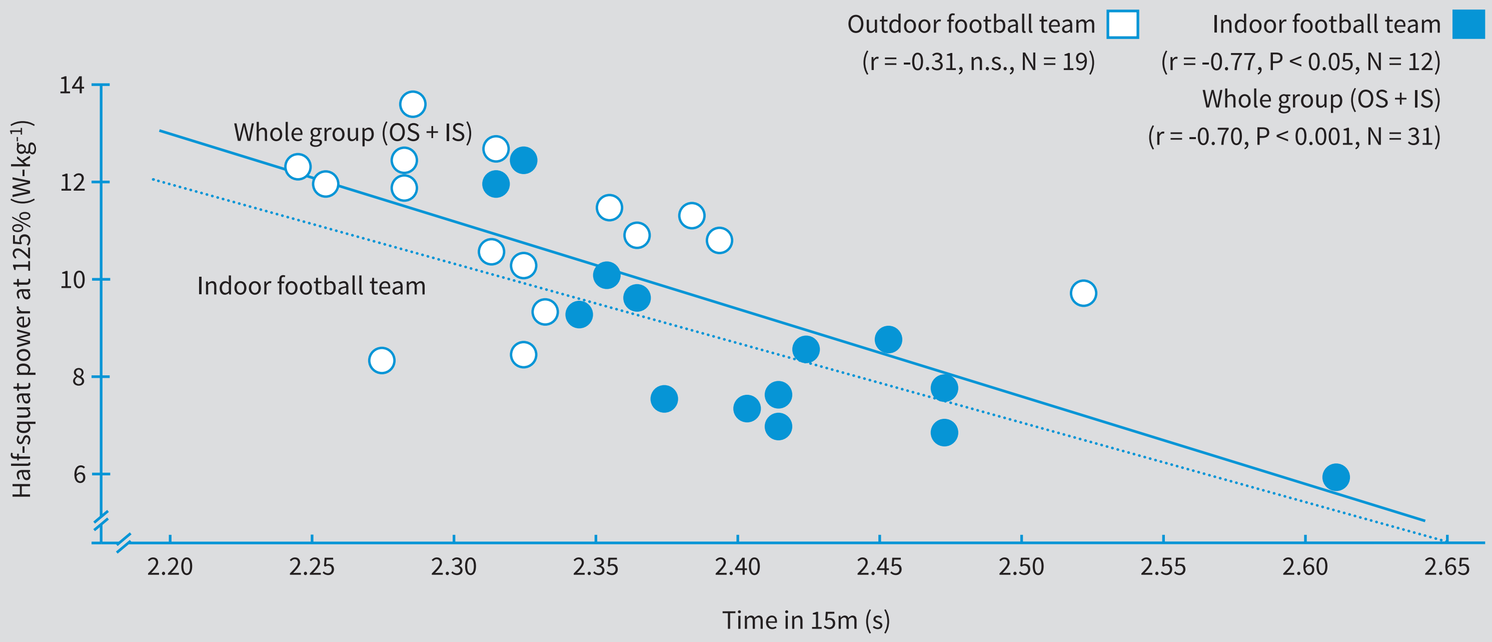
Several researchers have assessed players' strength using isokinetic dynamometry to ascertain the peak torque values of the quadriceps and hamstring. De Lira et al. (2017) reported peak torque values at 60°.s-1 of the dominant leg as 223.9 ± 33.4Nm for the quadriceps and 128 ± 27.6Nm for the hamstrings while the non-dominant leg values of 224 ł} 35.8Nm and 124.1 ł} 20.1Nm were recorded. When the mixed H-Q ratio was assessed for the preferred and non-preferred limbs of 40 players, contralateral differences were found on the knee flexors' eccentric contractions and in the H-Q ratio in favour of the preferred limb (Nunes et al., 2018), which indicates dominance by one leg.

Training at the beginning of the competitive season aimed at improving power provides an increase in the lower limb power of futsal players, leading to an improvement in speed and the ability to intermittently perform HIA (Freitas et al., 2019).

Gorostiaga et al. (2009) identified the lower limb strength capabilities of elite Spanish futsal players while performing half-squats at loads of 75-125% of their bodyweight. The average power output index for all loads in futsal players was 625 ± 112W.



Mean (±SD) muscle power output, in absolute values, of the lower extremity muscle in the concentric half-squat action at 75, 100 and 125% of individual body mass (***P < 0.001).



The relationship between the individual values of maximal 15-m sprint running time and the individual values of concentric power production during the half-squat actions at the load of 125% of body mass expressed relative to kilogram of body mass, for the football players as a whole.

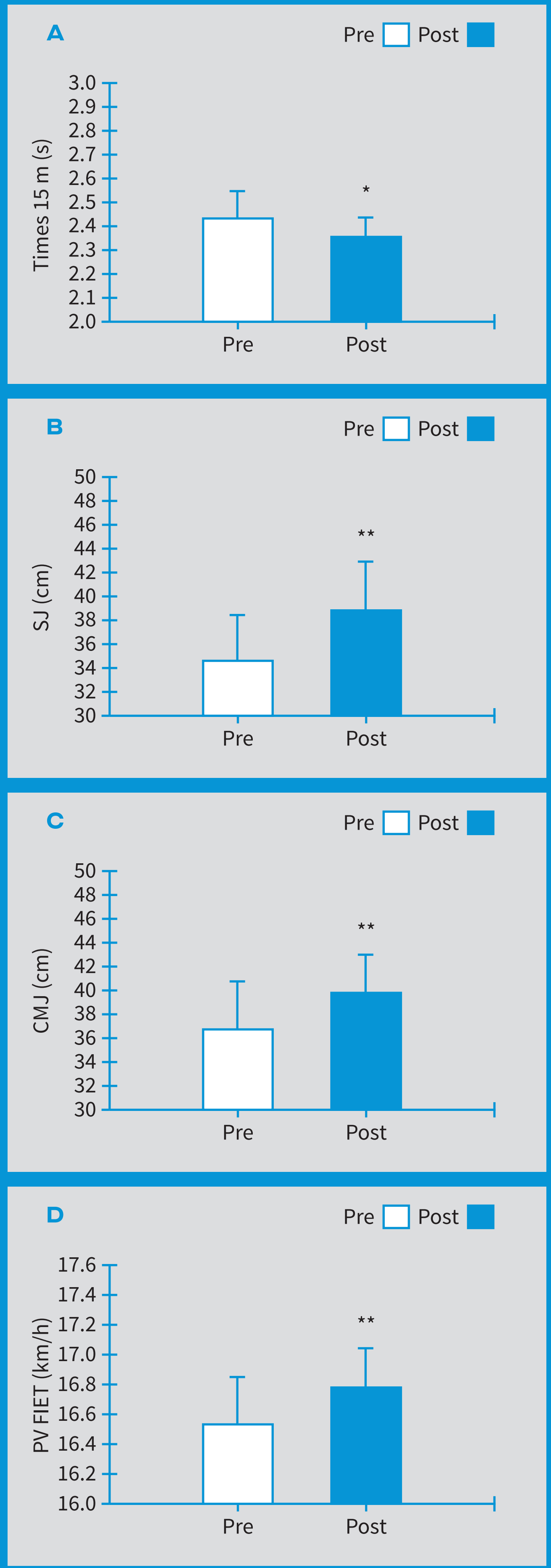
A negative correlation was found in the group of futsal players between the maximal five- or 15-metre sprint running times and concentric power production, suggesting improvements in lower limb strength/power can result in faster sprint times and improved acceleration abilities (Gorostiaga et al., 2009). Gorostiaga et al. (2004) emphasised the importance of combining adapted leg muscular strength/power training with sprint running training for improving short-distance sprint performance.

Actions such as kicking or tackling are also influenced by an athlete's ability to generate force and power (Marques et al., 2007; Loturco et al., 2016a; Spyrou et al., 2020). Although there is little jumping in futsal, it is still a necessary attribute for success.

Reactive strength, kicking speed and FSRAG are important qualities for successful futsal performance (Sekulic et al., 2021). Reactive strength has been shown to have a strong relationship with COD, agility and acceleration ability in field sport players (Young et al., 2015).

Reactive strength is crucial in high-intensity movements which utilise the stretch shortening cycle (rapid eccentric contraction followed by a concentric muscle action) such as sprinting, jumping, changing of direction speed, acceleration and deceleration (Flanagan et al., 2008; Zatsiorsky et al., 2020).

Elite Croatian and Bosnian players had better reactive strength, as expressed by a higher RSI, than the average elite player (Sekulic et al., 2021). Players with higher RSI are able to perform futsal-specific rapid motor actions more efficiently as the ability to decelerate is directly related to eccentric muscular properties (similar to RSI).



Performance in 15-metre speed tests (A), squat jump (B), countermovement jump (C) and FIET (D) at pre- and post-training. *p <0.05, ** p <0.01 - difference in the comparisons between pre- and post-training

6.9 Jumping ability

As lower-body strength and power movement are key performance qualities, researchers have investigated futsal players' power capacities by using jump assessments to infer performance changes. Loturco et al. (2018) analysed 63 professional players reporting jump heights of 37.8cm in the squat jump and 38.5cm in the countermovement jump (CMJ) as well as bar mean propulsive and peak power outputs of 9.2 and 20.4W/kg, respectively. Similar values for the CMJ (38±4.1cm) were reported for Spanish players from a team playing in the LNFS (Gorostiaga et al., 2009).

