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The effect of an intermittent protocol on strength performance in female football players: an exploratory study

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ABSTRACT

Football is a sport that involves a combination of continuous and intermittent effort. Therefore, players need to be able to recover quickly between moments of high intensity to continue to perform at a high level of output throughout the entire match. The present study aimed to evaluate the effect of an intermittent exercise protocol on the rate of high-intensive force production through the countermovement test (CMJ) in elite Portuguese female soccer players. The sample consisted of 12 players from the first division of women's football in Portugal (Age= 18.1± 0.9 years; Weight= 60.10± 5.8 Kg; Height= 1.63± 4.8 cm; BMI= 22.48± 1.5 kg/m^2). The players performed an intermittent exercise protocol on a cycle ergometer, lasting 8 minutes, in which each minute corresponded to 40 seconds of high-intensity (4 W/kg, based on the player's body weight) and 20 seconds of low-intensity (75W). Before and after the protocol, the players performed the CMJ. Through the results obtained, it was possible to observe that players presented a significant decrease in the height of the CMJ between the two moments (before- 29.92± 3.55 cm vs after- 26.92± 4.05 cm; $p < .01$). The present study allowed us to conclude that intermittent exercise protocol promoted a negative influence on CMJ performance.

KEYWORDS: soccer; fatigue; evaluation; laboratory; countermovement jump.

INTRODUCTION

Achieving high performance in football athletes is a permanent quest and a constant challenge for the sports science community, who are involved with improving athletic fitness. Like what happens in several collective sports, football has also evolved thanks to the participation of sport sciences (Raya-Castellano & Uriondo, 2015).

Therefore, as a result of football involvement, the entire activity underwent and continues to undergo greater and more detailed knowledge of the player, with clear repercussions on the improvement of their level of athletic aptitude for the competitive practice of football (Raya-Castellano & Uriondo, 2015).

Football is a game of cooperation and opposition between players and teams, which results in complex and unpredictable dynamics (da Silva, 1998). During official games and training sessions, players perform an intermittent effort, where they are exposed to varied physical demands, including

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races, jumps, sprints, accelerations, decelerations and constant changes of direction, requiring strength and power of lower limbs (Stølen, Chamari, Castagna, & Wisløff, 2005).

The continuous production and loss of strength throughout the match generate physical exhaustion (Reilly, Drust, & Clarke, 2008). As the game progresses, energy levels decline, and fatigue builds up in the muscles, reducing force output and the players' ability to perform these actions with equal efficiency (Reilly, Drust, & Clarke, 2008). This loss in the effectiveness of movements may result from the player's loss of strength and power, which may affect his performance over 90 minutes of the game (Turner & Stewart, 2014). Some researchers applied jumping tests to assess the muscle power of the lower limbs in football players, for example, the counter-movement jump (CMJ) is largely used (Jiménez-Reyes et al., 2017).

Concurrently, women's football is continually developing, and the game itself demands greater physical capacity from female players (Scott & Bradley, 2020). In the last two editions of the Women's World Cup (i.e., Canada- 2015, and France- 2019), players had a higher average speed and covered greater distances during matches (cf., Scott & Bradley, 2020). These recent findings may suggest that the scientific community must carry out studies on female players to ultimately understand their needs and evolution.

The methods that can be used in competition to determine the physiological stresses associated with match-play are limited (Brownstein et al., 2017). The demands of match-play have been examined by observing matches, obtaining physiological measures during real and simulated games, and determining the physical capacity of elite players on performance tests (Drust, Reilly, & Cable, 2000). Such information is not always associated with the controlled conditions found in experimental investigations or subject to the depth and accuracy of laboratory-based analysis (Drust et al., 2000).

Several researchers have devised laboratory-based exercise protocols to assess the physiological and metabolic responses to intermittent exercise (Balsom, Seger, Sjödin, & Ekblom, 1992), allowing greater robustness in the results obtained (Lemmink & Visscher, 2005). Therefore, Lemmink and Visscher (2005) validated an intermittent exercise protocol on a cycle ergometer for football players. This intermittent protocol is performed on a cycle ergometer and lasts 8 minutes, each minute corresponding to 40 seconds of high-intensity (4 W/kg, based on the player's body weight) and 20 seconds of low-intensity (75 W).

