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Physical conditioning protocol for football referees

Protocolo de acondicionamiento físico para árbitros de fútbol

Protocolo de condicionamento físico para árbitros de futebol

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ABSTRACT

The substantial increase in physical demands in soccer competitions demands adequate physical fitness from the referee to ensure that he can monitor each play on the field. The objective of this study was to design a physical conditioning protocol for male soccer referees. The research was based on the diagnosis of the current situation through document analysis, interviews, surveys, observation and measurement. In the case of the experiment, it had a field design and a convenience sample, with 44 referees from the province of



Matanzas, distributed in two groups (control and experimental), to which the Cooper endurance test was applied. The data were analyzed in the Statgraphics Plus software Version 5.1, with a confidence level of 95%, and the Duncan multiple range test was used. The results showed statistically significant differences in the experimental group, with an increase of 13.4% and a notable improvement in 350 meters; however, no significant differences were observed in the results of the control group (increases of 6.7% and an improvement in 175 meters), which was trained with the traditional exercise program. The results obtained showed that the exercise protocol implemented allowed an improvement in the aerobic capacity of the soccer referees, which was adjusted to the demands of their preparation, from a physical point of view.

Keywords: referee, aerobic capacity, soccer, intervals, endurance test

RESUMEN

El aumento sustancial de la exigencia física en las competiciones de fútbol, demanda una adecuada aptitud física del árbitro que le asegure acompañar cada una de las jugadas en el campo. Precisamente, el objetivo de este estudio fue diseñar un protocolo de acondicionamiento físico, para árbitros de fútbol del sexo masculino. La investigación tuvo como base el diagnóstico de la situación actual, a través del análisis de documentos, la entrevista, la encuesta, la observación y la medición, En el caso del experimento, tuvo un diseño de campo y una muestra por conveniencia, con 44 árbitros de la provincia de Matanzas, distribuidos en dos grupos (control y experimental), a los cuales se les aplicó el test de resistencia de Cooper. Los datos fueron analizados en el software Statgraphics Plus Versión 5.1, con un nivel de confianza del 95 %, y se utilizó la prueba de múltiple rango de Duncan. Los resultados evidenciaron diferencias, estadísticamente significativas en el grupo experimental, con incremento de 13.4 % y una notable mejoría en 350 metros; en tanto, no se apreciaron diferencias significativas en los resultados del grupo control (incrementos de 6.7 % y una mejoría en 175 metros), que se preparó con el programa de ejercicios tradicionalmente utilizado. Los resultados obtenidos demostraron que el protocolo de



ejercicios implementados permitió una mejora en la capacidad aeróbica de los árbitros de fútbol, lo que se ajustó a las demandas de su preparación, desde el punto de vista físico.

Palabras clave: árbitro, capacidad aeróbica, fútbol, intervalos, test de resistencia

RESUMO

O aumento substancial da exigência física nas competições de futebol exige preparo físico adequado do árbitro para garantir que ele apoie cada uma das jogadas em campo. Justamente, o objetivo deste estudo foi elaborar um protocolo de condicionamento físico para árbitros de futebol do sexo masculino. A pesquisa baseou-se no diagnóstico da situação atual, através da análise de documentos, da entrevista, do levantamento, da observação e da medição. No caso do experimento, teve um desenho de campo e uma amostra de conveniência, com 44 árbitros da província de Matanzas, distribuídos em dois grupos (controle e experimental), aos quais foi aplicado o teste de resistência de Cooper. Os dados foram analisados no software Statgraphics Plus versão 5.1, com nível de confiança de 95%, e foi utilizado o teste de múltiplos intervalos de Duncan. Os resultados mostraram diferenças estatisticamente significativas no grupo experimental, com um aumento de 13,4% e uma melhoria notável nos 350 metros; Entretanto, não foram observadas diferenças significativas nos resultados do grupo de controle (aumentos de 6,7% e melhoria de 175 metros), que foi preparado com o programa de exercícios tradicionalmente utilizado. Os resultados obtidos demonstraram que o protocolo de exercícios implementado permitiu uma melhoria na capacidade aeróbica dos árbitros de futebol, a qual foi ajustada às exigências da sua preparação, do ponto de vista físico.