Lower-body strength is indirectly assessed by different jump and sprint performance tests with the CMJ and 5-20-metre sprint as the most frequently used tests (Naser and Ali, 2016; Sekulic et al., 2021). Elite Croatian and Bosnian futsal players had a CMJ similar to that of futsal players from the Brazilian *Liga Nacional de Futsal* (38.7 v. 39.2cm, respectively), as well as 5- and 10-metre sprint test speeds (0.98 v. 0.99 and 1.7 v. 1.69s, respectively), and shooting speeds (104.3-108.8km/h v. 99.7- 109.1km/h) (Nakamura et al., 2016; Sekulic et al., 2021; Milioni et al., 2016; Vieira et al., 2016).

Players of a higher competitive level did not record a better performance in the acceleration tests (5m and 15m), change of direction ability, bilateral vertical jump and horizontal jump in comparison with players of a lower competitive level or a younger age (Ayarra et al., 2018). Despite the different levels, Naser and Ali (2016) identified no significant differences in CMJ height between elite and sub-elite futsal players. It appears that elite futsal players do not display greater jumping ability than their sub-elite counterparts, potentially because there is limited need for jumping ability in the game (Spyrou et al., 2020).

A four-week training block of strength and power training at the beginning of the competitive season increased the lower limb power of futsal players (improved SJ and CMJ performance) with a consequent improvement in speed and the ability to perform intermittent actions at high intensity (De Freitas et al., 2019).

6.10 Fatigue and neuromuscular function

A professional futsal season imposes a large physiological and mechanical stress on athletes (Rabelo et al., 2016; Spyrou et al., 2020; Spyrou et al., 2022). Match loads alter the hormonal response, biochemical milieu, causes glycogen depletion due to its high-intensity intermittent nature and results in muscle damage, leading to acute neuromuscular fatigue (i.e. failure of the musculoskeletal system to generate/maintain the required force or power output) and impaired physical capabilities (i.e. a reduction in running actions, repeated high-intensity efforts and sprints) for anything up to 72- 96 hours after a match (Caetano et al., 2015; Ribeiro et al., 2020; Milioni et al., 2016; Milanez et al., 2020; Spyrou et al., 2020).

Training and competition loads can lead not only to acute neuromuscular fatigue, but also residual and potentially chronic fatigue throughout the season, if training is not modified in line with players' fatigue type and status (Spyrou et al., 2022).

Spyrou et al. (2022) investigated the changes in physical capacities (sprinting, horizontal and vertical jump performance and CMJ kinetic variables) across the season, identifying the impact of a prolonged and congested schedule in professional futsal on neuromuscular function. Twelve players from the LNFS (who also played in the UEFA Futsal Champions League) were assessed in the 2019-2020 season, which ran from August to March due to the COVID-19 restrictions imposed in Spain.

Sprint time, standard long jump distance and vertical jump height all gradually declined throughout the season, while concentric peak power (CMJ) decreased significantly, and other CMJ metrics considering the three phases (i.e. eccentric, concentric and landing) showed small to moderate changes.

Sprint times were 5% slower in January than in September, which suggests a gradual decrease in maximal sprinting ability across the season, possibly related to the effect of concurrent training between power and endurance with insufficient recovery during congested periods (Spyrou et al., 2022).

Jumping ability declined throughout the season with mean CMJ height and SLJ distance values of 5.1% and 3.9% lower in January when compared to September. An analysis of the CMJ identified a large decline in concentric peak power and a decline in eccentric and landing phase metrics (i.e. peak power and velocity, RFD, duration). Residual fatigue or a reduction in training load may have negatively affected the players' fitness and power production capabilities as the competitive season progressed.

6.11 Biochemical response

Futsal matches and intensified training result in acute and chronic physiological, neuromuscular and biochemical changes (Spyrou et al., 2020; Nemčić and Calleja-González, 2021). De Moura et al. (2012) highlighted that matches lead to high levels of stress, fatigue, muscle damage and inflammation. Prolonged intermittent sprint exercise provokes disturbances in skeletal muscle structure and function, associated with reduced contractile function, an increase in inflammatory responses, perceived soreness and a delayed return to optimal physical performance.

Neuromuscular capabilities (e.g. peak force) and biochemical variables (e.g. creatine kinase (CK) and the testosterone-cortisol ratio) change significantly following competition (Milioni et al., 2016; Bekris et al., 2022). Increased plasma CK is reported, which is associated with muscle damage and/or increased permeability of the muscle cell membrane. Increases in the blood CK concentration can be associated with decreases in performance and increases in injury risk (Miloski et al., 2016). The acute CK response peaks 24-96 hours after exercise, depending on the type, intensity and duration of such exercise. The blood CK concentration chronically increases after an intensified training period and returns to pre-training levels after a week or two of reduced training loads (Coutts et al., 2007; Freitas et al., 2014; Miloski et al., 2016).

Bekris et al. (2020) examined the biochemical and metabolic responses as well as the muscle damage induced by futsal competition and identified increased CK levels and a reduced testosterone-cortisol ratio after the match. The testosterone-cortisol ratio (T:C) provides an insight into the body's anabolic-catabolic balance.

Testosterone concentration is associated with strength and power performance (Crewther et al., 2012; Crewther et al., 2009; Miloski et al., 2016). Following intensified training periods, there is a reduced testosterone concentration and increase in cortisol (stress), which reduces the T:C ratio that can negatively affect both performance and recovery (Miloski et al., 2016). As such, CK, testosterone and cortisol measures can be used as markers for monitoring changes in performance capacity caused by training-induced fatigue (Freitas et al., 2014; Johnston et al., 2012; Coutts et al., 2007; Moreira et al., 2011; Miloski et al., 2016).

Despite the T:C ratio remaining unchanged during the season compared to baseline values, an increase was observed in cortisol concentration associated with a decrease in T:C ratio after a period with the highest number of matches per week (Miloski et al., 2016).

The hormonal environment reported during the season suggests that futsal players were able to cope appropriately with stress demands caused by the training programme and competition schedule, because a sustained decrease in T:C ratio associated with performance impairment was not observed for these athletes (Miloski et al., 2016).

A biomarker associated with responses to exercise is the decreased concentration of salivary immunoglobulin A (SIgA), which is a marker of excessive training (Petersen and Pedersen, 2005). Moreira et al. (2011) noted a reduction in the absolute concentration of SIgA, secretion rate and saliva flow following a futsal match, which suggests an increased risk of respiratory tract infection.

As competing in a futsal match provokes muscle damage and inflammation, which places the player at an increased risk of injury and sub-optimal performance, it is vital to consider how players can best recover between training sessions and matches (Nemčić and Calleja-González, 2021).

Futsal requires players to perform intermittent HIA (i.e. high-speed runs, sprints, changes in direction, accelerations, decelerations and jumps), physical demands that carry a high risk of injury. The size of the playing area creates a low pitch-to-player ratio, which ensures repeated player contact, increases the risk of collisions and entails a hard playing surface, all of which increase the risk of injury (Illa et al., 2021). Identifying the characteristics and incidence of futsal injuries and how and when they usually occur can inform medical and performance staff how to design and implement training to reduce injury risk (Lopes et al., 2023; Junge and Dvorak 2010; López-Segovia et al., 2019). Minimising injury rates and maximising training and match availability is a key performance metric (Hägglund et al., 2013) with the aim of >85% training availability.

7.1 Competition injury analysis

Junge and Dvorak (2010) analysed the injury characteristics during three FIFA Futsal World Cups (2000, 2004, 2008) and reported a total of 165 injuries from 127 matches – an incidence of 1.3 injuries per match.

The majority of injuries (66%) were caused by contact with another player and 34% occurred without contact, however, most did not require a substitution. The incidence of non-contact injuries is avoidable and can potentially be reduced through improved fitness and player conditioning.

Most injuries affected the lower extremity (70%), followed by head and neck (13%), upper extremity (10%) and torso (7%) with the knee (15.8%), thigh (13.9%), ankle and lower leg (each 12.1%) being the main injured parts of the body. Most injuries were diagnosed as contusions (44.2%), sprains or ligament ruptures (19.4%), and strains or muscle fibre ruptures (17.6%). The most frequent diagnoses were contusion of the lower leg (11%), ankle sprain (10%) and groin strain (8%). Multiple sprints with frequent changes in direction contributed to the high incidence of non-contact injuries observed, such as groin and thigh strains and ankle sprains.

At least 67 injuries (48.6%) were expected to prevent players from participating in matches or training. On average, one time-loss injury in every two matches was reported.

Diagnosis of injuries at FIFA Futsal World Cups 2000 - 2008

	No. of injuries		
Location and type	**Total***	**Without absence**	**With absence**
Head/neck	21 (12.7%)*	16 (13.9%)	4 (6.0%)
Concussion	7*	4	2
Sprain	4	4	0
Contusion	8	8	0
Laceration	2	0	2
Torso	12 (7.3%)	6 (8.3%)	6 (9.0%)
Strain	2	0	2
Contusion	6	5	1
Laceration	2	1	1
Others	2	0	2
Upper extremity	17 (10.3%)*	13 (18.1%)	3 (4.5%)
Fracture	1	1	0
Sprain	3	2	1
Contusion	10*	9	–
Others	3	1	2
Hip/groin	17 (10.3%)*	8 (11.1%)	8 (11.9%)
Strain (all groin)	13	5	8
Others (all hip)	4*	3	–
Thigh	23 (13.9%)*	3 (4.2%)	15 (22.4%)
Strain	9	1	8
Contusion	10*	2	3
Others	4	0	4
Knee	26 (15.8%)*	6 (8.3%)	14 (20.9%)
Ligament rupture	3*	–	2
Lesion of mensicus	1	–	1
Sprain	9*	1	6
Contusion	10*	4	3
Others	3	1	2
Lower leg	20 (12.1%)*	11 (15.3%)	5 (7.5%)
Contusion	18*	9	5
Strains	2	2	0
Ankle †	20 (12.1%)*	6 (8.3%)	9 (13.4%)
Sprain	16*	5	8
Contusion	3*	1	1
Foot/toe	9 (5.5%)*	3 (4.2%)	3 (4.5%)
Fracture	1	0	1
Strain	1	0	1
Contusion	7*	3	1