The protocol abovementioned can bring the advantage of stimulating the anaerobic system, which is essential for bursts of speed and high-intensity efforts in football (Strudwick & Iaia, 2018), increasing their ability to produce energy quickly without relying solely on oxygen supply (Strudwick & Iaia, 2018). Using a cycle ergometer protocol is also a low-impact form of exercise, which means that it causes less stress on the joints, preserving the player's physical integrity (Werstein & Lund, 2012). However, it must be addressed that this protocol may not perfectly replicate the movement patterns and the real physical demands found during a football match, generating a lack of specific neuromuscular stimulus (Werstein & Lund, 2012).

Studies conducted using female football players are necessarily increasing since women's football has been developing more and more, attracting the attention of fans and the media (Vezzali et al., 2023). Therefore, the present study aimed to analyse the effect of an intermittent exercise protocol on strength performance in female Portuguese football elite players. Moreover, we expected female players to perform worse in the counter-movement jump results after performing an intermittent exercise protocol.

METHODS

Sample

Twelve elite female football players from the Portuguese First Division were recruited to participate in the present study (Age= 18.1± 0.9 years; Weight= 60.10± 5.8 Kg; Height= 1.63± 4.8 cm; BMI= 22.48± 1.5 Kg/m^2). The participants played in the Portuguese Premier League, and all of them played for their national teams (Portugal and Brazil). The G*Power version 3.1.9.7 was used to calculate the sample size, and a minimum of 12 players were required (f^2= 1.1, α= 0.05, and β= 0.96) (Verma & Verma, 2020).

The players had their anthropometric data collected before the protocol was initiated, namely: height (SECA 213 portable stadiometer, Germany), weight and body mass index (BMI) (Omron Body Composition Monitor BF511, Japan). The procedures were presented to the participants, who then provided informed consent. The study was approved by the Ethics Committee of the host university (protocol number M25A21), and all procedures were conducted in accordance with the Declaration of Helsinki.

Procedures

Intermittent exercise protocol

The players performed an intermittent exercises protocol validated for football players by Lemmink and Visscher (2005). The height and saddle distance of the computer-controlled

stationary bicycle (SRM Ergometer, Germany) were standardised for each participant. Based on the players' body mass, the high-intensity loads (4 W/kg) were calculated and, together with the low-intensity loads (75 W), imported into the computer. The use of a personal cycle protocol related to body mass aimed at comparable intensity among participants. After 2 min of warm-up at 75 Watts (W), each player performed it for a total duration of 8 min, divided into 8 blocks of intermittent exercise (each block had 1 min). In each block, players alternated high-intensity exercise at 4 W/kg for 40 seconds and low-intensity exercise at 75 W for 20 seconds. During the first 15 seconds, both in periods of high-intensity (4 W/kg) and periods of low-intensity (75 W), the workload was permanently changed continuously to avoid abrupt transitions between exchanges of workload across the protocol. At the end of the 8 minutes of protocol, a cooling of 1 min at 75 W was performed.

The players were instructed throughout the test to maintain the cycling frequency between 70 and 80 rotations per minute (RPM). Exercise workloads were recorded using heart rate (HR) in 5-sec interval short-range telemetry (SRM DUAL ANT+, Bluetooth Smart running heart rate monitor, Germany). To obtain the HR_{max} of each player, the formula proposed by Alder, Broadbent and Poolton (2021) was used (HR_{max}= 220 - Age).

To assess the maximum height of the players, the CMJ was immediately collected at the beginning and at the end of the protocol (or where the participants could sustain the effort) using the Optojump Photocell System (Microgate, Bolzano, Italy). The Optojump is an optical measuring system which can be used for vertical jump height measurement. It consists of two bars, a transmit and a receive bar, each measuring 39.4x1.2x1.6 inches and containing between 33 and 100 LEDs. This tool allows the measurement of all jumps performed by the players in centimetres (cm). Each player performed three successful CMJs with hands on her hips from a standing position. Rest periods of half a minute between the jumps were assumed. Additionally, players were instructed to jump as high as possible and pose with both feet (cf., Jiménez-Reyes et al., 2017).

The players performed the intermittent protocol and the CMJ once to familiarise themselves with the task, and after a week's interval, the data was collected.

Statistical procedures

The distribution of data sets was analysed using Shapiro-Wilk tests, and the values obtained were expressed as mean± SD and 95% confidence intervals (CI). The Paired T-Test was used to compare the CMJ values obtained before and after the protocol (Ross, Willson, Ross, & Willson, 2017). The statistical software used was "SPSS for Windows 20.0". The alpha level for significance was set at $p< 0.05$ and the value of t (5.911).

