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Physical and physiological demands of futsal

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ABSTRACT

Futsal, the 5-a-side version of soccer (i.e. 1 goalkeeper and 4 outfield players), was introduced in 1930 and continues to grow in popularity around the world. Competitive games comprise of two 20-min periods of high-intensity and intermittent activities requiring substantial physical, tactical, and technical efforts from the players. A greater understanding of the physical and skill requirements will aid the development of futsal and enable practitioners to undertake appropriate training regimes for the demands of the sport. The objective of this review is to examine key aspects of futsal such as match analysis, physiological demands, energy requirements, fitness measurements, and skill requirements. Futsal players experience fatigue as the game progresses due to the high-intensity nature of the game and the repeated maximal sprint efforts required. The intermittent nature of the sport necessitates the use of aerobic and anaerobic energy pathways throughout exercise. Therefore, a futsal player needs to have a great capacity of intermittent endurance, repeated sprint ability, and leg power, while technical aspects include the ability of high level shooting and passing skills, agility and coordination. Future research is warranted to help practitioners develop more specific tests into futsal performance, especially with regards skill.

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1. Introduction

Futsal is the official name for the 5-a-side indoor version of soccer (i.e. 1 goalkeeper and 4 outfield players) that is sanctioned by soccer's international governing body Federation Internationale de Football Association (FIFA). Futsal was introduced in 1930 and its popularity is growing worldwide. Since 1989, the Futsal World Cup has been contested by countries from all continents every 4 years and involved 16 teams in 1989 growing to 24 teams in 2012. Futsal is a 2 × 20-min game of high-intensity and intermittent actions requiring high physical, tactical, and technical efforts from the players. The court measures approximately 40 × 20 m with 3 × 2-m goals. Futsal is played within both professional and amateur leagues and uses a smaller (size 3 or 4) low-bounce ball, relative to normal, outdoor soccer. During FIFA-organised competitions, teams are made up from a squad of 12 players (2 goalkeepers and 10 outfield players) and unlimited substitutions are permitted. Futsal was designed to maintain the rhythm and intensity of play

throughout the match, and achieved via 'rolling' substitutions.¹ The time is stopped when the ball is out of play and for any events that may waste time, meaning that the game usually lasts 70–85% longer than the scheduled total of 40-min.¹

Despite its popularity, limited research has been undertaken into futsal possibly due to the lack of financial interest in the game (relative to soccer). And, of these research articles, most have addressed the game analysis and/or physiological demands on players during match play and training,^{1–3} with little or no evidence relating to skill performance (e.g. shooting and passing). Skilled soccer players can recognise and recall patterns of play more effectively than their less skilled counterparts.⁴ Understanding futsal skills would allow practitioners to transfer beneficial information to the player and so a greater understanding of the physical and skill requirements would certainly aid in the development of the sport. Therefore, the aim of this review is to highlight the current body of evidence relating to the physical, physiological and skill demands of futsal and identify gaps for future research.

1.1. Match analysis

There has been limited time-motion analysis of futsal players

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during match play.³ The activity patterns of futsal may differ from other sports since each player has to perform both attacking and defensive tasks constantly at a high tempo.¹ Barbero-Alvarez et al.¹ reported that futsal is a multiple-sprints sport in which there are more high-intensity phases than in other intermittent sports. Although comparing against other sports has its limitations, some useful comparisons can be made with similar intermittent team sports such as soccer, basketball, and handball. For example, it has been shown that the total distance covered at a high-intensity and maximum speed is greater in futsal than soccer,^{5,6} basketball,⁷ or handball,⁸ thus reflecting the high-intensity nature of futsal.

The work-to-rest ratio in futsal is approximately 1:1, where rest means the player is stationary, walking or jogging, and work means the distance covered at medium, high or maximum speed.^{1–3} The intensity of match play of futsal was shown to be higher than soccer,¹ possibly as a direct consequence of the unlimited substitution rule during futsal. Professional futsal players cover 13.7% of their total distance at high-intensity (speed $\geq 15 \text{ km} \cdot \text{h}^{-1}$) and 8.9% sprinting (speed $\geq 25 \text{ km} \cdot \text{h}^{-1}$)^{1–3} with players performing 8.6 activities per minute of match play.^{2,3} In addition, players perform a low-intensity effort every 14 s, a medium-intensity effort every 37 s, a high-intensity effort every 43 s, a maximum-intensity effort every 56 s,³ and change locomotor activities every 3.3 s.⁹ From these findings it can be concluded that futsal is an anaerobic multiple-sprint sport in which high-intensity exercise constitutes a greater proportion of match time than in soccer and other multiple-sprint sports.