	Guatemala 2000	Chinese Taipei 2004	Brazil 2008
No. of matches	40	40	56
Injury report forms returned	66 (82.5%)	80 (100%)	107 (95.5%)
Player hours documented	220	266.7	356.7
No. of injuries	42	63	60
Per 1,000 player hours (95% CI)	190.9 (133.1 to 248.7)	236.0 (177.8 to 294.2)	168.5 (125.8 to 211.2)
Per 1,000 player matches (95% CI)	127 (88.6 to 165.4)	158 (119.0 to 197.0)	111 (83.0 to 149.0)
Circumstances	No. (%)	No. (%)	No. (%)
Non-contact injuries	10 of 41 (24%)	19 of 58 (33%)	28 of 58 (48%)
Contact injuries	31 of 41 (76%)	39 of 58 (67%)	30 of 58 (52%)
Contact injury caused by a foul	14 of 27 (52%)	25 of 39 (64%)	4 of 27 (15%)
Foul sanctioned by the referee	6 of 13 (46%)	18 of 25 (72%)	3 of 4 (75%)
Estimated severity of injury	No. (%)	No. (%)	No. (%)
0 days	21 (53.3%)	29 (64%)	21 (41%)
1-3 days	12 (31.6%)	8 (18%)	23 (43%)
4-7 days	1 (2.6%)	6 (13%)	0 (0%)
>1 week <1 month	3 (7.9%)	2 (3%)	8 (15%)
>1 month	1 (2.6%)	0 (0%)	1 (2%)
Missing	4	18	7
Time-loss injuries*	17	18	32
Per 1,000 player hours	≥77.2	≥67.5	≥89.9
(95% CI)	(40.5 to 113.9)	(22.3 to 98.7)	(58.8 to 121.0)
Per 1,000 player matches	≥52	≥45	≥60
(95% CI)	(27.3 to 76.7)	(24.2 to 65.8)	(39.2 to 80.8)

*Information on time lost from sport is missing for 27 injuries.

Incidence and characteristics of injuries at the FIFA Futsal World Cup 2000-2008

Fixture congestion correlates to a higher injury rate. During the FIFA Futsal World Cup, the players play approximately every two to three days. High match intensity and a lack of rotation increase the fatigue experienced by the players and the injury risk during matches therefore increases (Junge and Dvorak, 2010).

Longer recovery periods between matches and/or the greater use of substitutions could provide players with enough time to recover and prevent the accumulation of fatigue, which reduces the risk of injury.

7.2 Preseason injury analysis

López-Segovia et al. (2019) described the incidence and characteristics of injuries amongst 11 professional Spanish futsal teams (161 players) during preseason, both in training and matches.

A total of 62 injuries were reported (48 during training sessions and 14 during match play), indicating that a professional futsal team could expect an average of 5.6 injuries per preseason and 0.39 injuries per player. Of these injuries, 92.1% involved lower limbs. When data from training and competition was analysed together, the highest incidence of injuries affected the ankle (21%), the hip/groin and knee (19.4% each) and thigh (17.7%). Muscle ruptures, tears and strains were the most frequent diagnoses, both in training (28.3%) and in competition (35.7%).

During training, the highest percentage of injuries affected the knee (23.9%), followed by the ankle and hip/groin (21.7% each), while during matches, the thigh (35.7%) followed by the ankle (21.4%) were the most affected body parts. Interestingly, during training sessions, most injuries affected joints, whereas during matches, the thigh muscles were affected most by injury.

7.3 Injury type

The most common injury types diagnosed were muscle ruptures, tears and strains (32.3%), followed by sprains/ligament injuries (29.0%) and tendon injuries (ruptures, tendinosis and bursitis) (17.7%).

During competition, three of every five injuries were due to overuse (60.7%), and only 39.3% were due to acute trauma. Most were caused without contact with another player (58.5%).

During training sessions, most injuries were caused without contact (71.1%), and only 13.2% were due to contact with another player, whereas during matches, only 28.6% injuries were caused without contact, while 50% were the result of contact with other players. This lower percentage of injury as a result of contact in training compared with during competition (13.2% v. 50%) is possibly due to less aggressive/competitive challenges between players during training.

Diagnosis on injuries				
Location and type	**Training**	**Match**	**Total**	**Days absent**
Head/neck	1 (2.2%)*	1 (7.1%)	2 (3.2%)	2
Sprain	1	0	1	1
Strain	0	1	1	1
Upper extremity	1 (2.2%)	0 (0.0%)	1 (1.6%)	2
Sprain	1	0	1	2
Lower back/pelvis/sacrum	1 (2.2%)	0 (0.0%)	1 (1.6%)	1
Strain	1	0	1	1
Hip/groin	10 (21.7%)	2 (14.3%)	12 (19.4%)	47
Strain (all groin)	8	2	10	45
Tendon injury	1	0	1	1
Contusion	1	0	1	1
Thigh	6 (13.7%)	5 (35.7%)	11 (17.7%)	81
Strain	4	3	7	54
Contusion	0	2	2	4
Tendon injury	2	0	2	23
Knee	11 (23.9%)	1 (7.1%)	12 (19.4%)	322
Ligament rupture	0	1	1	155
Lesion of meniscus	2	0	2	53
Sprain	4	0	4	104
Tendon injury	4	0	4	9
Others	1	0	1	1
Lower leg	3 (6.5%)	1 (7.1%)	4 (6.5%)	17
Strains	0	1	1	3
Tendon injury	3	0	3	14
Ankle	10 (21.7%)	3 (21.4%)	13 (21%)	50
Sprain	8	3	11	43
Contusion	1	0	1	4
Tendon injury	1	0	1	3
Foot/toe	3 (6.5%)	1 (7.1%)	4 (6.5%)	4
Contusion	1	1	2	2
Laceration	2	0	2	2
Others	2 (4.2%)	0 (0.0%)	2 (3.2%)	2
Total	**48 (100.0%)**	**14 (100.0%)**	**62 (100.0%)**	**1,054**

Approximately 40% of injuries were due to overuse during matches, whereas during training sessions, overuse represented 71.1% of the figure. This was probably the result of an accumulation in the load caused by both training and matches.

The accumulated fatigue and lower fitness levels of futsal players during the preseason period may explain the injury profile. During preseason, there was a higher proportion of overuse injuries. Weeks three and four of the study were the periods in which injuries were more frequent (42.6%), which may indicate a peak of accumulated fatigue after the first two weeks of training. The rest of the injuries were suffered during the first two weeks and the last two weeks (29% and 27.9%, respectively).

Injury severity and recurrence

Some 60% of injuries were minor and caused absences of less than one week. The time lost per injury reported was 5.7 ± 9.5 days, which was equivalent to 5.6 ± 7.8 days lost during training and 1.3 ± 1.9 matches missed. A total of 32.3% of players missed at least one training session or match as a result of injury. Muscle ruptures, tears and strains were the most frequent diagnoses, both in training (28.3%) and in competition (35.7%).

Understanding the mechanism and incidence of injury provides an insight into how to minimise risk. Data supports the need to develop a strength and conditioning programme for players to reduce the incidence of soft tissue injury. In the design, periodisation and planning of training, sufficient variation and recovery help to avoid excessive overload. Injury prevention protocols should focus on the ankle, knee and muscle strain prevention.

Injuries sustained over a season

Lopes et al. (2023) described the injuries sustained by elite, international-level, male futsal players from nine teams competing in Portugal's top tier (*Liga Placard*) during the 2019-2020 season over an eight-month period, including an average of 22 ± 6 official matches and around 143 ± 32 training sessions.

Lopes et al., (2023) showed that the injury incidence in futsal is high and that elite, international-level, male futsal players are more prone to non-contact injuries, primarily affecting the lower limbs. The incidence during matches is nine times greater than that of training sessions.

7.4 Injury site

A total of 133 injuries were recorded, sustained by 92 players (67.6%). The groin and the knee (both 18.8%) were the most affected body parts, followed by the thigh and the ankle (17.3% and 15%, respectively) with the most prevalent being sprains/ligament injuries (29%) and muscle ruptures, tears and strains (32%).

During futsal matches and training, players repeatedly stand on one leg while controlling or protecting the ball from their opponents, which may apply stress on the lower leg's joints, predisposing the foot and ankle to injury (Cain et al., 2007).

A low injury incidence rate in training (three injuries per 1,000 hours) was reported compared to the incidence rate of matches, which was much higher (27.4 injuries per 1,000 hours) and may reflect the standard, performance demands and competitiveness of the *Portuguese Campeonato Nacional da I Divisão de Futsal* (Spyrou et al., 2020).

Lopes et al. (2023) reported that training injuries represent 64% of the total. Such a low training incidence can be explained by the training sessions' design, avoiding non-contact and overuse injuries, less contact between players, and lower levels of aggressiveness and competitiveness compared with competition.

Non-contact injuries were the most frequently reported mechanism (65%), while 30% were due to direct or indirect contact with another player and 24% were overuse injuries. Some 86.5% (115) of injuries sustained by athletes were the first occurrences, meaning that only 13.5% (18) were a reoccurrence.

Recurrent injury rates may be related to a premature return to training or playing, or incomplete or inadequate rehabilitation. The lower rate of recurrent injuries may be thanks to professional clubs in Europe having good medical support and strength and conditioning programmes associated with the programmes responsible for team and individual preparation.

