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Original Article

The impact of resistance training on physiological performance among amateur senior soccer players: An integrated training approach

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Abstract
Purpose. Numerous studies suggest that specialized respiratory muscle training can enhance physical capacity, pulmonary function, and athletic performance, particularly in soccer players. Due to the significant influence of respiratory muscle performance on exercise capability and cardiopulmonary reaction to physical activity, systematic conditioning and assessment of respiratory muscle performance ought to be contemplated in athletes. Therefore, this research aimed to determine whether intermittent resistance training could improve the endurance capabilities of amateur soccer players involved in competitive recreational soccer. Methods.The study involved twenty (n = 20) senior soccer players (mean age 41.2 ± 3.1 years) participating in competitive amateur soccer. The participants were divided into two groups, each subjected to different levels of resistance during both training sessions and matches, while all participants possessed standard medical and fitness parameters. The soccer participants were divided into two categories (Control Group A and Experimental Group B with lower resistance levels), ensuring regular attendance at prescribed weekly training sessions and additional sessions over a six-month period. A standardized assessment motor test (Cooper test), and Spirometry were administered at baseline and after training. Results. The processed data enabled the determination of VO2max, considering the mixed energy expenditure characteristics of football. A significant portion of the team (65%) exhibited inadequate performance in terms of fatigue resistance, potentially linked to an incomplete 12-minute test. This underscores the necessity for enhancing endurance and stamina. Conclusions. The present investigation offers evidence that supports a positive correlation between physiological performance and the impact of resistance training in amateur senior soccer players.
Key words: endurance, physiology, sport, VO2max, skills, exercise.

Introduction

Sports performance, similarly in the elite and amateur athletes, requires a teamwork between researchers, coaches, and other sport practitioners (Di Onofrio, Montesano, Mazzeo, 2019; Greco et al., 2019 Latino, & Tafuri, 2023, 2024a-b; Silva et al., 2021; Tafuri, & Latino, 2024). Moreover, some studies suggest that specific respiratory muscle training programs can improve physical ability lung function and exercise performance, in many sports but especially in soccer players (Farì et al., 2021; Latino, Saraiello, & Tafuri, 2023; Mazzeo, & Liccardo, 2019; Mackała et al., 2019). Unequivocally, there's a strong connection between pulmonary function and endurance performance in soccer players, including amateur athletes. Moreover, studies have shown that elite soccer players have superior pulmonary function compared to their amateur counterparts (León-Morillas et al., 2021). This is to be expected to due to a combination of factors including genetics, training adaptations, and overall fitness level. Nevertheless, even for amateur players, cardiovascular and respiratory muscle training can help improve pulmonary. Specific exercises that strengthen the muscles used for breathing can improve lung efficiency (Aidar et al., 2022; Cataldi et al., 2019; Latino et al., 2021; Montesano, & Mazzeo, 2018). The respiratory system is a complex network of organs and tissues responsible for gas exchange. Various drugs and substances can impact this system and its control mechanisms. Here's a breakdown of current literature on this topic. Coaches and athletes are constantly striving for improvement, and there's a lot to unpack when it comes to what makes a good performance (Farì et al., 2023; Mazzeo, 2018). The study by Ferraz et al. (2017) reinforces the idea that athletic performance is a complex interplay of various factors (Ferraz, van den Tillar, & Marques, 2017; Mazzeo, & Volpe, 2016). Endurance, as a conditional motor skill, is directly connected to an athlete's ability to sustain effort throughout a race (Vahia et al., 2018). Moreover, the ability to execute complex actions that have been programmed through training, represent a crucial element in athletic performance (Clemente-Suárez et al., 2018; La Torre et al., 2023; Montesano et al, 2013).