The distance covered during futsal matches (based on five studies) can be found in Table 1. It is believed that the distance covered in a game can discriminate between levels of players. However, distance covered per minute (relative distance) seems to be more representative of the general intensity of futsal and may be used as an overall index to provide more precise information about the demands of futsal.¹ The total movement of players seems to be affected by many different parameters such as the position on the field, tactical disposition, and characteristics of the match itself, all of which in some way can affect the amount of space covered by players. Most research shows no differences between playing positions (excluding goalkeepers) in distance covered or percentage distance covered at different intensities, indicating some similarity both in the quantity and quality of the movements made by all the players on the court.¹ This evidence seems to demonstrate the versatility of futsal players. Certainly, futsal players can fulfil two or even three distinct functions depending on the circumstances of the match, the team's needs at a specific moment or the characteristics of the players on the court at that time.

The similarity in the data obtained by Oliveira¹⁰ and Barbero-Alvarez et al.¹ in comparison with Molina's¹¹ estimates appear to indicate an increase in the demands and dynamics of the game over time. The development of offensive (4-in-line) and defensive (pressure in all parts of the court) tactics has increased the demands made by competition, a fact reflected in the greater distance

covered per minute. Barbero-Alvarez et al.¹ 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. This paradox was explained by the notable 12% increase in the total time played in the second half. Moreover, the reduction in the distance covered per minute of participation in the second half may be related to the decline in the intensity or work rate towards the end of the game as a result of muscular fatigue. A reduction in the distance covered in the second half has also been observed in soccer.⁵

Barbero-Alvarez et al.¹ showed that of the total distance covered by professional futsal players, almost a quarter (22.6%) is spent at high-intensity and can, on occasions, exceed a third. During the second half, players ran fewer metres per minute and the percentage of distance covered at high speed decreased, although there were no differences in the percentages of high-intensity exercise between the two halves. Furthermore, the average distance covered by futsal players depends on the time participated in the game (range 601–8040 m).^{1,9} This variance by players demonstrates why distance covered cannot be taken as a performance indicator in futsal due to the unlimited substitutions rule, unlike other team sports such as soccer.

Running speeds at the ventilatory threshold (VT) and $\dot{V}O_2\text{max}$ were higher in professional futsal players relative to body mass-matched semi-professional players.¹² These findings are consistent with those reported by Ziogas et al.¹³ who showed running speed at lactate threshold could discriminate endurance characteristics of soccer players of different competitive levels more accurately than $\dot{V}O_2\text{max}$. These results suggest that speeds associated with $S_{\dot{V}O_2\text{max}}$ ($S_{\dot{V}O_2\text{max}}$) and VT (S_{VT}) should also be assessed in futsal players as they may better reflect competitive level differences than cardiorespiratory variables alone.¹² These findings are interesting because it is well accepted that the distance covered at high-intensity during soccer matches is a valid measure of physical performance, and discriminates players of different competitive levels.¹⁴ However, there is no similar information in futsal. A greater distance covered at high intensities in those players with higher S_{VT} and $S_{\dot{V}O_2\text{max}}$ would be expected.¹² Although Alvarez et al.¹⁵ found that $S_{\dot{V}O_2\text{max}}$ on a treadmill was similar between professional and semi-professional futsal players there is limited information on players at different competitive levels. Therefore, further research is needed with different player cohorts to identify and discriminate possible differences between players assisting practitioners in developing suitable training requirements based on player profiling.

1.2. Physiological demands

Direct assessment of match $\dot{V}O_2$ has shown that players must be able to work at an intensity of $50\text{--}55 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ to play futsal professionally.^{15–17} Previous studies have suggested the importance of high aerobic power levels for inducing quicker recovery (e.g. improved PCR recovery) between high-intense efforts or even

Table 1

Mean and standard deviation of total distances covered and percentage of distances performed and high-intensity running and sprinting speeds.