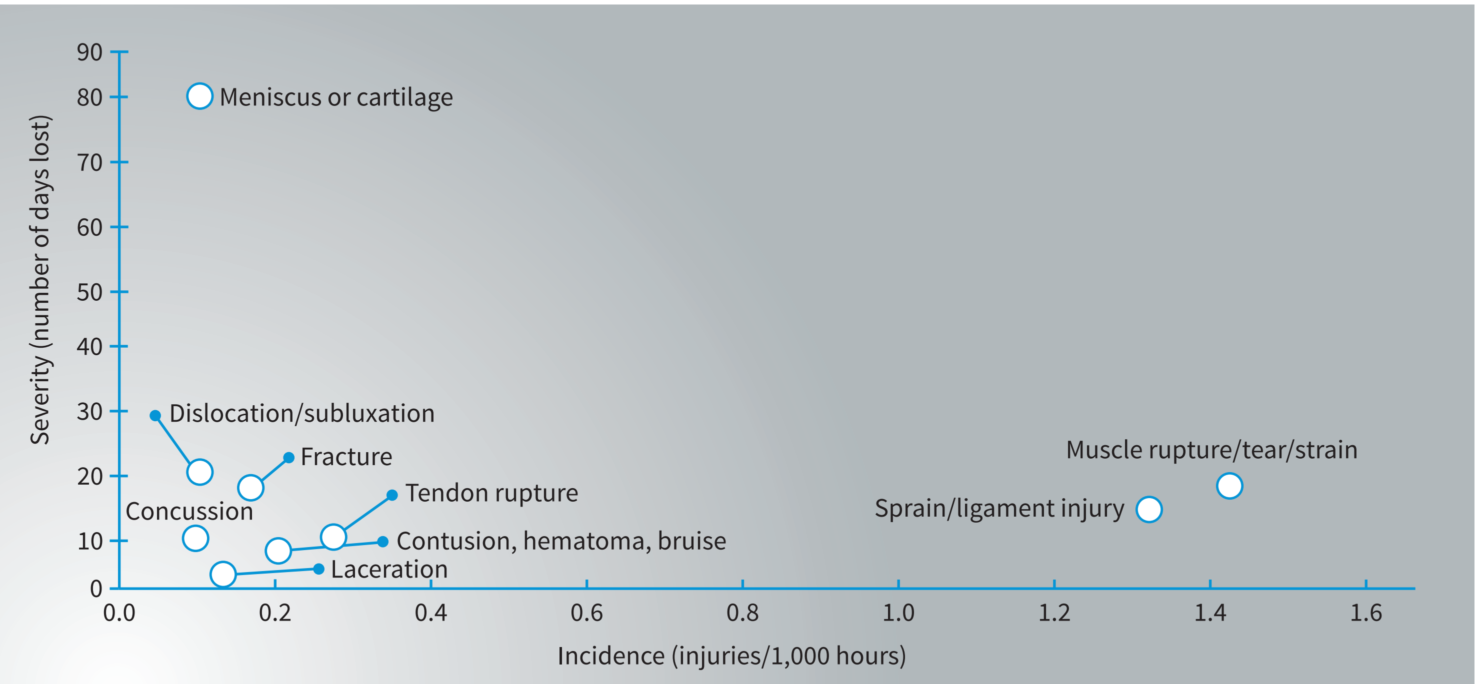
7.5 Type, location and mechanism of injuries

	N	%	Incidence rate	95% CI
Type of injury				
Concussion	3	2.3	0.10	−0.02 to 0.22
Fracture	5	3.8	0.17	0.02 to 0.32
Other bone injury	1	0.8	0.03	−0.03 to 0.10
Dislocation/subluxation	3	2.3	0.10	−0.02 to 0.22
Sprain/ligament injury	39	29.3	1.31	0.90 to 1.73
Other injuries	15	11.3	0.50	0.22 to 0.80
Meniscus or cartilage	3	2.3	0.10	0.03 to 0.24
Muscle rupture/tear/strain	42	31.6	1.41	0.95 to 1.88
Tendon rupture	8	6.0	0.27	0.03 to 0.38
Synovitis	1	0.8	0.03	−0.03 to 0.10
Contusion/hematoma/bruise	6	4.5	0.20	0.05 to 0.37
Laceration	4	3.0	0.13	−0.03 to 0.30
Nerve injury	3	2.3	0.10	−0.10 to 0.30
Injury location				
Head and torso	**12**	**9.0**	**0.40**	**0.18 to 0.63**
Head and face	2	1.5	0.07	−0.03 to 0.17
Sternum/dorsal region	1	0.8	0.03	−0.03 to 0.10
Abdomen	2	1.5	0.07	−0.03 to 0.17
Lumbar region/waist area	7	5.3	0.24	0.06 to 0.43
Upper limb	**10**	**7.5**	**0.34**	**0.07 to 0.61**
Shoulder/clavicle	3	2.3	0.10	−0.02 to 0.22
Elbow	2	1.5	0.07	−0.03 to 0.17
Forearm	3	2.3	0.10	−0.10 to 0.30
Hand/finger	2	1.5	0.07	−0.03 to 0.17
Lower limb	**111**	**83.5**	**3.73**	**3.00 to 4.46**
Groin	25	18.8	0.84	0.44 to 1.24
Thigh	23	17.3	0.77	0.43 to 1.10
Thigh (anterior)	18	13.5	0.61	0.27 to 0.94
Thigh (posterior)	5	3.8	0.17	0.02 to 0.32
Knee region	25	18.8	0.84	0.51 to 1.17
Lower leg and Achilles tendon	5	3.8	0.17	0.02 to 0.32
Ankle	20	15.0	0.67	0.38 to 0.97
Foot	13	9.8	0.44	0.17 to 0.67
Total	133	100.0	4.47	3.67 to 5.28

Classification of injuries type and location (injuries, %, incidence rate and 95% CI)

7.6 Severity and burden of injuries

A total time loss of 1,658 days was recorded for all nine participating clubs during the season. The most common were moderate injuries (44%), followed by mild injuries (24%). Minimal and severe injuries represented 17% and 16% of all injuries, respectively. On average, each injury led to nine days of time loss. The injury burden was 73.8 days lost per 1,000 hours of total player exposure.



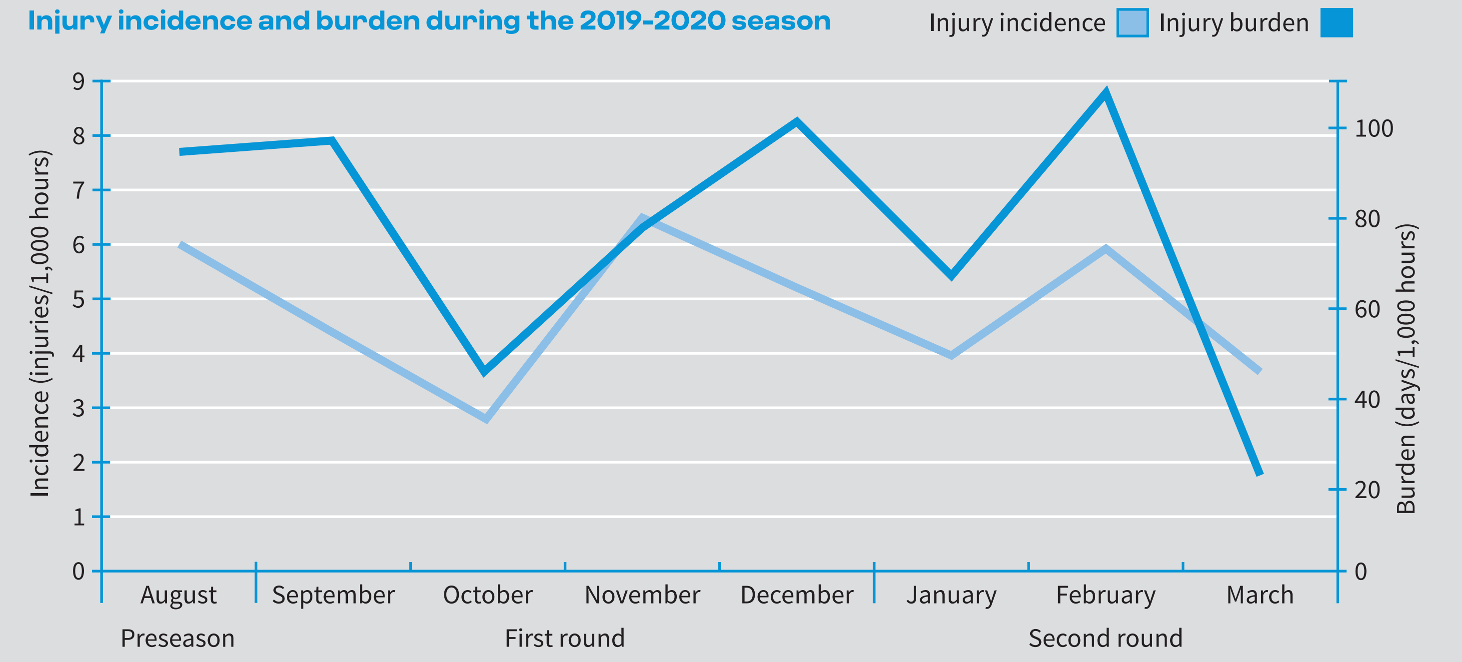
Quantitative risk matrix of injuries. Relationship between time loss days and injury incidence.

The quantitative risk matrix of injuries created for this study displays the relationship between incidence and severity for each of the most common time-loss injuries reported throughout the 2019-2020 futsal season in Portugal.

7.7 Distribution of injury incidence and injury burden during the season

Injury risk was high and player availability reduced during key periods of the season:

- August (preseason) recorded the highest monthly injury incidence (5.9 per 1,000 hours) and monthly injury burden (92.3 days of absence per 1,000 hours).
- The highest injury incidence was recorded in November (6.7 injuries per 1,000 hours).
- The highest injury burden was recorded in February (105.5 days of absence per 1,000 hours).