RESULTS

During the execution of the protocol, several football players reached a significant level of intensity, reaching 90% of their HRmax. Moreover, in less than a minute, the players showed an increase in their HR, surpassing 80% of their maximum capacity. The elevated HR values were maintained throughout the remainder of the protocol (Figure 1).

The CMJ values obtained after and before the protocol intervention are presented in Table 1.

According to the results obtained, the female players had a lower performance in the CMJ performed after the protocol (26.92± 4.05 cm) compared to the jump performed before the protocol (29.92± 3.55 cm).

DISCUSSION

Intermittent exercise is a strategy commonly used in football training, both for men and women, aiming to improve athletes' aerobic and anaerobic capacity (Gabbett & Mulvey, 2008). However, it is important to investigate the effects of intermittent effort on female football players. Therefore, the present study aimed to analyse the effect of an intermittent exercise protocol on strength performance in female Portuguese football elite players. As expected, the results confirmed that the intermittent exercise protocol proposed by Lemmink and Visscher (2005) negatively affected the CMJ performance in female football players.

The rapid increase in HR values along the protocol suggested that the exercise was challenging the players' cardiovascular system, requiring considerable effort to sustain the required intensity (Marcora, Bosio, & Morree, 2008). Moreover, the intensity and physical demands required by the protocol may have been too excessive for players 1, 2, 5, 6, 8, 9, 10 and 11 (Figure 1), resulting in withdrawals during the activity. The female players who were able to complete the protocol maintained their HR at 85% of their HR_{max} from the fourth minute of the protocol, which is considered to be a high-intensity workload (Marcora et al., 2008).

The strength ability is fundamental to compete effectively in game situations that involve ball disputes in the air, such as headers and interceptions, both in attack and defence (Jiménez-Reyes et al., 2017). That is why the researchers used valid and reproducible tests that may assess this particular ability, like CMJ (Morcillo et al., 2015).

Our findings showed a significant decrease in the CMJ performance of female players (p< .01) due to intermittent effort applied by the intermittent protocol. The CMJ performance requires a quick and high intensive production of muscle strength to propel the body into the air (Pedley, Lloyd, Read, Moore, & Oliver, 2017), and this ability was impaired by the intermittent protocol implemented. It is important to notice that CMJ is a movement that requires a combination of strength, speed, and muscle power to produce an efficient jump (Sporiš, Milanović, Jukić, Omrčen, & Sampedro Molinuevo, 2010), and when there is a loss of muscle strength due to physical wear during a match or after an intense exercise protocol, like our players, the ability to produce the necessary strength for jumping can be compromised (Pedley et al., 2017).

Although this kind of experiment has not been carried out with female football players, some studies evaluated the

Table 1. Mean (m± SD) values of Countermovement jump (CMJ) before and after the intermittent protocol.

	Before Protocol (m± SD)	After Protocol (m± SD)	p-value
CMJ (cm)	29,92± 3,55	26,92± 4,05	.000