Reference	Players	Total distance (m)	Total distance per minute covered during a game ($\text{m} \cdot \text{min}^{-1}$)	% Total distance at high-intensity running (speed $\geq 15 \text{ km} \cdot \text{h}^{-1}$)	% Total distance sprinting (speed $\geq 25 \text{ km} \cdot \text{h}^{-1}$)
Molina ¹¹	Brazil League club		108		
Oliveria ¹⁰	Portugal League club		113		
Barbero-Alvarez et al. ¹	Spanish Professional League club	4313 (range 601–8040)	117.3	13.7	8.9
Dogramaci et al. ⁹	Australian National Team	4277 \pm 1030		23.3	2.4
Dogramaci et al. ⁹	Australian State (New South Wales) League Team	3011 \pm 999		24.4	3.2

after exhaustion.¹⁸ Nevertheless, matched for body mass and age, Pedro et al.¹² found that neither $\dot{V}O_2\text{max}$ nor $\dot{V}O_2$ (at similar workloads) was different between professional and semi-professional futsal players. The researchers also found that the $\dot{V}O_2\text{max}$ and $\dot{V}O_2$ at the VT were not significantly different. In contrast, Alvarez et al.¹⁵ compared $\dot{V}O_2\text{max}$, VT, and running economy of futsal players of different competitive levels to determine whether aerobic fitness is a discriminative variable for futsal success. The study found that professional futsal players had significantly higher $\dot{V}O_2\text{max}$ (62.8 vs. 55.2 ml·kg⁻¹·min⁻¹) and $\dot{V}O_2$ values than the semi-professional team. The professional futsal players showed significantly higher $\dot{V}O_2$ at VT than the semi-professional players. However, when normalised relative to $\dot{V}O_2\text{max}$, this difference was minimal. This finding was attributed to the characteristics of futsal, a high-intensity intermittent sport associated with a significant anaerobic component and major number of matches and training session of elite futsal players during a competition session.⁵

The average HR and percentages of HR_{max} recorded during futsal matches have been shown to be comparable to other team sports. A high HR (>80% of HR_{max}) for over 80% of the actual playing time in futsal players has been found,^{1,16,19} values that are similar to professional soccer²⁰ and tennis.²¹ The average HR and percentage HR_{max} in futsal is probably a result of the high anaerobic metabolism.¹ Furthermore, during match play HR rarely falls below 150 beats·min⁻¹, possibly due to short and incomplete rest periods. Barbero-Alvarez et al.¹ also observed a reduction in average HR and HR_{max} in the second half, as well as a reduction in the time of HR being over 170 beats·min⁻¹. Barbero-Alvarez et al.¹ also observed a decrease in the percentage at intensities above 85% of HR_{max} and an increase in the percentage of time when HR was between 65–85% of HR_{max} as game time progressed. Moreover, changes in HR_{max} may be influenced by changes in game situation and tactical alterations. These findings reflect physiological processes that may be associated with fatigue (i.e., intensity reduction) that occurs in the second half.

The majority of futsal game play requires numerous high-intensity movements such as sprinting and tackling that stresses the anaerobic energy systems. However, there is limited research into contribution of the anaerobic systems in futsal. Krustup et al.²² showed that muscle fibres selectively deplete their glycogen and creatine phosphate stores after Yo-Yo intermittent recovery (IR) tests in futsal players. The selective depletion was reported in lower limb fast-twitch muscle fibres and not slow-twitch which may impair repeated sprint ability as a player approaches exhaustion.²³ Research in soccer has shown that approximately 12% of the total energy expenditure is provided by the anaerobic systems.²⁰ The extent to which a sport is considered 'demanding' can be supported by the blood lactate concentrations. Castagna et al.¹⁶ observed a mean blood lactate concentration of 5.3 mmol·L⁻¹ in futsal players which was similar to reported concentrations in other soccer studies.²⁰ These limited findings provide some indirect evidence that the impairment of repeated sprints in futsal players is caused by a similar physiological phenomenon.

1.3. Fitness components of players

Table 2 summarises player physiological profiles from 11 studies pertaining to futsal. The average age of the players ranged from 17.2–26.2 years, height ranged from 1.73–1.80 m and body mass ranged from 69.8–76.9 kg. The level of playing experience varied among studies from a range of 3–10 years with players specialising from being semi-professional to professional. Physiological measures of $\dot{V}O_2\text{max}$ ranged greatly from 55.2–71.5 ml·kg⁻¹·min⁻¹ whilst HR_{max} values also showed a wide variation (174–204

b·min⁻¹). The only study to report body composition, Gorostiaga et al.,²⁴ showed that elite futsal players have higher body fat percentages than elite soccer players, and the maximal sprint time correlated positively with this higher body fat percentage but negatively with leg extension power production and vertical jump height (as measured by countermovement jump, CMJ). The researchers concluded that futsal players are likely disadvantaged during a match by this increased fat mass.²³