Monthly injury burden and injury incidence throughout the season.

In the Portuguese league, preseason takes place in August. Players experience the highest number of training sessions and friendly matches during this period, which resulted in a high level of injury incidence and burden (Lopes et al., 2023).

Following the winter break – which took place between the end of December and mid-January – February recorded the highest level of injury incidence and burden. Following these breaks, it is possible that a high volume of training and matches may result in psychological and physical fatigue, which would result in a reduction in performance and an increased risk of injury (Ekstrand et al., 2004).

With a positive correlation between training load and the probability of injury (i.e. the higher the load, the greater the probability of injury) (Killen et al., 2010), recent studies have indicated that the volume of training completed during preseason can offer a protective effect, which leads to a reduction in the risk of injury during the season (Windt et al., 2016; Ekstrand et al., 2020).

Warm-up progression

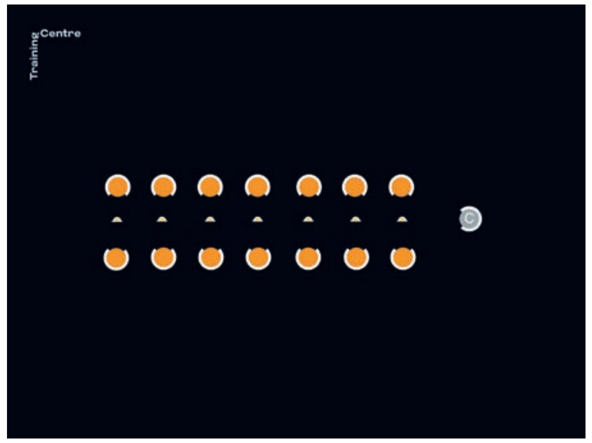
Part 1: Reaction drill – cone snatch

Organisation

- Divide the players into pairs.
- Place as many cones as the number of pairs in a line.
- Assign each pair to a cone.
- Position each member of the pair either side of each cone.

Explanation

- The coach randomly calls out the following commands: "Head", "Shoulder", "Knees" and "Feet", and each player has to touch the relevant body part.
- When the coach calls out "Grab", the members of each pair race each other to pick up the cone.
- The first player to pick up the cone wins.



FIFA Training Centre

Warm-up progression

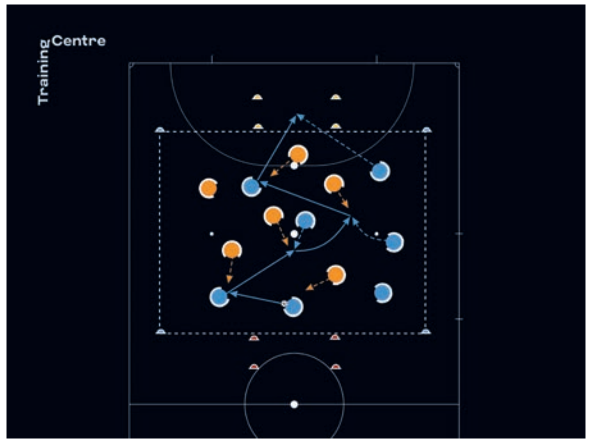
Part 2: Basketball game

Organisation

- Mark out a 20m x 20m exercise area using cones.
- Mark out a 1m x 2m target zone at either end of the exercise area (one using red cones and the other using yellow cones).
- Divide the group into 2 teams and assign each team a direction in which to attack.

Explanation

- The exercise starts with a tipoff.
- Players must throw the ball to each other and cannot dribble.
- A basket is scored when a player runs into the target zone and catches a pass by a team-mate.
- An attacking player cannot occupy the target zone for a prolonged period. If a player in the target zone does not receive a pass, they must leave the zone before re-entering.



FIFA Training Centre

Part 3: Dynamic warm-up – mobility exercise

Organisation

- Lay out 2 cones 12m apart and place another identical set parallel to them.
- Divide the group into 2 teams (the same teams as in the previous part of the warm-up).
- Assign a team to each row of cones.

Explanation

- The coach asks the players to perform a series of mobility exercises, as shown in the video.

Warm-up progression

Part 4: Passing and dribbling drills

Organisation

- Mark out a 12m x 18m exercise area using cones.
- Place a cone in the middle of the exercise area.
- Position an equal number of players in each corner of the exercise area.
- Give the players at each corner station a ball between them.

Explanation

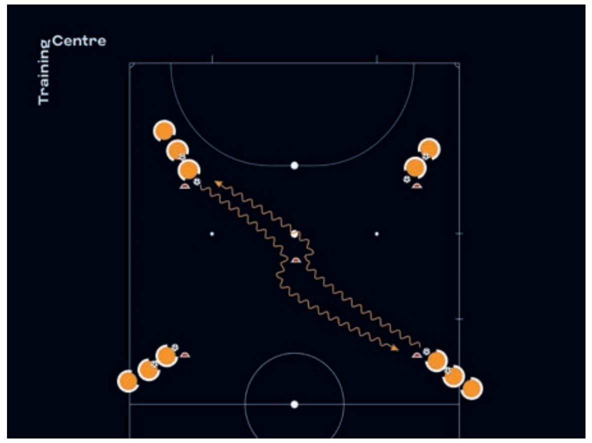
- Players positioned in diagonally opposite corners of the exercise area dribble simultaneously towards the central cone, bypassing each other en route to the diagonally opposite corner.
- Players should get as close to the central cone as possible without bumping into each other, staying on the right side of the central cone.
- When they reach the diagonally opposite corner, the player plays the ball to the player at the front of the queue.
- Once each of the players has performed the sequence several times, ask the players to stay on the left side of the central cone.

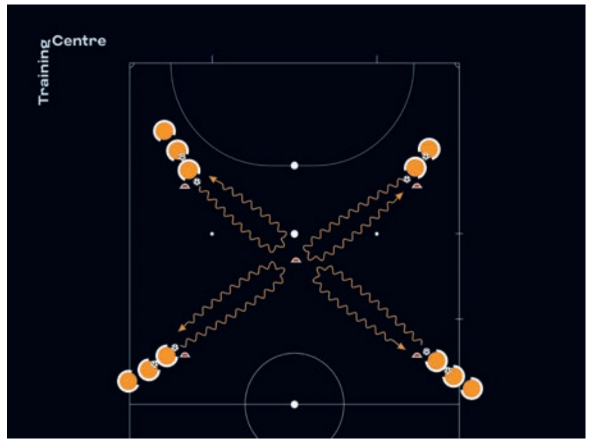
Variation

- When players reach the central cone, they perform a change of direction to dribble back towards their starting station before passing the ball to the player at the front of the queue.

Coaching points

- The exercise involves hidden running.
- Players should keep up the intensity.
- Players should perform a range of dribbling actions.
- Take the opportunity to intervene to offer technical input and increase the demands on players.





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Agility & speed activation

Part 1: Sprint and reaction drill

Organisation

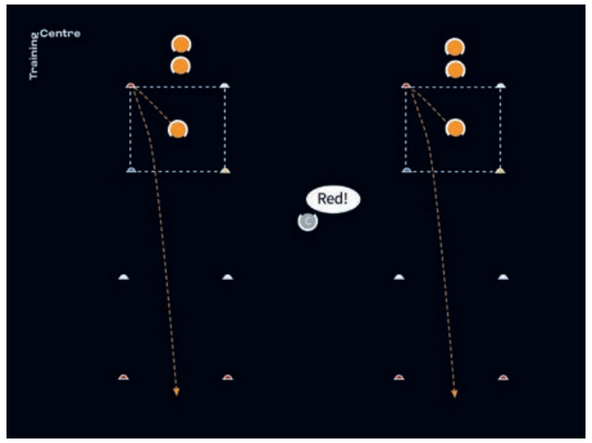
- Mark out 2 squares, each comprising the same 4 different coloured cones, as displayed in the graphic.
- Mark out a white gate 5m in front of each square and a red gate 10m in front of each square.
- Divide the group into 2 teams and assign each team to a square.

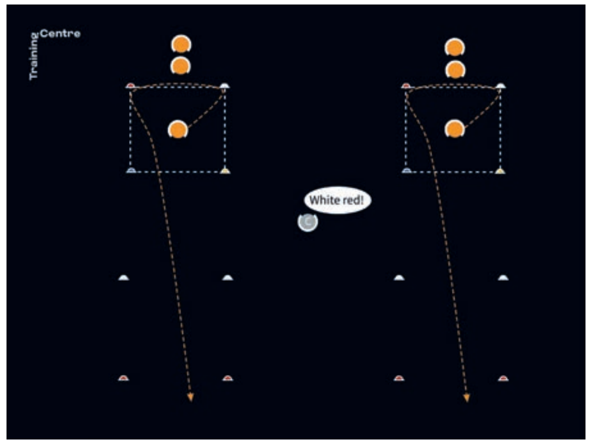
Explanation

- One player from each team takes up a position in the middle of the square, with their team-mates forming a queue behind the square.
- The coach calls out the colour of 1 of the 4 cones that make up the square.
- The player in the square races to touch the cone of the relevant colour with their foot before sprinting to the white gate.

Variation

- The coach calls out 2 colours, and the players have to touch them with their feet in the same order in which the coach called them out before sprinting to the 10m gate.





