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The flag effect on the physical performance of soccer assistant referees

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Abstract: The aim of the study is to compere the performance of the assistant referee without and with the flag, based on existing and novel tests. Introduction: Millions of fans around the world are invested in the game of soccer, cheering on their favorite team, practicing their skills in the park, or simply watching from afar via the media. As such, fairness in refereeing is of the utmost importance, regardless of the level of game or the teams who are playing. The refereeing team plays a critical role in enforcing the rules of the game and ensuring fair play on the field. In addition to working together in the utmost coordination, the referee, two assistant referees, and the standby official are required to oversee the entire match, while making crucial decisions in split seconds. In addition to their verbal communications, assistant referees must carry and use their flag throughout the game, as means for signally their decisions. When running along the sideline, assistant referees hold the flag in opposite hand to the direction in which they're moving at that time – resulting in up to 30% of their movements during the game being sideways movements. Testing and comparing the athletic abilities of assistant referees is therefore an essential component in ensuring the accuracy and fairness of soccer matches. Assistant referees play a critical role in enforcing the rules of the game, and their ability to run quickly and accurately while holding a flag can have a significant impact on the outcome of the performance. Participants: 18 assistant referees (two female) who are on the staff of the National League in the Israel Soccer Association. The participants' mean (±SD) variables were as follows: age=29yrs (±3.4); height=178cm (±0.06); weight=68.22kg (±10.45); fat percent=14.67% (±4.86); and seniority on the league=3.11yrs (±1.45). Results: Show that in all the tests the performance was significant better without the flag (RST, agility test and linear speed), the performance decrement % (RST), show no significant result, $P<0.05$, $t(0.91) = 17$. Conclusions: the referee run faster without the flags but the no deferent in the fatigue, so they have to train and testing with flags like in the game.

Keywords: *Assistant referee, Change of direction, Flag, Repeated sprint, Soccer.*

1. Introduction

Soccer is one of the most popular sports in the world, with exposure to billions of people across the globe via television and additional media channels. It transcends boundaries of culture, language, socioeconomics, and gender. In the research literature, a growing focus can be seen on the activity levels and physical strain of soccer referees [1], yet little emphasis has been placed on understanding the physical demands that are placed on assistant referees. Traditionally, governing bodies have trained and evaluated their *assistant referees* alongside their *referees*, treating them as a unified group. However, more recent research highlights the importance of addressing assistant referees as a distinct population, due to the unique and specific physical requirements that they must perform during soccer matches [2].

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1.1. The Refereeing Team: Four Official Referees

In all soccer matches, the refereeing team is comprised of four official referees, including the main referee, two assistant referees, and a fourth official who is on standby. As of 2020, two video-assistant referees (VAR) have also become an integral part of the on-field refereeing team in most major leagues. While each member of the refereeing team is assigned a unique task, their cooperation is imperative to the correct implementation and enforcement of the rules of the game, with minimum errors in their decision-making [3].

It is not just the soccer players who need to exhibit excellent physical fitness throughout the game. The referees must also meet various physical requirements. In order to make the most accurate and fair decisions in a split second, the referees must closely observe the events taking place across the field. As such, soccer referees must be athletically skilled, able to quickly perform a range of anaerobic requirements, such as moving out of the way, changing direction, exhibiting agility, and running at speed [4].

On average, a soccer pitch is 90–120 meters long and 65 meters wide. The *referee* traverses the field in a diagonal and oblique manner, from the righthand side of one goalkeeper's box to the opposite corner on the other half of the pitch. In contrast, *assistant referees* have a unique running style and direction, that differ from those of both the players and the referee. Assistant referees move along one side of the halfway line, on one half of the field, and are required to hold a flag throughout the entire game. The flag must be held in the opposite hand to the direction in which they are moving. In other words, as they move to the right, they must hold the flag in their left hand, and vice versa. Moreover, each decision throughout the game is portrayed to the players by the assistant referees through a different waving pattern. For example, the flag is waved upwards for an offside, sideways for a corner kick, and upwards for a few seconds and then sideways for a foul [5].