Leg muscle power is an essential feature required for jumping and sprinting in intermittent athletes. Maintaining or improving leg power may be essential to futsal athletes who perform many repeated sprints during training and matches that induce significant muscle fatigue.^{1,9} Leg muscle power may be obtained indirectly from the measurement of the maximal height achieved from a CMJ. Although there are fewer jumps taking place within futsal, as the game requires more ground passes than soccer, it is still a necessary attribute for success. Silva et al.²⁵ found that futsal players had similar CMJ performance to soccer players whereas Gorostiaga et al.²⁴ observed lower jump height in elite futsal players relative to elite soccer players. This discrepancy may be related to the fact that Gorostiaga et al.²⁴ included goalkeepers in their testing. Soccer goalkeepers are most likely capable of jumping higher than futsal goalkeepers as jumping is a big part of soccer goalkeeping whereas futsal goalkeepers are mostly trained on shot stopping and keeping a low gravitational centre. However, this proposal is speculative and requires further research into leg power within different playing positions between futsal and soccer.

Skill can be defined as the learnt ability to select and perform the correct technique as determined by the demands of the situation.²⁶ Futsal players are required to perform multiple skills such as controlling the ball, choosing to make a pass and shooting at goal. Research and empirical observations in soccer demonstrate that shooting skill displays the most variability, where coefficient of variation values were found to exceed 20% in shooting tasks that involve a moving ball.²⁷ Shooting is a very important characteristic of futsal players; indeed, more goals are scored per minute of play than soccer.¹⁶ To date, limited research has been done into futsal with more skill research undertaken in soccer. However, elite futsal players were found to have superior shooting and passing skill compared to semi-elite players in futsal specific tests.²⁸ Research in soccer suggest that top teams complete longer passing sequences and more short passes than their less successful counterparts.²⁹ This is associated with an increased number of attempts at goal as well as goals per possession within these successful teams. Moreover, Olsen³⁰ assessed the passing ability of soccer players in international competitions and found that 57% of goals were scored after a period of play that included short passes; however, the distance of these short passes was not mentioned. As futsal is played at a faster tempo and in a smaller environment compared to soccer, players are required to make, select and perform the correct technique in a high intensity situation. Therefore, future research into the skill performance of futsal (decision making, shooting and passing skills) is warranted to develop suitable training programs to aid coaches and game development.

The ability to make quick changes of direction of the entire body represents a fundamental movement in sport.^{31,32} Milanovic et al.³¹ found that elite futsal and soccer players do not differ in agility performance, while another study in soccer players reported that each player performs approximately 600 turns of 0–90° to both the left and right side, and 95 turns of angles higher than 90° (up to 180°).⁶ Futsal players are expected to perform more turns with and without the ball than soccer players, reflecting the higher time on the ball. The technical proficiency of futsal players is influenced by the small ball, as well as the reduced court size which puts players under constant pressure from opposing players and frequent

Table 2
Mean and standard deviation of anthropometrical, playing experience and physiological variables.

Reference	Number of participants	Age (year)	Height (cm)	Body mass (kg)	Playing experience	$\dot{V}O_2$ max (ml·kg ⁻¹ ·min ⁻¹)	Heart rate max (b·min ⁻¹)
Barbero-Alvarez et al. ²	8	22.5 ± 1.7	177.8 ± 8.7	75.3 ± 7.3	Professional	64.6 ± 5.2	
Barbero-Alvarez et al. ¹	10	25.6 ± 2.5	175.8 ± 6	73.8 ± 5.7	Professional Spanish league club Mean		174 ± 7
Alvarez et al. ¹⁵	11	22.8 ± 1.5	178 ± 7.4	75.3 ± 6.3	Professional Spanish top-ranked second division team At least 5 years' experience	62.8 ± 5.3	191 ± 8
Alvarez et al. ¹⁵	13	24.6 ± 2.7	175 ± 4.2	69.8 ± 6.6	Semi-professional Italian top-ranked third division team players At least 5 years' experience	55.2 ± 5.7	198 ± 13
Castagna et al. ¹⁶	8	22.4	177	75.4	Professional Spanish second division team	64.8	191
Gorostiaga et al. ²⁴	25	25.2 ± 3.2	180 ± 5.7	76.6 ± 5.8	Professional Spanish outdoor first division team		
Gorostiaga et al. ²⁴	15	26.2 ± 4.1	176 ± 7.6	76.9 ± 10	Professional Spanish indoor first division team		
Castagna et al. ¹⁷	18	20.6 ± 3.1	175 ± 7.9	71.6 ± 8.5	Professional Spanish second division team	65.1 ± 6.2	193 ± 8
Dogramaci et al. ⁹	8	25.5 ± 3.8	176 ± 7	74.8 ± 4.7	Professional Australian National Team		
Milanez et al. ³⁶	9	22.8 ± 2.2	174.3 ± 6	70.6 ± 6.4	Professional Brazilian state first division		
Milanovic et al. ³¹	40		176.2 ± 6.8	70.3 ± 5.33	Professional Croatian league At least 3 years' experience	59.6 ± 2.5	190.4 ± 6.4
Rodrigues et al. ¹⁹	14	22.5 ± 3.1	172.8 ± 5.5	70 ± 6.3	Professional Brazilian state first division At least 10 years' experience	71.5 ± 5.9	199.8 ± 8.5
Pedro et al. ¹²	9	22.6 ± 4.2	174.3 ± 6	70.6 ± 6.4	Professional Brazilian state first division 5-10 years' experience	63.7 ± 4.1	189 ± 7
Pedro et al. ¹²	11	17.2 ± 0.8	175 ± 4	70.4 ± 6.5	Semi-professional Brazilian state first division 5-10 years' experience	62.1 ± 4.4	204 ± 11