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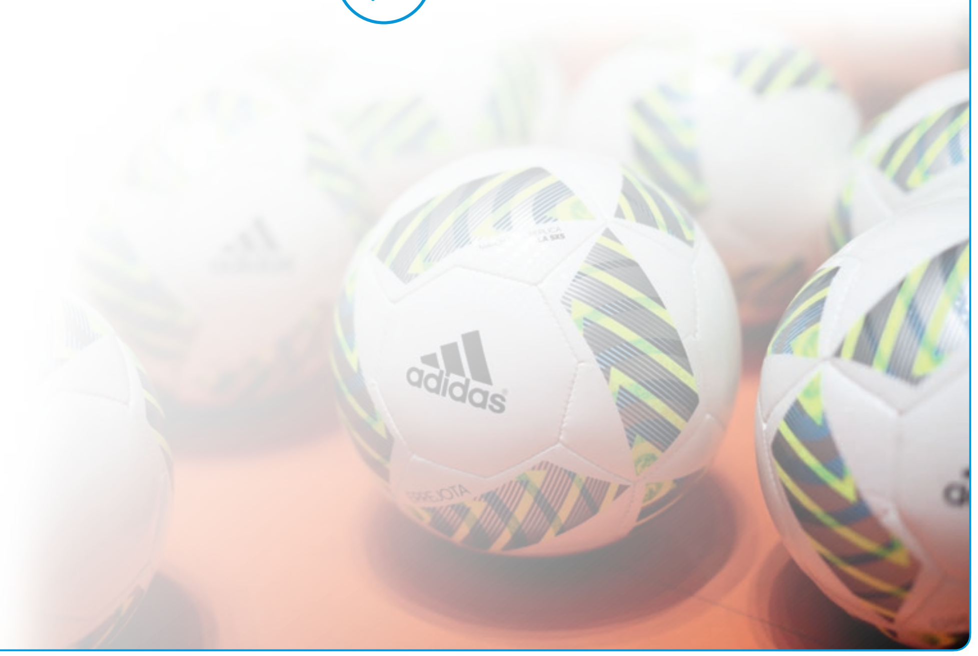


Agility & speed activation

Part 2: Agility drill

Organisation

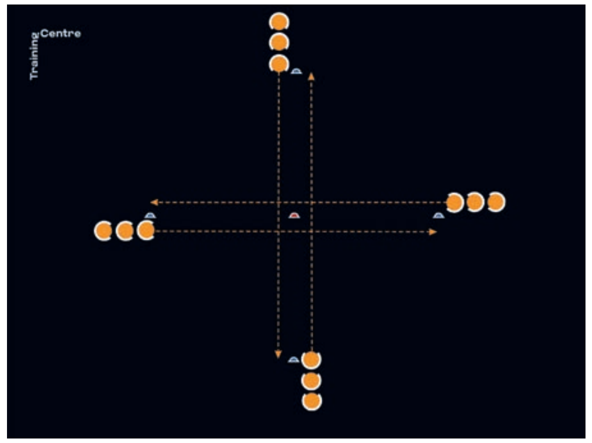
- Divide the group into 4 teams.
- Mark out a 5m x 5m exercise area, placing a cone at the midpoint of each side.
- Line each team up behind a cone.
- Place another cone in the middle of the exercise area.

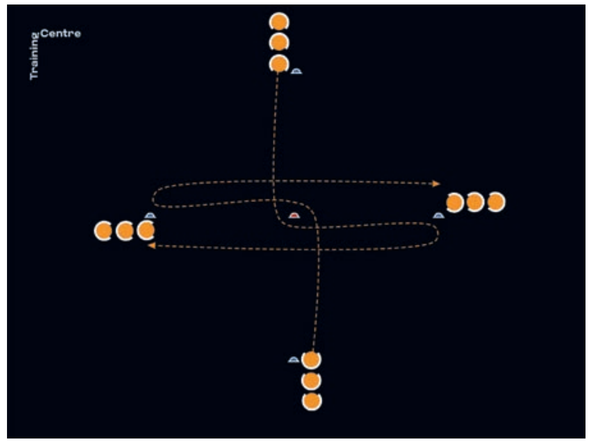
Explanation

- The player at the front of the queue in 1 of the 2 pairs of teams positioned opposite each other runs towards the opposite team, sticking to the right of the central cone, and joins the back of that team's queue.
- The same sequence is then repeated by the players in the other pair of teams positioned opposite each other.
- The exercise continues in this way, with the players in the pairs of teams taking it in turns to run towards the opposite team and join the back of their queue.

Variation

- The player at the front of the queue in 1 of the 2 pairs of teams positioned opposite each other runs to the central cone before running backwards to the cone to the left of their starting cone and then sprinting to the cone directly opposite them.





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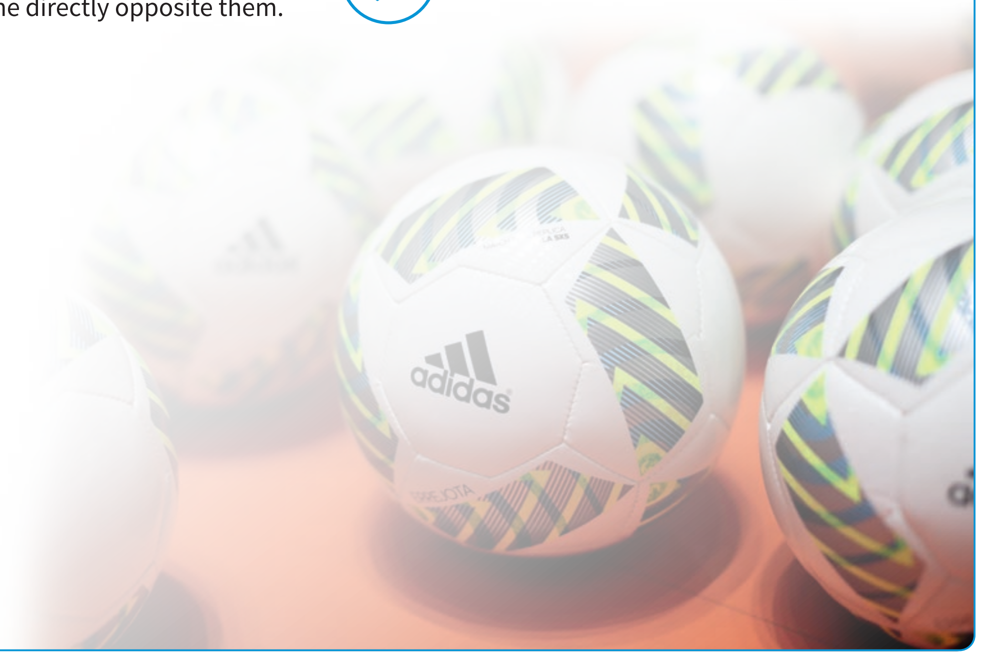


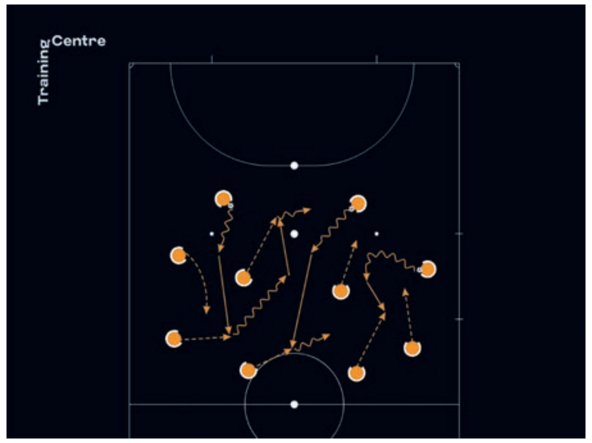
Agility & speed activation

Part 3: Technical skills

Organisation
- Use one half of the pitch.
- Give 5 players a ball.

Explanation
- The players with a ball dribble freely inside the exercise area.
- The players without a ball call to receive possession.
- Players must not stand still.

Coaching points
- Players should keep their head up at all times.
- Players with a ball should establish eye contact with the intended recipient of their pass.
- Players should show good awareness of the players around them.
- Players should weigh their passes correctly.
- Players should make good movement to receive the ball.
- Players should give careful consideration to the timing of their passes.



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Multiball passing

Organisation
- Mark out an 11m x 11m exercise area.
- Distribute the players evenly around the edges of the exercise area.
- Give 5 players a ball.

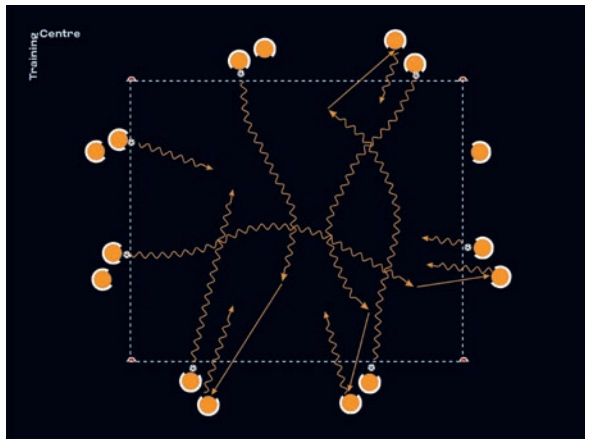
Explanation
- The players with a ball dribble into the exercise area simultaneously.
- Each player makes eye contact with a player positioned around the outside of the exercise area before passing the ball to them.
- The passer swaps position with the recipient, and the recipient dribbles the ball into the exercise area.

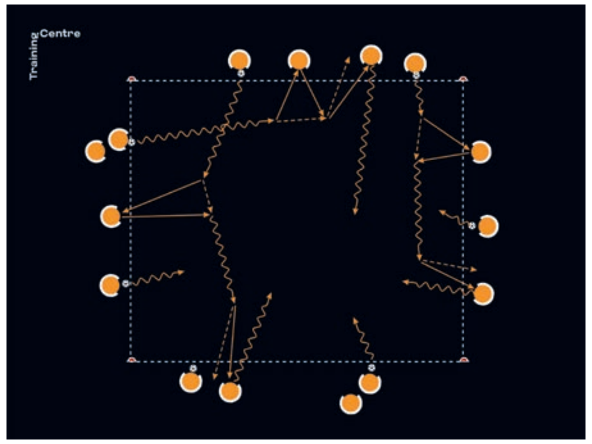
Variation

Variation 1
- The passer plays a bounce pass with a player on the outside of the exercise area before passing the ball to another outside player.