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Overall, developing respiratory capacity through specific training is a crucial step for athletes aiming for consistent performance. While it is not the sole factor, it plays a significant role in delivering oxygen, managing fatigue, and allowing the athlete to perform at their best throughout the competition (Chtourou, & Souissi, 2012). The enhancement in resistance is intricately connected to the functionality of the cardiocirculatory system and respiratory system, which supply the necessary energy for sustaining prolonged aerobic and anaerobic efforts, alongside the quantity of red fibers found in the muscles (Myllymäki et al., 2011). It is somewhat accurate to suggest that maximal enhancement in respiratory capacity typically occurs only following the complete development of larger systems around the age of 12-13 years. While strength training offers significant advantages, caution must be exercised to prevent overtraining, which could negatively impact speed, explosive strength, and ultimately overall performance (Huang et al., 2009). Athletes, such as soccer players, necessitate a bioenergetic profile that blends anaerobic and aerobic capacities (Cipryan, & Gajda, 2011). Soccer demands quick sprints, changes in pace, and sustained running throughout a match. Furthermore, an individualized training regimen tailored to the athlete should take into account the specific requirements of their sport and their unique physical attributes. This tailored approach establishes a solid base for enhancing performance and minimizing injury risks. Various elements can influence an athlete's performance, including external factors like microclimate and field conditions, as well as internal psychophysical factors such as fitness levels, overtraining, nutrition, and stress levels (Nédélec et al., 2015; Mazzeo, Santamaria, & Montesano, 2019). During both competitions and training sessions, athletes likely engage different metabolic pathways, including anaerobic alactacid (such as jumps and sprints), anaerobic lactic (like sprinting with short recovery periods), and a mix of aerobic and anaerobic processes (seen in technical-tactical drills and competitions) (Ferrara, Goldberg, Ortmeyer, & Ryan, 2006; Suarez-Arrones et al., 2018).

The general resistance facilitates the extension of a moderate/medium intensity muscular effort, with the specification enabling the maintenance of a higher intensity work level while upholding consistent performance. In both scenarios, the onset of fatigue, stemming from the buildup of lactic acid in the muscles and bloodstream, hinders the continuation of the work itself. Moderate exertion leads to a slight rise in lactic acid, which is offset by the usual oxygen supply, whereas intense exertion disrupts the normal oxygen flow required for adequate compensation. Enhanced endurance, denoted by an escalation in resistance, significantly enhances the capacity to endure increasingly substantial workloads. The adaptability of the respiratory system broadens the scope of activities beyond gas exchange, with its primary role being the transfer of oxygen from the air to the blood and the elimination of carbon dioxide (Amann et al., 2008; Mazzeo et al., 2016; Messina et al., 2015).

The efficiency of respiratory muscles plays a pivotal role in the correlation between respiratory fitness and overall exercise capacity. Various muscles within the respiratory system, such as the diaphragm and intercostal muscles, are crucial for the expansion and contraction of the lungs during breathing. As exercise intensity rises, the body's oxygen requirements for muscle function increase, prompting physiological adjustments to fulfill this need: heightened breathing frequency, augmented tidal volume (the volume of air inhaled and exhaled during each breath), and overall ventilation (the multiplication of breathing frequency and tidal volume, reflecting the total air exchange in the lungs per minute, sees a notable increase. Studies suggest that respiratory muscle fatigue (distinct from overall bodily fatigue) diminishes the capacity to complete resistance exercises. Counteracting or delaying respiratory muscle fatigue during exercise could potentially enhance overall physical performance (Guerra et al., 2014; Muscogiuri et al., 2016; Montesano et al., 2013).

Overall, while the healthy respiratory system may have excess capacity at rest, athletes in mixed sports push their ventilation to its limits. Training to improve respiratory muscle function and overall fitness can help them meet these demands and potentially enhance performance. Among the various training methods, the one that would seem to be most effective in improving these parameters is intermittent training. Interval training is comprised of a sequence of repeated cycles of physical activity, varying in duration from a few minutes to mere seconds. Within each interval, individuals have the opportunity to engage in exercise at a predetermined level of exertion for a specific time frame or distance (referred to as the work interval), followed by a period of low-intensity recovery (recovery interval). This method enables the manipulation of pace, length of activity, and rest intervals to cater to distinct objectives in one's training regimen. The utilization of interval training proves beneficial for enhancing both aerobic (requiring oxygen) and anaerobic (absence of oxygen) energy pathways. Notably, it significantly contributes to the enhancement of VO_2max and anaerobic threshold, facilitating the ability to sustain higher levels of exertion for extended durations.