The role of the assistant referees is to assist the referee in enforcing the rules of the game; they determine when the ball leaves the field, when fouls and offsides occur in their vicinity, and in cases of events that are hidden from the referee's sight [5]. When such an event occurs, the assistant referee signals to the referee and to the team players about his or her decision using the judging flag. Nowadays, in professional leagues, the referee team uses an electronic audio system through which they discreetly communicate with one another throughout the game. Regardless, assistant referees must clearly express their decisions in the same manner as they did prior to the introduction of such technology: using the judging flag [6].

1.2. Physical Demands and Movement Patterns of Assistant Referees

The physical abilities and performance of soccer players have greatly increased in volume over time, reflected, for example, through the total running distance covered during a game, the intensity of the players' running, the number of sprints that they perform, and the length of each sprint. In line with the improved physical performance of the soccer players, the physical demands on the refereeing team have also increased. As the players cover greater running distances and at greater speed, the number of refereeing events in a game also increases, as does the speed and complexity of these events [2].

Mallo et al. (2007), for example, found that in international soccer games, the referee runs a total distance of 9.5–12km per game (with an average distance of 10.4km), and is required to run about15% more in the first half of the game than in the second half. Differences were also seen in international games (such as the World Cup and Champions League), where referees are required to run at almost double the intensity (over 13 km/h) than in local leagues in Europe (such as in Finland and Italy). The researchers proposed dividing the distances covered by the referee during a game into the following five categories, based on speed: (1) *standing*, 0–3.6 km/h, 27.4% of the entire game; (2) *walking*, 3.61–7.2 km/h, 30.3% of the entire game; (3) *jogging*, 7.2–13 km/h, 25.5%; (4) *running*, 13.01–18 km/h, 12.2%; and (5) *sprinting*, 18+ km/h, 4.6% of the entire game [7].

In contrast, a later study by Mallo et al. (2009a) found that assistant referees cover a distance of 5–7km per game, with an average of 6.1km. Additionally, they were found to run an average of 20% more

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in the first half of the game than in the second half. Moreover, in international soccer matches, the assistant referees engage in almost 2.5 more high-intensity activities (>13km/h) than in local leagues in Europe. Moreover, the researchers found that following intense involvement due to an event in the game, the assistant referees benefit from a brief recovery period, during the transitions in possession; in contrast, the referee is required to cover the entire length of the field during these transitions, presenting a notable difference in their physical demands. Finally, using the same categories as those presented above for the referees, the researchers found that assistant referees cover the following distances during a game: (1) *standing*, 52.1% of the entire game; (2) *walking*, 24.1%; (3) *jogging* 16.2%; (4) *running*, 4.7%; and (5) *sprinting*, 2.9% of the entire game. In other words, it is clear that the physical fitness of both the players and the refereeing team plays a critical role in the success of a game [8].

When addressing movement metrics among soccer referees, two main parameters tend to be evaluated: (1) total distance covered (TDC); and (2) high-intensity running (HIR). Several factors can affect the running volume and intensity of referees and assistant referees during a soccer game, such as the players' and the teams' physical fitness, playing levels, and soccer styles (such as moving the ball, as seen in the Spanish League, or deep balls, as seen in the English League), as well as the distance that the ball moves across, which directly impacts the running distance, speed, and intensity that the referees perform during the game. Studies show that in local leagues, these metrics are almost half those that are seen in international games. For example, in international games, the referees' average distance covered, from events that take place in the center of the field, is about 13.4m – compared to local league games, where this distance is about 15% less [6].

Due to the unique movement of the *assistant referees* along one half of the field – in addition to their primary role of enforcing the offside rule and the need to be facing the field at all times – almost 30% of their movements throughout a game are sideways movements. Yet due to lower efficiency, the energy expenditure of sideways running movements is much greater (26%–40%) than regular running [8]. When combining these unique movement requirements with the characteristics of the game of soccer, the most important components of aerobic fitness for assistant referees include agility, the ability to quickly change direction, acceleration, and reaction speed. Moreover, as these assistant referees are required to make dozens of split-second decisions throughout the game, they need to be positioned opposite the last defending line of the defending team. Yet assistant referees who are limited in their aerobic abilities may not be able to position themselves properly, rendering them too far away from the events that they must observe and judge. As such, assistant referees need to possess the ability to combine aerobic ability (quickly reacting to changes in the game) and anaerobic ability (performing short yet intense) – to meet the requirements of the game [9].