Variation 2
- Introduce more balls into the exercise and ask players to increase the tempo at which they perform the exercise.

Coaching points
- Players should dribble at pace while keeping their head up in order to make eye contact with the intended recipient of their pass.





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Aerobic power through 3v3 small-sided game

Organisation
- Use half of a pitch.
- Position a goal at each end of the exercise area.
- Place a goalkeeper in each goal.
- Set up a 3v3 scenario inside the exercise area.

Explanation
- A 3v3 match is contested in which the standard futsal rules apply.
- The teams contest 5 sequences comprising 2 minutes of high-intensity play followed by a minute to recover.
- This set is repeated with a two-and-a-half-minute rest between sets.
- If a team score, they retain possession and restart play from their goalkeeper.

Variation

Variation 1
- Players are limited to 2 touches.

Variation 2
- A neutral player is introduced to create a 4v3 numerical advantage in favour of the in-possession team.
- There is no limit on the number of touches.

Coaching points
- Players should perform the exercise at high intensity, attack quickly and be positive on the ball.
- Players are encouraged to shoot on sight.

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Anaerobic training using a possession game

Organisation
- Mark out a 15m x 20m exercise area.
- Set up a 3v3 plus 1 scenario inside the exercise area.

Explanation
- The objective for both teams is to retain possession for as long as possible.
- The neutral player plays for the in-possession team.
- The exercise involves 60 seconds of play followed by a 40-second rest. This sequence is repeated 4 or 5 times.
- If the ball goes out of play, the coach introduces a new ball.

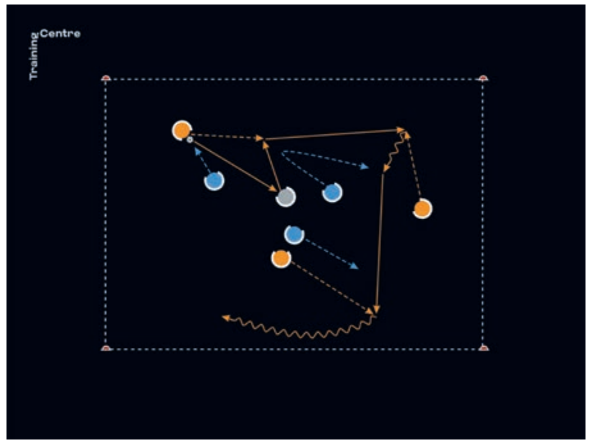
Variation

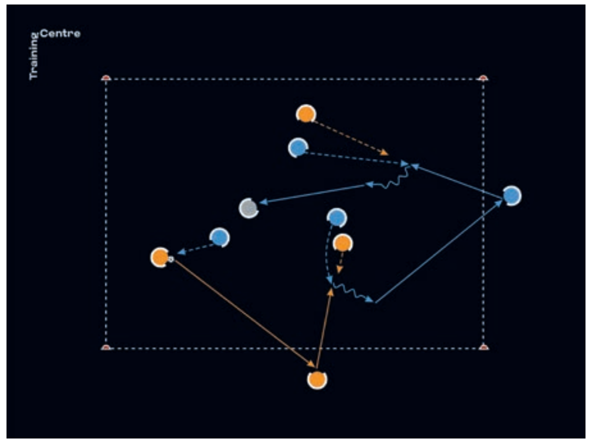
Variation 1
- Players are limited to 2 touches.

Variation 2
- A team are awarded a point each time they complete 10 passes.

Variation 3
- One player on each team is added on the outside of the exercise area. This player is limited to 1 touch.

Coaching points
- Players should make good movement to receive the ball.
- Out-of-possession players should press opponents aggressively.
- Players should perform the exercise at high intensity.





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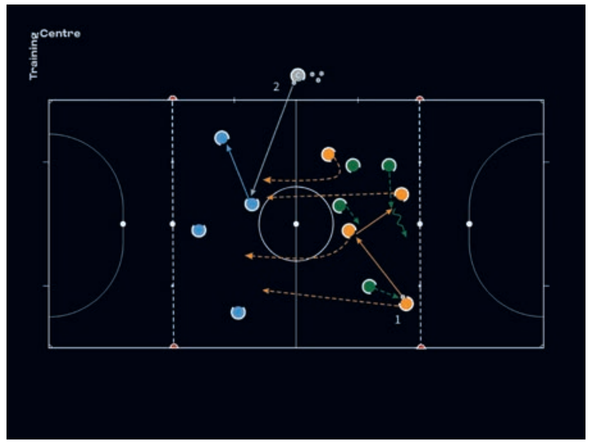
Pressing 4v4 plus 4



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Organisation

- Set up the exercise field like in the graphic above.
- Divide the group into 3 teams of 4 players (blues, oranges and greens).
- Position an attacking team in each half (oranges and blues) and assign the other team as the defending team (greens).

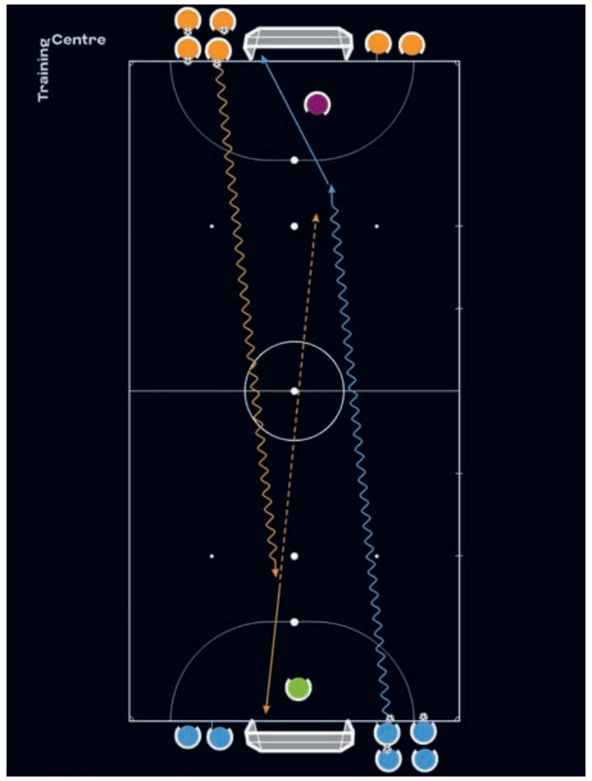
Explanation

- The exercise starts with the coach serving a ball to the oranges.
- The aim for the oranges and blues, whose players are limited to 2 touches, is to retain possession.
- The greens look to regain possession.
- All players are free to move in all areas of the exercise area.
- If the greens win the ball or force it out of play, the team that lost possession become the defending team.
- If an orange or blue player takes more than 2 touches, their team become the defending team.

Coaching points

- Attacking players should look to retain possession by creating passing options for team-mates.
- Attacking players should make good movement to receive the ball.
- Defending players should press aggressively as a unit to try to regain possession.

Recovery runs



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Organisation

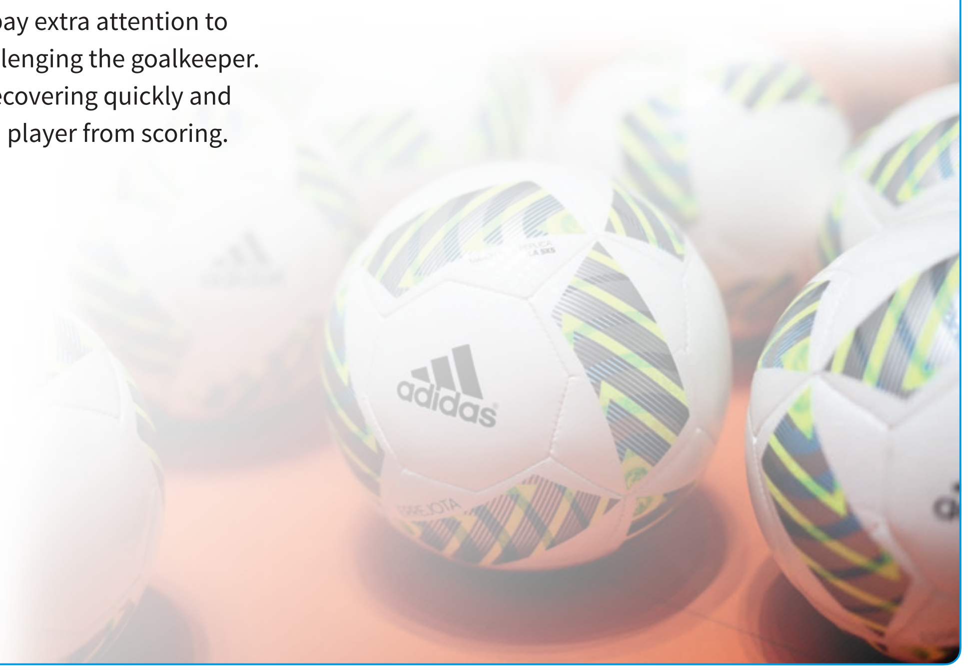
- Use a full pitch.
- Place a goalkeeper in each goal.
- Divide the group into 2 teams of 6 (oranges and blues).
- Line each team up beside a goal and give each player a ball.

Explanation

- The first orange player in the queue dribbles as fast as they can towards the goal at the opposite end of the pitch.
- As soon as they enter the end zone (delimited by the 10-metre mark), the first blue player in the queue dribbles as fast as they can towards the opposite end of the pitch.
- Immediately after making an attempt on goal, the orange player chases the blue player and tries to prevent them from scoring.
- If the ball goes out of play by passing over a touchline, the move is over, and the next player advances towards goal.
- The sequence is repeated until all players have had a go.