Although all players benefit from a strong foundation in endurance training, the specific types of exercises might vary depending on their positions:

- Midfielders: Often cover the most ground, so their training might emphasize long-distance runs, tempo runs, and interval training.
- Forwards: Need a combination of speed and endurance for sprints, pressing, and attacking runs. Their training might include shorter bursts of high-intensity activity with recovery periods.
- Goalkeepers: While they may not cover as much distance, they need short bursts of explosive power for dives and saves. Their training might include plyometric exercises and specific drills for agility and reaction time.

- Defenders: Require a mix of endurance, strength, and agility to mark opponents, win tackles, and make attacking runs. Their training might incorporate elements of all the above.

In modern football, midfielders are often considered the "engines" of the team due to their high level of endurance. However, with the increasing intensity and demands of the sport, all positions, including goalkeepers, forwards, and defenders, benefit from a well-developed capacity for resistance (Mardiyah et al., 2024).

Therefore, the aim of the present study was to explore whether training conducted through the intermittent method could improve the endurance skills of a sample of amateur football players participating in competitive recreational football activities. The key points we have discussed, considering the specific context of this sample are: age**:** 35-45 years old (senior athletes) and activity (Competitive recreational football). All the athletes not using performance-enhancing drugs.

Methods and Materials

Study Participants

- 20 volunteered male senior athletes
- Average age: 41.2 years old (with a standard deviation of 3.1 years)
- Participating in competitive recreational football activities
- All deemed medically fit for sports participation

Study Design

Athletes were distributed into two groups (group A and group B). The groups likely underwent different training programs with varying resistance levels. The resistance variations were also present during the actual race/competition itself. The assessment was conducted through the implementation of motor and respiratory evaluations. Subsequently, a supplementary training regimen was developed in accordance with the standard protocol. Overall, incorporating motor and respiratory tests followed by personalized training programs strengthens the study design. This approach allows for a more targeted intervention that can potentially lead to greater performance improvements and a reduced risk of injuries for the participating athletes.

Increase the resistive capacity to improve the performance in the race.

Detection criteria

The participating athletes enclosed, are suitable for athletic-sport-type visits and soccer players for many years. The investigation was carried out utilizing an observational approach along with both manual and computerized detection methods. It spanned a period of six months, during which spirometry was administered to evaluate the applicability of Cooper's 12-minute run test (CRT) in predicting VO_2max, involving initial and final assessments. Data acquisition encompassed the initial parameters such as distance covered, and time taken in the preliminary assessment. This facilitated the categorization of athletes into two distinct groups: the control group, comprising individuals with superior endurance performance, designated as "group A", and the intervention group, comprising those with lower indicators, labeled as "group B". Throughout the competitive season, both groups adhered to a conventional training regimen. This likely involved a weekly training session incorporating athletic conditioning, technical skill development, and tactical training. They also participated in training competitions as outlined by Rae et al. (2015).

Group B only, received an additional 18 training sessions spread out over the racing season, averaging 3 sessions per month.

Moreover, by implementing these strategies, Group B can potentially improve their resistive capacity and experience better performance in races.

Methodology

This analytical approach taking care of the detection of the parameters distance (in meters) and time (in sec/min) and providing the reference of the consumption of VO_2max as well as of the active recovery speed. Although it has limitations, it can be valuable for coaches and athletes to track progress and identify areas for improvement.

Materials and equipment

- Regulatory football field (100m x 55m)
- Computer
- Cones
- Detection grid
- Signal flags
- spirometer
- stopwatch

Used Tests

Spirometry

Spirometry represents the initial and most frequently conducted pulmonary function assessment. The Forced Expiratory Volume in 1 Second (FEV1), Forced expiratory flow 25% to 75%, Peak expiratory flow (PEF), Maximum voluntary ventilation (MVV), Slow vital capacity (SVC), Total lung capacity (TLC), Functional residual capacity (FRC), Residual volume (RV), Expiratory reserve volume (ERV) collectively constitute the more prevalent lung function parameters evaluated through this particular examination.