1.3. Fitness Tests for Soccer Referees

Periodically, both *referees* and *assistant referees* must pass a range of fitness tests [10] , as defined by the Fédération Internationale de Football Association (FIFA). Over the years, these fitness tests have undergone numerous changes. Up until about 2005, the Cooper Test[11] was used for examining the aerobic capabilities of soccer referees. First, the refereeing team were tested on anaerobic runs, comprised of two 50m sprints and two 200m sprints, with 2–3 minutes rest between each sprint. Following a 10min recovery, they were then required to run for a 12min period, while covering a distance of at least 2,700 meters within this given timeframe [6].

However, these tests do not reflect the physical activities of the refereeing team during a soccer game – as they are rarely required to continuously run such distances and for such long periods of time, as required in the Cooper test. The 50m sprint, for example, covers almost half the length of a soccer pitch. Referees in general, and assistant referees in particular, are rarely required to exert such effort during a game. As such, the Cooper test does not predict or reflect concrete game situations, nor do they simulate the reality and kinematics of the demands on the refereeing team throughout the game. It was therefore decided to create a more specific and dedicated fitness test for both referees and assistant referees [8].

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In 2005, FIFA determined that the referees and assistant referees would be tested using the 50x150-meter test, comprised of 20 consecutive repetitions of 150m running and 50m recovery (walking). To further improve the physical fitness of the referees and assistant referees, they sought fitness tests that would have higher correlations with their physical demands on the field. Newer fitness tests include anaerobic tests and an intense aerobic test, that are performed on an athletic field [10].

The new anaerobic test includes six 40m sprints, with a 90s recovery time between each sprint. Each referee is positioned about 1.5m in front of the electronic sensors, and must then run and cross the finish line within 6.2s (after this timeframe was decreased from the original 6.4s). If the referee did not manage to perform one of these sprints within the given timeframe, they had one more chance to achieve the required time; otherwise, they were disqualified and were not permitted to continue to the aerobic test [10].

After successfully completing this anaerobic test, the referees have 6–8 minutes recovery before embarking on the aerobic test. Replacing the Cooper test, the new anaerobic test is conducted in the form of 20 high-intensity intervals of 150m – each of which must be completed within 30s – and with active recovery through 50m walking between each run – each of which must be completed within 35s (after this timeframe was decreased from the original 40s recovery time). In this test, the referee is required to cover a total of 4,000m, comprised of 10 laps of the 400m field – with 3,000m of these being covered through 20 intense runs of 150m each, with walking recovery between each one [8].

However, even with this newer aerobic test, low correlations were seen between the test and the physical demands of referees and assistant referees during an actual soccer games. Indeed, while the test is structured in the form of intervals, similar to the game itself, the length of the sprints, the duration of the intense runs, and the location of the tests (on athletics surfaces rather than on a soccer field) are not highly correlated with the physical performance of the refereeing team during a game, where they have greater recovery times, shorter intervals, and lower pulse rates [1].

Indeed, this test provides a suitable tool for examining cardiovascular abilities and can be used by FIFA for examining the physical fitness of soccer referees. However, this cannot serve as the main test as it does not adequately simulate game situations. Moreover, this test does not enable comparisons between referees, since they are all required to run equal distances and within equal timeframes [8]. FIFA (2018) later built a similar test, also comprised of 40 repetitions of 75m running within 15s, and 25m recovery within 20s [1].

The most relevant test to date for measuring the aerobic fitness of soccer referees is the Yo-Yo Intermittent Recovery Test (YYIRT), with great consensus among sports researchers regarding its ability to predict and simulate physical performance among soccer referees [12]. This test was first used in 2005, prior to the FIFA Confederations Cup. This intense fitness test, in the form of multiple intervals of high intensity running activities, is conducted on grass rather than on an athletic track – similar to soccer game conditions. The referee is required to run 20m in one direction and then immediately run back the same distance (40m in total), followed by a 5m walking recovery segment, also there and back (10m in total within 10s). Throughout the running and walking, a beep rhythm is sounded to set the required pace. The referees must perform this test until they are unable to keep up with the set pace, as per the beep rhythm. Their total distance covered is then recorded [5].