Palavras-chave: árbitro, capacidade aeróbica, futebol, intervalos, teste de resistência



INTRODUCTION

The increase in physical performance and physical fitness (PF) in soccer referees (SR) is interrelated with that of the players during the match (Walker, et al., 2019). Soccer is a collective sport, intermittent in nature and extremely complex, in which, as Castillo et al. (2021); Jafarigilandeh et al. (2021) refer, multiple biomechanical, physiological, nutritional, psychological and PF factors intervene, among others.

As a consequence, the SR must have a PF level that allows them to be correctly positioned and helps them in decision-making during the competition. Although PF is not the only performance factor in refereeing, it is one of the most relevant to obtain a higher success rate on the field; that is why the elite-level SR is exposed to physical demands similar to those of the soccer player, so that he must be able to cope with the game conditions imposed by them, being a fundamental piece in the correct performance of the competition (Muñoz & Castillo, 2020), in order to control their behavior and apply the rules during the match.

In this regard, there is a recognition that in order to maintain a good position and perform their tasks effectively, SRs must have a good PF status, and heart rate thresholds above 80-90% (Muñoz, et al., 2022) which constitute the main support to promote higher success rates in decision-making in matches. In this sense, it is considered that in order to achieve a high level of physical preparation, both for elite athletes and STs, it is necessary to plan consistent and effective training of motor skills.

It is important to consider that the SR must be prepared to respond to the wide variety of demands in each of the 90-120 minutes that the game lasts, and one of the aspects of said preparation is based on athletics training; a distance covered of 9 to 13 kilometers per game has been reported, all this effort demands an energy expenditure and must be rewarded, because if they are not adequately prepared, their executions are affected by wrong decisions, insecurity and poor communication with their assistants on the field of play, among others.



This range of physical efforts makes the development of work plans and programs very complex because it is not about preparing an SR for just one gesture, but rather there are many and very varied requirements to be met, and it happens that the excessive increase of one quality can be detrimental to another. In addition, this great athletic capacity must be integrated with the mastery of PF elements, great strength, power, coordination, skill and endurance.

Regarding physical activity in aerobic and bodybuilding modalities, Platonov & Bulatova (2019); Verkhoshansky (2019) delimit it with positions close to García et al. (2019) who summarizes them as the development of motor capacities characterized by an effective integration of its different components, given by the organic, anatomical, physiological, biomechanical, biomedical and psychological conditions, supported by the state of the individual's motor performance capacity to perform any physical activity or exercise, with moderate or high intensity that delays the onset of fatigue and contributes to competitive success.

According to Aragüez (2013, as cited in Pineda, et al., 2020), PF refers to basic motor skills, such as strength, endurance, and speed; where general and specific physical preparation plays an important role in determining physical fitness. PF means that after a short preparation the athlete is able to perform a task that he or she can perform after a few weeks of training (Karpovich, 1965, as cited in Pineda, et al., 2020).

In the context of SR, what is mentioned above is known as training microcycles that are completed each year before entering the competitions; on the other hand, decision-making is determined by multiple factors such as stress, visual perspective, level of education, fear of making a mistake in the decision and the details of the plays.

The preparation process in physical conditioning routines is a multifactorial matter (García et al., 2019), and physical conditioning programs for SR are not exempt from this; therefore, their physical preparation takes on special importance and must induce physiological adaptations that favor the necessary requirements in the game. Within this preparation process, sensory - perceptual management is considered for decision-making, taking into



account the weather, the intensity of the match, the playing field, the media and the complexity of referee decisions that move from a state of physical to a mental functionality, which reduces the tensions of a professional soccer match.