Cooper Test and calculation of the VO_2 max

The Cooper Test offers a general approximation of VO_2 max, with some level of variation observed in the outcomes. Nevertheless, it can serve as a valuable instrument for monitoring advancements in physical fitness over a period. This assessment was conducted to evaluate the efficacy of the systems accountable for an athlete's aerobic endurance, ensuring their overall "physical fitness" or "fitness". The primary aim of the Cooper test is not to gauge an athlete's enhanced running speed. Instead, the assessment determines the extent to which an athlete can increase their running pace over a continuous 12-minute duration on a designated field or track featuring markers every 500-1000 m, along with indicators placed at 50-100 m intervals. The outcome of the test is merely the distance covered by the athlete during the specified 12-minute period. This distance is subsequently utilized to approximate the athlete's VO_2max through a predetermined mathematical equation.

Results

By understanding the reference values and valuation methods from the specific tables (Table1; Table 2), athletes aged 30-39 and over 40. For athletes subjected to detection was proposed an adaptation reduced by around a table 20% considered age and reduced ability to test.

Table 1 – Parameter Tests.

Benchmarks Cooper Test				**Correspondence distance/VO2max**		
Evaluation	Age 30-39 years /distance mt)	Age >41 years /distance (mt)		Fitness Category	Distance (mt)	VO_2max in ml/kg/min
Very lowly	< 1990	<1600		Bad	< 1.600	28.0
Poor or mediocre	1900 - 2090	1600 - 2.000		Mediocre	1600 - 2.000	28.1- 34.0
Enough or discreta	2100 – 2330	2000 - 2400		Enough	2.000 - 2400	34.1- 42.0
Good	2340 – 2510	2400 - 2800		Good	2400 - 2800	42.1- 52.0
Very good	2520 – 2720	2400 - 2800		Excellent	> 2800	> 52.0
Excellent or higher	> 2720	idem				

In relation to the performance of individual athletes, the maximum oxygen consumption (VO_2max in ml/kg/min) varies depending on the distance covered, calculated by the formula $VO_2max = -10.25 + (0.022 \times mt)$. The data obtained from these tests enabled the researchers to devise a supplementary training regimen and evaluate the athletic performances of those exhibiting favorable parameters in contrast to those displaying less favorable parameters.

Additional program contents

In addition to the core technical skills of dribbling, passing, and shooting, a well-rounded soccer program will incorporate a variety of other elements to develop well-rounded players. The supplementary training sessions have been acknowledged for their integration of work and recovery phases, incorporating general activation, stretching, joint mobilization, and workloads specific to the intermittent training method. This method is characterized by repeated short to medium-length exercise sequences, with frequent alternation between work and rest periods as outlined by Seiler et al. (2007). The intermittent training method is indeed very intense, pushing the body's limits in terms of oxygen usage and load transport.

Table 2 - Distances, duration and recovery time of supplemental program.

Distance (mt)	Time (sec.)	Recovery (sec.)	Tot. Reps/minutes
40	10	20	5 rip. in 6 min.
50	10	15	5 rip. in 5 min.
80	10	10	5 rip in 4 min
100	12	12	4 rip in 3 min.
120	15	12	3 rip in 3 min
150	18	12	2 rip in 2 min

Initial data revealed several critical issues observed in athletes who failed to complete the 12-minute course. Two distinct groups (Table 3) were established based on the test results obtained, taking into account that approximately 65% of the team demonstrated subpar performance. Group A, referred to as the control group, will adhere to the standard training regimen, while Group B will be exposed to an additional training program (Figure 1; Figure 2). Despite being athletes 4, 11, and 13 who are recuperating from injuries and a prolonged period of inactivity, all three aged 41, their outcomes did not show significant improvement compared to counterparts over 45 years old. Following the categorization into groups, the VO_2max was computed using specific methodologies. The approach employed was analytical in nature, involving the determination of variables such as distance (measured in meters) and time (in seconds/minutes), and establishing the corresponding values for VO_2max consumption and active recovery pace.

Table 3 – Initial recognition.