Compared to other tests, the YYIRT was found to have the highest correlations with the necessary physical performance of referees and assistant referees during a soccer game. In addition to taking place on a grass field, it requires high running intensity, active recovery, and change of directions. The test also meets FIFA requirements, as it enables comparisons between the physical achievements of the participating referees, unlike the 150*50m tests, where all referees cover the same distance and at the same speed [5].

Later, FIFA developed a dedicated version of the YYIRT, specifically adapted to the running movements of the assistant referees. This test is comprised of a 40m round-trip running section (20m each direction, similar to the original test), immediately followed by a 25m round-trip running section, performed solely through lateral movements (12.5m each direction) [13].

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Based on this literature review, the aim of this study was to examine the differences between the various physical tests for assistant referees in soccer, with and without their carrying the flag during these assessments.

2. Methods

2.1. Participants

The research population included 18 assistant referees (two female) who are on the staff of the National League in the Israel Soccer Association – second in ranking to the Premier League. The participants' mean (±SD) variables were as follows: age=29yrs (±3.4); height=178cm (±0.06); weight=68.22kg (±10.45); fat percent=14.67% (±4.86); and seniority on the league=3.11yrs (±1.45). In Israel, assistant referees are required to participate in aerobic and anaerobic training sessions once or twice a week, and are tested for physical fitness once in the pre-season period and three additional times during the season. They are also examined by a sports nutritionist three times a year, who measured their weight, height, and fat percentage.

2.2. Research Procedure and Tools

The participants completed three anaerobic physical assessment tests without holding the flag. One week later, the same participants were asked to complete the same tests once again, this time while holding the flag throughout the assessments. The tests all replicate movements and skills that are required of the assistant referees during soccer games throughout the season. The tests were conducted on a grass field and in optimal weather conditions (22°C); the participants wore their regular referring uniforms and soccer shoes. To measure the participants' capabilities in the three tests, standard marking tape was used to mark distances, cones were used to mark starting and finishing points, and Microgate electronic sensors were used to measure running speeds. The three anaerobic tests included the sprint test, change of direction abilities (CODA) test, and the related sprint ability (RSA) test, as follows:

Test 1: Sprint test. The participants were instructed to run a 30m sprint as quickly as possible.

Test 2: CODA test (Figure 1). The participants stood 1.5m from the starting line where the electronic sensor was placed (point A). They were then instructed to run as quickly as possible 10m to the finishing line (point C), change directions and run back 8m in lateral movements (to point B), change directions and run back 8m, also in lateral movements (to point C), and then finally, change directions once again and run back to the starting line (point A).

Figure 1.
Change of Direction Abilities (CODA) Test.

Test 3: RSA test (Figure 2). In this test, the participants performed five sprints covering 30m with a 90s recovery interval after each sprint, during which time they were required to walk back to the starting point. Three measures were calculated from the RSA Test, including (1) *total time* of all five

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sprints; (2) ideal time (seconds), i.e., the time of the fastest sprint (seconds); and (3) performance decrement (%), based on the difference between the participants' total time and ideal time.

Figure 2.
Repeated sprint ability (RST) test.

2.3. Statistical Analysis

Statistical analyses were conducted using SPSS 26 (IBM Inc.). Dependent T-tests were performed for comparing between the obtained data, with and without the flag. Cohen's d-effect size was also performed, to examine the magnitude of the competitive season's effect in each group, with d<.30 being considered low; .30–.70 representing a moderate effect; and >.70 representing a strong effect. Pearson's linear correlations were conducted to evaluate relationships between the tests. Data are presented as mean ±SD. Significance was set at $p \leq .05$.