Coaching points

- Players should perform all actions at maximum intensity.
- When making an attempt on goal at maximum intensity, players should pay extra attention to hitting the target and challenging the goalkeeper.
- Players should focus on recovering quickly and preventing the opposition player from scoring.



High-speed transitions

Organisation

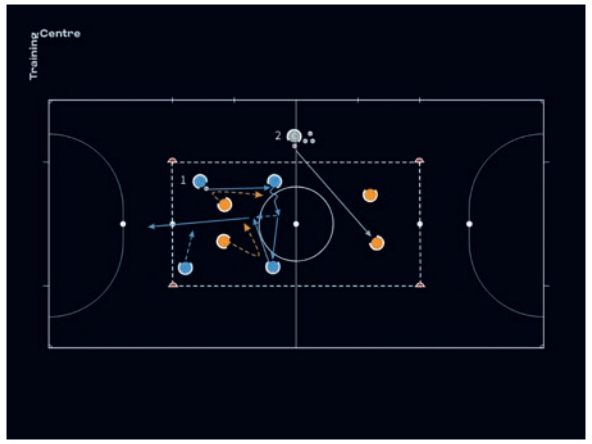
- Mark out a 20m x 30m exercise area either side of the halfway line.
- Divide the group into 2 teams of 4 (oranges and blues) and assign a team to each half of the exercise area.
- Place 2 orange players inside the blues' half.

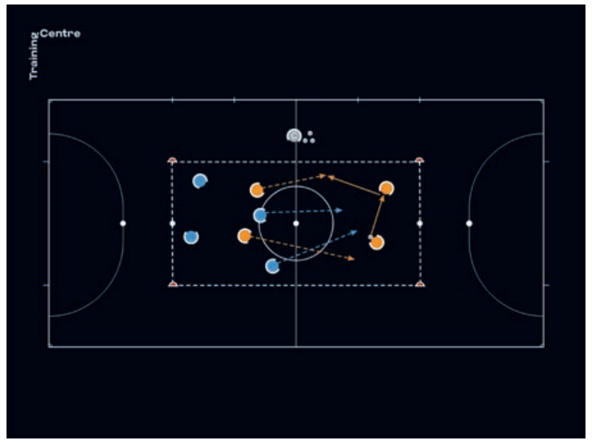
Explanation

- A 4v2 possession game is contested inside the blues' half.
- The blues' objective is to complete 10 passes. If they manage to do so, they are awarded a point.
- The 2 orange players try to win the ball back.
- If an orange player gets a touch to the ball or a blue player puts the ball out of play, the coach feeds a new ball into an orange player in the other half of the exercise area, and the 2 orange pressing players move into the other half and become in-possession players.
- Two blue players enter the oranges' half to try to regain possession.

Coaching points

- Pressing players should apply a coordinated press.
- Encourage in-possession players to take no more than 2 touches.
- In-possession players should create passing angles for the ball carrier.
- In-possession players should make good movement to receive the ball.
- Pressing players should press at high intensity.
- Players must recover quickly between transitions.
- In-possession players must weigh their passes.





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Strength through shielding

Organisation

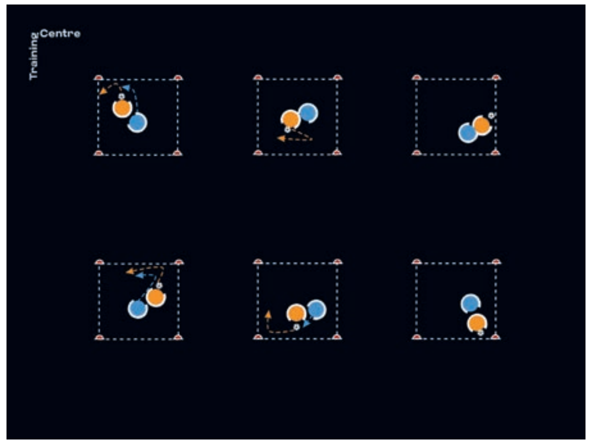
- Mark out a series of 4m x 4m squares in both halves of a full pitch.
- Divide the group into 2 teams (oranges and blues).
- Set up a 1v1 scenario in each square and give each pair of players a ball.

Explanation

- The attacker tries to shield the ball from the defender while keeping the ball inside the square.
- The defending player tries to dispossess the attacker.
- The players in each square swap roles after 30 seconds.

Coaching points

- Players shielding the ball should stay strong and position their body between their opponent and the ball.
- Players shielding the ball can extend their arms to create space between themselves and their opponent whilst taking in information without having to look.
- Players shielding the ball should keep it out of their opponent's reach by using their furthest foot to move it around the square.



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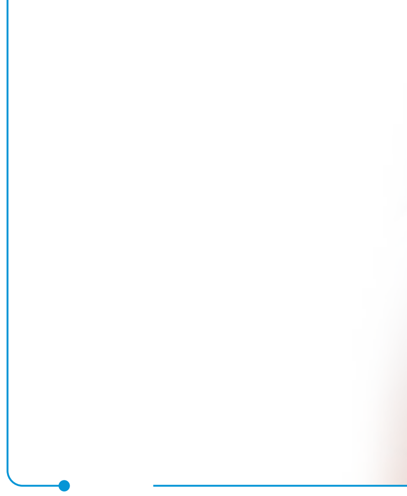

Transition and pressing from 4v2 to 4v6

Organisation
- Mark out a 30m x 20m exercise area.
- Create a 5m x 5m square in the middle of the exercise area.
- Divide the group into 2 teams (6 oranges and 4 blues).
- Set up a 4v2 scenario inside the square, with the numerical advantage in favour of the blues.
- Position an orange player in each corner of the exercise area.

Explanation
- The coach plays the ball to a blue player.
- The blues try to keep possession in the square, while the oranges attempt to win the ball.
- If the oranges manage to gain possession, they play the ball to a team-mate positioned outside the square and all players leave the square to create a 6v4 scenario.
- The blues become the pressing team and try to win the ball back within 30 seconds.
- If they do not manage to do so, the coach stops play and the sequence is restarted.
- If an orange player plays the ball out of the exercise area, the sequence is restarted.

Variation
- To keep player motivation and intensity levels high, challenge each team to complete 10 passes (the blues inside the square, the oranges outside it).

Coaching points
- In-possession players should look to secure the first pass after winning possession with a view to initiating the next action successfully.
- In-possession players should provide clear passing lanes to offer the ball carrier as many options as possible.

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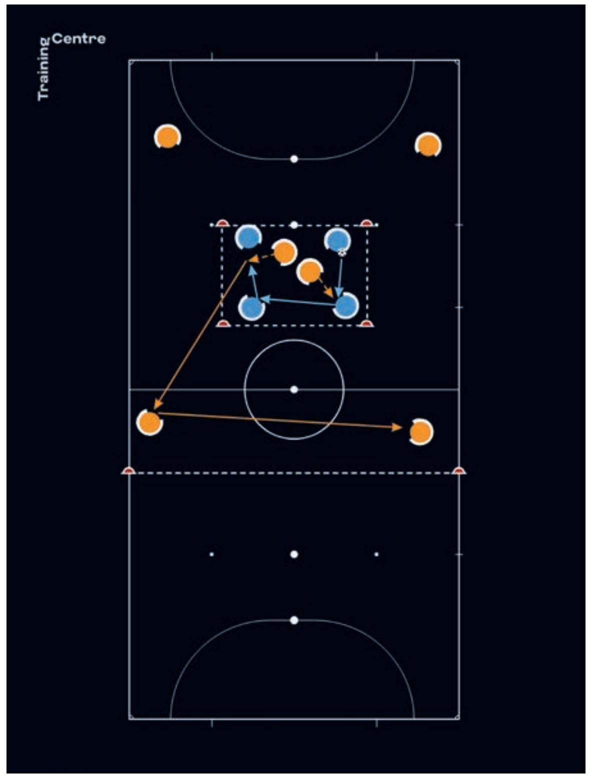

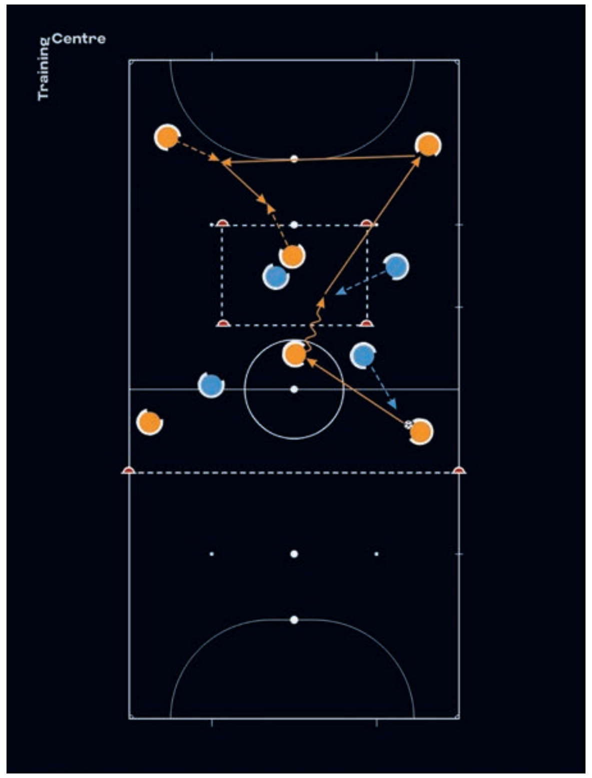

Published by:
Fédération Internationale de Football Association
FIFA-Strasse 20, P.O. Box, 8044 Zurich, Switzerland
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