Group A							Group B					
Athletes	Role	Age	Distance (mt)	Time (minutes)	VO2max		Athletes	Role	Age	Distance (mt)	Time (minutes)	VO2max
1	Goalkeeper	35	1400	10	20,55		3	Defender	45	1250	10	17,25
2	Defender	37	2100	12	35,95		4	Defender	41	850	9	8,45
6	Defender	44	2000	11	33,75		5	Defender	43	1050	10	12,85
8	Midfielder	37	1850	12	30,45		7	Midfielder	43	1100	11	13,95
10	Midfielder	40	1300	12	18,35		9	Midfielder	42	1200	11	16,15
14	Midfielder	41	1300	12	18,35		11	Midfielder	41	1000	10	11,75
15	Midfielder	36	1900	12	31,55		12	Midfielder	45	650	8	4,05
16	Midfielder	44	1550	11	23,85		13	Midfielder	41	900	9	9,55
18	Forward	40	1950	12	32,65		17	Midfielder	44	1300	12	18,35
20	Forward	39	1600	12	24,95		19	Forward	42	1200	12	16,15

Table 4 – Final recognition.

Group A							Group B					
Athletes	Role	Age	Distance (mt)	Time (minutes)	VO2max		Athletes	Role	Age	Distance (mt)	Time (minutes)	VO2max
1	Goalkeeper	35	1750	10	28,25		3	Defender	45	1450	10	21,55
2	Defender	37	2200	12	38,15		4	Defender	41	1300	11	1835
6	Defender	44	2050	11	34,85		5	Defender	43	1300	10	18,35
8	Midfielder	37	1900	12	31,55		7	Midfielder	43	1550	10	23,85
10	Midfielder	40	1800	12	29,35		9	Midfielder	42	1550	11	23,85
14	Midfielder	41	1650	12	26,05		11	Midfielder	41	1300	11	18,35
15	Midfielder	36	2050	12	34,85		12	Midfielder	45	1000	9,5	11,75
16	Midfielder	44	1700	11	27,15		13	Midfielder	41	1500	11	22,75
18	Forward	40	2200	12	38,15		17	Midfielder	44	1800	12	29,35
20	Forward	39	2100	12	35,95		19	Forward	42	1450	12	21,55

Figure 1 – Final Distance traveled - Group A.

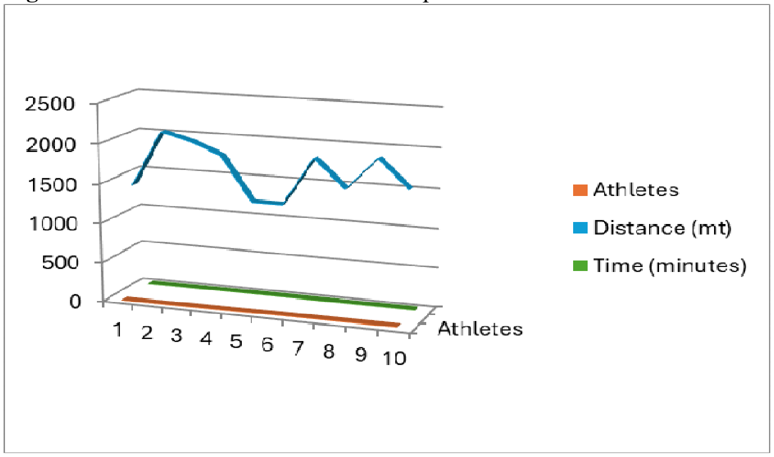
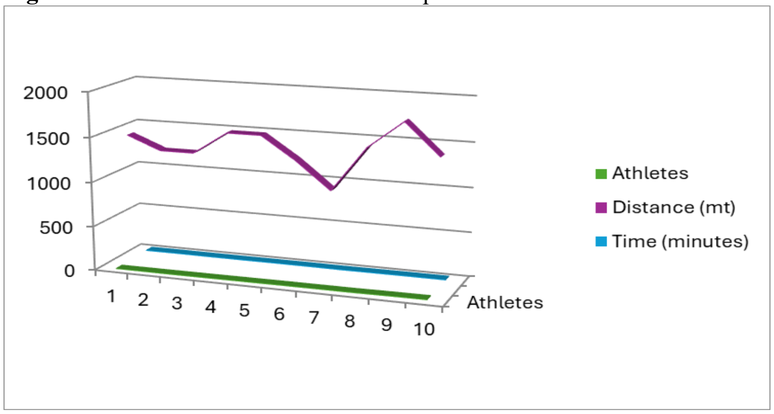


Figure 2 – Final Distance traveled - Group B.