3. Results

First, we compared between the results of the three tests with and without the flag (Table 1, Figures 3–5). In the 30m sprint tests, significant differences were seen between the participants' performance (5.59=17, p<0.05, whereby their mean speed *without* the flag (M=4.332, SD±0.284) was significantly faster that *with* the flag (M=4.56, SD±0.31), and with a large effect size (Cohen's d=1.31).

Significant differences were also seen in the CODA tests (p<0.05, $t_{(4.63)}$=17), whereby the participants' mean speed *without* the flag (M=9.28, SD±0.46) was significantly faster than *with* the flag (M=9.74, SD±0.49), and with a large effect size (Cohen's d=1.09).

In the RSA tests, significant differences were seen (p<0.05, $t_{(5.62)}$=17), whereby the participants' ideal time (RST) *without* the flag (M=21.65s, SD±1.41) was significantly faster than their ideal time *with* the flag (M=22.81s, SD±1.59), and with a large effect size (Cohen's d=1.32). Significant differences were also seen in their mean total time (p<0.05, t (6.43), whereby their performance *without* the flag (M=22.09s, SD±1.37) was significantly faster than *with* the flag (M=23.32s, SD±1.49), with a large effect size (Cohen's d=1.51).

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Table 1.
Test results with/without the flag.

Test	Without flag	With flag			
	Mean ±SD	Mean ±SD	t	Cohen's d	r
30m repeated sprint test (sec)	4.33±0.28	4.56±0.31	5.59	1.31	*0.83
Change of direction test (sec)	9.28±0.46	9.74±0.49	4.63	1.09	*0.61
Ideal time (sec)	21.65±1.41	22.81±1.59	5.62	1.32	*0.83
Total time (sec)	22.09±1.37	23.32±1.49	6.43	1.51	*0.84
Performance decrement (%)	2.02±1.22	2.30±1.28	0.91	0.21	0.44

However, no significant difference between the participants' performance decrements ($t_{(0.91)}$=17, P<0.05) *without* the flag (M=2.02%, SD±1.22) and *with* the flag (M=2.30%, SD±1.28).

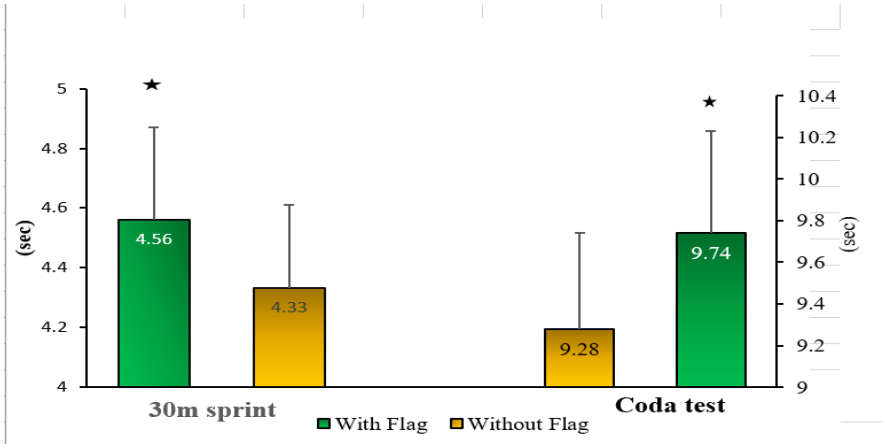

Figure 3.
Comparisons between the RSA and CODA tests, with and without the flag.
Note: *P<0.05.