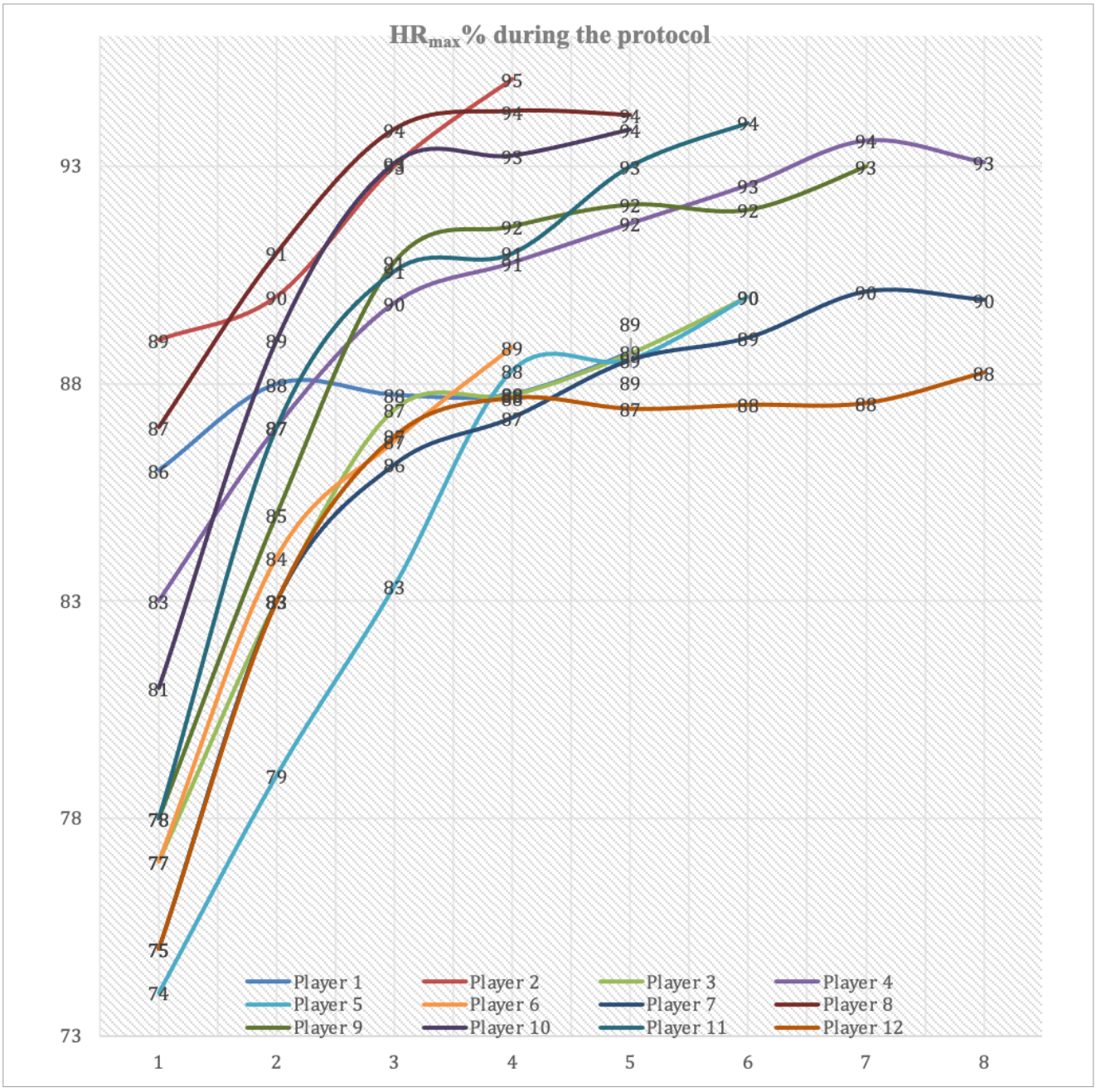

Figure 1. Percentage of HR_{max} (% HR_{max}; Y-Axis) of female players (X-Axis) during the intermittent protocol.

influence of fatigue-inducting protocol on the strength production capacity of a football player. Morcillo et al. (2015) used the CMJ as a tool to analyse the relationships between repeated sprint ability, mechanical parameters and metabolites in 18 professional male football players in Spain. Torreblanca-Martinez, Otero-Saborido and Gonzalez-Jurado (2017) evaluated the effects that a fatigue-inducing protocol generated on the kick of 15 U-18 male football players from a professional club, using the CMJ as an assessment tool. Both studies reported that after the fatigue induction protocol, players lost the ability to generate maximum strength, which was pointed out as one of the reasons for the loss of players' performance.

In addition, the loss of muscle strength can decrease the speed and muscle power of the player, directly influencing the performance in the CMJ (Loturco et al., 2019). McFarland, Dawes, Elder and Lockie (2016) analysed CMJ performance after repeated sprints and change of direction in 20 male and 16 female NCAA Division II players, and their results evidenced that players lost execution speed and worsened their CMJ performance after testing, suggesting that physical exhaustion generated by the intermittent protocol may have generated peripheral muscle fatigue, and inhibited the muscles to maintain the expected performance (Marcora et al., 2008).

CONCLUSIONS

The present study suggests that intermittent exercise protocol used negatively affects female football players' strength performance. Moreover, the used intermittent protocol enhanced peripheral fatigue like those found during high intensity periods of a football match.

FUTURE SUGGESTIONS

The intermittent protocol can simulate fatigue situations like those found during a football match. This challenges players to maintain high-quality performance even when they are tired. This coaching approach can help improve players' ability to make quick decisions. Laboratory studies allow us to obtain more robust scientific results and increase player safety throughout the testing sessions. Therefore, we pointed out some other research questions that the community should study, particularly: What would be the effect of high temperature on female football players during an intermittent protocol that can simulate a match? How could this affect the physical, physiological and, especially, cognitive demands?

It is essential for the scientific community to develop studies that can provide tools to help the football staff identify and overcome possible underlying causes of performance loss by female players, optimising their ability to perform their skills within the game.

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