The main characteristics of the SR are knowledge of the game, decision-making skills, physical preparation, communication, game control and psychological and strategic skills; for this purpose, a more specific test is used that allows measuring the aerobic resistance of the referees called: *va y viene*, with the aim of verifying the PF of the SR. Likewise, Yanci (2014, as cited in Pineda, et al., 2020) emphasizes specific training programs for SR, since in his work he has been able to observe the loss of performance in the acceleration capacity.

The performance of the SR is a condition for fulfilling his responsibility, assessed during each sporting match, through a series of factors such as the ability to move with the same regularity as each player, leadership and the skills to control and make decisions at every moment.

In soccer, in the case of Cuba, it has been found that the main and assistant referees who work in different categories have deficiencies in reaching the zone of doubt and blind spots, which prevents the making of correct decisions; although these are often based on the theoretical knowledge accumulated in training courses and improvement programs.

This problem is evident in the low participation of Cuban SR in international tournaments, as they fail to pass physical, theoretical and medical tests. In addition, the physical preparation systems currently used do not facilitate the viability of exercises in the daily training routine, which is not treated as a process and has little scientific basis, which generates deficiencies in coordination, balance, mobility, speed, resistance, flexibility and strength.

These irregularities lead to a series of errors such as controversial decisions, fatigue, insecurity in making a judgment due to being far from the conflict zone, and as a result, their professionalism is called into question and does not allow them to rise in the ranks of arbitration.



In response to the demand for this component and its priority nature, being one of the main supports for the good performance of the referees in this sport modality, it was recognized as an *objective* from the research to design a physical conditioning protocol for male SR.

MATERIALS AND METHODS

The study included a quantitative research approach, with a field design, in which data was collected directly from the subjects investigated, without controlling any variable.

The sample used was selected intentionally, considering the convenient accessibility and proximity of the subjects to the researchers. The study consisted of a total of 44 male SRs, organized into two groups by category:

The referees of the provincial category of Matanzas (A) are the most experienced, with ages between 22-35 years, whose average age, experience in the activity and body weight were controlled, respectively (25.84 ± 0.72 years, 6.37 years and 71.62 ± 5.21 kg), with them the experimental group (GEX) was formed and they were trained with the physical conditioning protocol for SR, designed in the research.

The candidates for provincial referees in training category B were those with less experience, aged between 21-25 years (22.4 ± 0.37 years, 67.45 ± 3.27 kg of body weight and 2.6 years of experience), who made up the control group (GC) and trained with the current provincial SR conditioning program.

All participants underwent identical tests under the same conditions in the morning (8:00 AM) and trained a minimum of three times a week (approximately 9 to 12 h/week) for 8 weeks. Before the start of the study, all participants signed an informed consent form specifying the objective, description of the test and its risks, as well as the benefits of participating. The guidelines established in the World Medical Association Declaration of Helsinki (2013) were followed, as well as the ethical standards established for research in sports and exercise sciences.



Weight values were taken with the minimum amount of clothing and without shoes. Subsequently, the 12-minute Cooper test was performed, widely used and disseminated in the evaluation of SR, due to its reliability and validity. This test consisted of running the maximum number of meters (m) possible on the pre-marked circuit in a time of 12 min, in which the efforts were dosed throughout the race. After the test time had elapsed, the subject was told to stop, and the number of meters run was recorded, with a maximum rounding of 25 m.

Cooper test equation:

$$VO2\text{máx}_{\text{ml/kg/min}} = \frac{\text{Covered distance} - 504}{45} \quad (\text{ec. 1})$$

The following instruments were used:

- PCE-TS 150 model scale, to obtain the weight of the referees with a weighing range of up to 150 kg.
- Cones, to delimit the route every twenty-five m.
- Stopwatch, to record time in minutes, using a CASIO electronic stopwatch with a precision of 0.1 c/s and an error of ± 0.001 s.