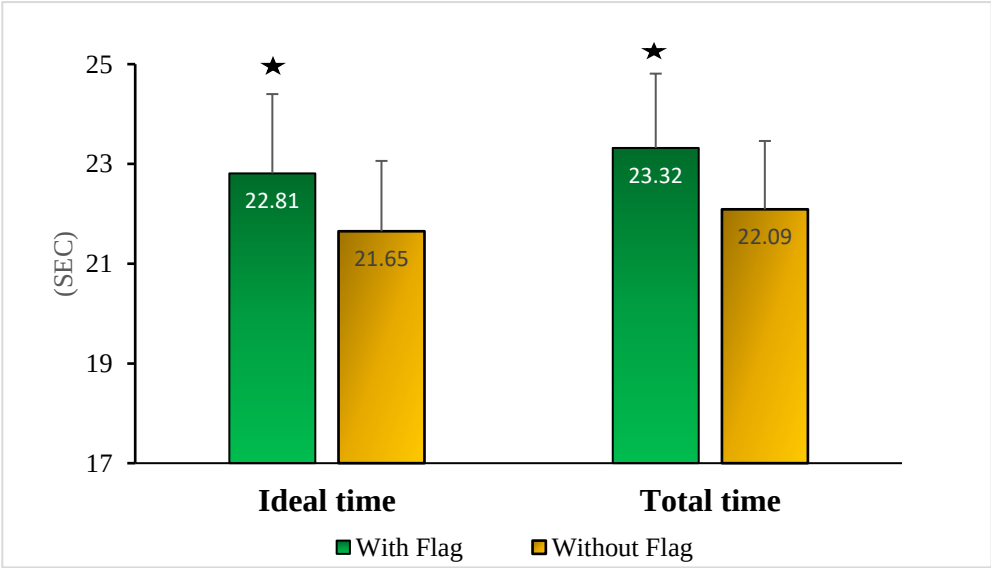

Figure 4.
Comparisons between ideal time and total time, with and without the flag.
Note: *P<0.05.

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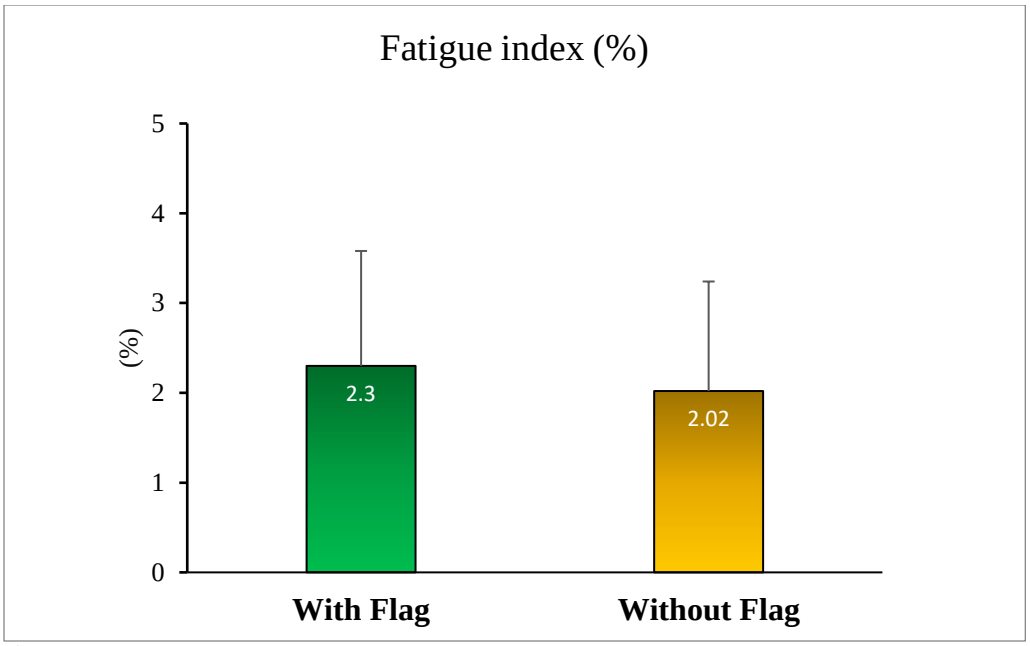

Figure 5.
Comparisons between the performance decrement index, with and without the flag.

4. Discussion

The aim of this study was to examine the tests that are commonly used for assessing the physical fitness of soccer assistant referees – with and without a flag in their hands during their assessments. As the assistant referees must be physically fit, to enable them to clearly follow the events of the game while making split-second decision that impact the entire game – suitable assessments are of the utmost importance. The main findings indicate that with the exception of the performance decrement, the participants achieved higher scores in all tests when they were not carrying the flag.