Discussion

The specific content of a soccer program will vary depending on the age, skill level, and goals of the players. However, all programs should include a balance of technical, tactical, physical, and mental training to help players develop their full potential. The research was carried out to explore whether training conducted through the intermittent method could improve the endurance skills of a sample of amateur football players participating in competitive recreational football activities. This was achieved by juxtaposing the findings of the study with pertinent scholarly works (Corvino et al., 2020; Hopkins et al., 2009; Latino et al., 2021; Rocca et al., 2016) and potentially gathering additional data (Destriani et al., 2024; Setyawan et al., 2024a,b), we showed that a stronger understanding of how the intermittent training method might influence respiratory function and athletic performance.

The approach of using registry variables to estimate VO_2max for assessing respiratory function and resistance capacity in athletes has both advantages and limitations (Raiola et al., 2014). Really, this study involving Cooper's Test, identified a potential issue with resistance in a group of senior athletes, particularly those over 45. By analysing, the Cooper's test results in more detail, considering potential explanations, and implementing targeted training programs, you can address the "poor resistance index" and potentially improve the performance of these senior athletes. Our study showed a reduction of about 20% for the distances traveled compared to the standard indices. The whole team has received the preliminary results, and all the players have shown more determination and diligence in training sessions.

The training program, particularly the additional training for Group B, was successful in improving performance. Both groups of athletes showed improvement in their performance after completing the training program. Group A recorded a performance increase of about 18-20% while group B of over 25% with indexes, in some cases, close to 30%.

Therefore, overall, maintaining good lung health and improving pulmonary function are important aspects of enhancing endurance performance for soccer players of all levels.

This information suggests that further analysis with specific performance measures and long-term monitoring would strengthen our research findings.

The present investigation offers evidence that supports a positive correlation between physiological performance and the impact of resistance training in amateur senior soccer players; nevertheless, certain constraints within the study warrant further examination. Chiefly, the modest sample size of 20 participants in the study was a result of challenges faced in recruiting participants. Additionally, the lack of control over participants' dietary and sleep patterns presents a significant limitation. The study also failed to address socio-emotional factors associated with physical activity, pointing to another area of limitation. Hence, forthcoming research endeavors should investigate similar variables using a more extensive and diverse sample. Despite these restrictions, the findings obtained could offer valuable insights for future research ventures. As a result, the study's effectiveness was bolstered by a systematic approach that led to immediately applicable positive outcomes for everyday training regimens.

Conclusions

The decision to allocate athletes into distinct proficiency tiers was appropriate due to the necessity of evaluating performances between athletes possessing varying respiratory and resistance indices. The inclusion of an extra training regimen in the weekly training schedule has yielded favourable outcomes, particularly as the athletes under scrutiny were not engaged in professional or semi-professional sports at a competitive level. Consequently, it became imperative to evaluate the influence of attention and focus on the caliber of athletic performances. This conclusion highlights the key difference in performance between Group A and Group B. This information reinforces the conclusion that the training program, especially the additional program for Group B, was successful in improving performance. The "fairly constant" performance of Group A further strengthens the argument that the additional training program made a significant difference.

This additional consideration, approve that the training program, including its focus on attention and concentration, influences the performance of athletes, particularly those who are not professional or semi-professional. In addiction, the VO_2max indices calculated with results data from Cooper test can be compared with outcomes of resistance-specific training. The present study highlights the importance of a well-designed training program that addresses the specific needs of senior athletes participating in competitive recreational football. By focusing on endurance, mixed energy systems training, respiratory function, and player-specific needs, these athletes can potentially optimize their performance and continue to enjoy the sport.

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