In the research, theoretical and empirical methods were applied. Among the former, the analytical-synthetic method was used to substantiate the research topic, based on bibliographic analysis, to recognize the multiple relationships and components of the problem addressed separately, to then integrate them into a whole as it was presented in reality, and to interpret the information after consulting various authors.

The inductive-deductive method provided the determination of the problem and the differentiation of the objectives developed in the research process, to proceed to the creation of the proposed strategy, establish the relationships between the facts analyzed, the explanations and conclusions.



The historical-logical approach allowed the analysis of the historical development of the object of study to find the internal logic of the process, based on scientific criteria related to the physical conditioning of the soccer coach; and the systemic-structural-functional approach, to establish the relationship between the components of the research, achieve better results in terms of professional guidance and create a physical conditioning program for the SR.

As empirical methods, measurement was used to verify the initial state or starting point of the SR and the PF obtained at the end of the preparation, through the 12-min Cooper test (pre- and post-test), through which the control and registration of the times performed was carried out.

Statistical data processing was carried out using Statgraphics Plus Version 5.1 software, with non-parametric statistics given the small sample size of the study. Hypothesis tests were applied to determine the existence or not of significant differences in the results obtained between the GC and GEX groups, for the two moments (pre- and posttest).

The confidence level was set at 95% and p was 0.05, in order to compare the variables and establish significant differences between categories by means of Duncan's multiple range test. The effectiveness of the distance traveled in the Cooper test applied to the SR was calculated from the percentage increase, according to Guzhalovkij (cited in García *et al.*, 2019) based on the following equation:

$$\%Inc = \frac{\bar{x}_1 - \bar{x}_2}{0,5 * (\bar{x}_1 + \bar{x}_2)} * 100 \quad (\text{ec. 2})$$

Where: \bar{x}_1 and \bar{x}_2 : are the means of each sample

Physical conditioning protocol for soccer referees

In the field of soccer, in addition to taking theoretical tests, it is necessary to pass physical tests. This induces those people who want to start in the world of refereeing and those who want to move up a category must achieve an optimal PF, to successfully complete the physical tests (Fernández, et al., 2017).



One of the most relevant phenomena and aspects to take into account when assessing the PF of an SR is to pass the physical tests established by his territorial committee to carry out the refereeing, a fact that influences the promotion and/or relegation of category. The main challenge for the physical trainers of referees is that they manage to pass the physical tests in specific periods of the season.

The protocol presented complied especially with the adaptation to effort, characterized by the alternation of work and rest, supported by the laws and principles of sports training, as an essential aspect to improve physical qualities and allow achieving success, which in this case was the passing of the tests to promote the category of the candidates and provincial referees of Matanzas, in addition, the main theoretical and methodological foundations related to the capacity of aerobic resistance and training in mixed zones (aerobic-anaerobic) were offered.

This protocol responded to the need to guide SRs in light of the new trends imposed by the modern game. The first stage of the protocol, lasting three microcycles (Table 1), aimed to lay the foundations for aerobic capacity, based on exercises with high volume as a control mechanism that allowed regulating the internal load (Hughes et al., 2020) and moderate intensity, jogging as an aerobic exercise to oxygenate the cardiovascular system and generate short-term benefits and better performance.

At the beginning of this phase, the physical test (Cooper test) was carried out, in order to familiarize the SRs with the test, and to know their PF.



Table 1. Aerobic capacity training, to cover a distance of 4 km (variant 1).