The term *mechanical efficiency* in running refers to the energy needed for performing a movement task at a given speed. Moreover, *running speed* is measured as the runner's step length X step frequency, with their running efficiency referring to the energy that they need to exert for taking one single step [14]. As explained in the literature review above, during a soccer game, the assistant referees spend much of their time running in lateral movements along the length of the field, so that they can continue to face the field and the players. In some games, they may run in a lateral manner for up to 30% of the total distance that they cover. However, lateral running consumes up to 40% more energy than regular forward-facing running [8]. The relatively high energy expenditure of lateral running is due to its low mechanical efficiency. In this study, the decreased performance seen in almost all tests when running with the flag could stem from this impairing the mechanical efficiency of the assistant referees compared to their running without a flag.

In general, the findings of this study indicate that unlike the regular running that is required of soccer referees during a game, having to continuously hold a flag clearly decreases the running efficiency of assistant referees, and increases their energy expenditure – especially while combined with lateral running. As this significant difference was seen in all of the anaerobic tests, and in almost all of the measures that were examined, it is clear that holding a flag while running impairs the referees' motor skills. This is in line with Meckel et al. (2012), who also found that as the energy expenditure increases, the mechanical efficiency decreases. In their study, the researchers examined the performance of soccer players in RSA tests (6X30m) along straight or slalom (zigzag) routes, without a ball or while dribbling [15]. Their findings indicate that sprinting along a straight line – in terms of both ideal time and total running time – the participants' performance without the ball was significantly faster than

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when running with the ball [15]. Similarly, Reilly and Ball (1984) also examined the mechanical efficiency of running while performing an additional task with an accessory [16]. In their study, the researchers measured the levels of oxygen consumption, rate of perceived exertion, and blood lactic acid (lactate) while the participants were running on a track for five consecutive minutes at increasing speeds (9, 10.5, 12, and 13 km/h), with and without dribbling. Their findings indicate that as the running speed increased, so did their energy expenditure. When examining their measures while running and dribbling, a greater increase was seen in the rate of perceived exertion as the intensity/effort increased – yet only while running and dribbling. Moreover, the participants exhibited higher lactate levels as the running speed increased and without dribbling; with dribbling, these levels spiked much quicker, even at low running speeds [16].

Meckel et al. (2020) tested both referees and referee assistants from the top two leagues in Israel, via RSA tests (6X40m for referees and 5X30m for assistant referees), at the beginning and middle of the season [17]. Their findings indicate that the participants from the National League (i.e., the second top league) performed better than those from the Premier League. This could be due to the high motivation of referees from the National League to advance to the Premier League, which resulted in their improved physical fitness. Moreover, improved results were also seen among the participants mid-season compared to the beginning of the season. In the current study, the tests were conducted mid-season, when the assistant referees' physical fitness is expected to be high – with similar findings as those seen in Meckel et al.'s (2020) study [17].

4.1. Limitations and Future Research

This study offers important contributions to the literature regarding the flag effect on the physical fitness and capabilities of assistant referees during a soccer match. Yet a number of research limitations should be addressed. First, no biomechanical measures were taken to scientifically indicate the differences in the participants' running efficiency seen in the fitness tests applied in this study. Future studies could benefit from incorporating such measures in their studies. Moreover, a relatively small number of participants were included in this study, and all were from the same league. Future studies could conduct comparisons between assistant referees from different leagues, thereby increasing the number of participants in the study and increasing generalizations. Studies could also conduct comparisons between male and female assistant referees.

5. Conclusions

Based on the findings of this study, it is clear that the refereeing flag should be integrated into the fitness training and tests of referee assistants – as their ability to adequately handle the flag during a soccer game has a significant impact on their physical performance, and possibly also on their cognitive performance. Handling the flag during a game can decrease their running speed and ability to quickly change directions, resulting in decreased mechanical efficiency and increased energy expenditure. It is also imperative that the content of their fitness training and tests replicate situations that they experience during a game – to enhance their performance and skill mastery necessary for the job. Overall, improving the fitness training and testing of assistant referees will enhance their on-field performance, ensuring a fairer game with more efficient refereeing.

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