turnovers occur regularly. Therefore, players need to move accurately and quicker to keep or get the ball, and require fast sprint and decision-making capabilities.³³ For these reasons, futsal players may need superior agility than soccer players to receive, move, and score goals.³¹

Barbero-Alvarez et al.³⁴ developed a futsal intermittent endurance test (FIET) based on Spanish futsal match analyses in order to assess futsal-specific endurance. Players are required to perform straight line shuttle-running bouts (i.e., 3 × 15-m) at progressive speeds interspersed with passive rest of 10-30 s until exhaustion. The FIET was found to be a reliable and valid test that involves both metabolic and neuromuscular aspects that may determine a player's game performance, and has been shown to discriminate between different levels of futsal players in Spain and Italy.^{17,34} Although the distance and speed performed in the FIET may be applicable to match situations, the test may need to be modified in the future as elite players are now running further and faster than they were in previous years. The FIET also provides information on the athlete's ability to carry out anaerobic work (i.e., intermittent exercise) with maximal intensity in accordance with futsal physiological requirements i.e. a strong correlation between FIET performance and repeated sprint ability.³⁴ Moreover, players of equivalent competitive levels reach exhaustion at similar speeds (16.5 km h⁻¹) in both the FIET and Yo-Yo IR1 and IR2, respectively.²² However, the FIET requires higher distance coverage (45 vs. 40 m) and hence players must exert more effort and repeated accelerations than the Yo-Yo IR tests.^{22,35} On a similar note, there are more turns required in the FIET than that in the Yo-Yo IR tests³⁵ (3 vs. 2¹). These comparisons suggest that for both distance and amount of turns, the FIET is an acceptable simulation of a competitive futsal match which can be performed in a controlled environment. However, there is currently no data on the amount and angle of turns within futsal matches and such would be useful to develop more accurate endurance tests. Future research is required to more accurately assess the sports-specific fitness levels of futsal players

with a need for further rigorous performance tests to be developed.

1.4. Limitations of research and future directions

Although futsal has been played for over 80 years it has only recently grown in popularity. Due to the current limited research into futsal, future research should investigate in-depth physical demands during futsal matches, as well as variations in physical performances over seasons. Training modalities to optimise performance should be examined, which could compare different classic training programs with sport specific exercises. Furthermore, there is a lack of research in key areas, particularly regarding skill requirements and player development. Moreover, there is a significant body of evidence not available in the English language, therefore, limiting analysis of this already small body of evidence.

2. Conclusions

Futsal players experience fatigue as the game progresses due to the high-intensity nature of the game, and the ability to repeat maximal sprint efforts and resist fatigue is paramount to the player's overall game performance. Therefore, to play at a high level, a futsal player needs to have or develop a great capacity of intermittent endurance, repeated sprint ability, leg power, and agility. The activity patterns of futsal suggest that both the aerobic and anaerobic energy systems are utilised, in particular the phosphagen system. Research shows that many aspects are required to perform at a professional level including proficiency in repeated sprint ability, anaerobic fitness, shooting and passing skill, agility and coordination. However, the current literature is clearly not comprehensive, which makes it difficult to compare studies and draw detailed conclusions. Further research into these aspects can improve the knowledge within the sport and help practitioners to develop more specific tests into futsal performance and skill.

Conflicts of interest

The author(s) have no conflicts of interest relevant to this article.

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