Repetitions	Races (m)	Intensity (% MHR)	Micropauses (s)	Series	Macropauses (min)
1	1200 m	70-80%	120 s	Active	3 min
2	1000 m	70-80%	120 s	Active	
3	800 m	70-80%	120 s	Active	3 min
4	600 s	70-80%	120 s	Active	
5	400 s	70-80%	120 s	Active	
Total	4000 m	70-80%	120 s	1	6 min

In the second moment, lasting three microcycles (Table 2), the objective was to focus on the development of aerobic power with a higher intensity, and a predominance of aerobic-anaerobic exercises. These were accentuated in interval or fractional training, with intensities up to 85% of the maximum heart rate (MHR), known as fartlek, with short recovery periods of 60 s, without a total recovery for those who opted for the national category, according to the Technical Committee of Referees of the Royal Spanish Soccer Federation (2019); in order to adapt the body to fatigue conditions.

This type of work was aimed at improving maximum oxygen consumption and therefore aerobic performance, which ensured the referee's movement and his opportune location to make the correct decisions in the management of the game. At the end of this phase, the second control was carried out (Cooper test), which allowed to assess whether there were improvements in the distance covered as a result of the influence of the proposed protocol; if adverse, the training was reoriented.



Table 2. Interval or fractional training (variant 2).

Repetitions	Races(s)	Intensity (% MHR)	Micropauses (s)	Series	Macropauses (min)	
1	180 s	81-85%	90s	Active	3 min	
2	2x15 s	81-85%	30 s	Active		
3	180 s	81-85%	90s	Active	3 (mixed)	3 min
4	2x15 s	81-85%	30 s	Active		
5	180 s	81-85%	90s	Active	3 min	
6	2x15 s	81-85%	30 s	Active		
Total	630 s	81-89%	2-1 ratio	1	9 min	

The third moment, lasting two microcycles (Table 3), aimed to achieve the optimal PF of the SR, to pass the Cooper test, and was based on high-intensity interval training (HIIT), short up to 10 s and long 20-30 s, with intensities up to 95% of the MHR, with recovery periods of 60 s, and a moderate to low volume as a control mechanism. This interval allowed regulating the internal load (Hughes et al., 2020) and the duration of the sessions between 5-40 min, three times a week (on Tuesdays, Wednesdays and Fridays) with variability of the contents to be developed during the protocol.

The exercises were similar to those that the SRs had to overcome during the official test, with the aim of being within the optimal parameters set in the test; this sequence allowed them to closely follow the actions of the game and thus, avoid errors of judgment as much as possible (Borja, et al., 2019) .



Table 3. HIIT training proposed by (Bravo & Bravo, 2021), modified for the research presented (variant 3)

Repetitions	Races(s)	Intensity (% MHR)	Micropauses (s)	Series	Macropauses (min)
1	30 s	95%	30 s	Active	
2	60s	90%	60s	Active	1 (Ascending) 5 min
3	90s	90%	90s	Active	
4	120 s	90%	120 s	Active	
5	120 s	90%	120 s	Active	
6	90s	90%	90s	Active	1 (Descendant) 5 min
7	60s	90%	60s	Active	
8	30 s	95%	30 s	Active	
Total	600 s	90-95%	1-1 ratio	2	10 min

The selected content paid tribute to the development of aerobic endurance, as it is one of the main skills to be developed in SR, to cover the playing field during the sporting match and supervise each and every movement made by the players.

RESULTS

The effects of the work presented were based on a diagnostic study that included the analysis of documents, interviews with physical trainers, a survey of provincial SRs and observation of training. This evaluation, based on the scientific method, confirmed that the specific comprehensive training program for referees of the Cuban Soccer Association addressed the development of aerobic resistance in a limited way in relation to the requirements of their training (insufficient use of exercises and activities; as well as deficient use of methods, procedures, organizational forms and means).

The statistical characterization and the normality tests of the two study groups in pre- and posttest, of the Cooper test (table 1) showed that the four samples presented dispersion, since the coefficient of variation was greater than 12%, with a large variation interval in the



distances covered by the referees at each moment of the test, which could have been caused by the differences in the somatotypic indicators body weight and height (stride length) .

Table 4. Results of the statistical characterization and normality tests of the two study groups in pre- and posttest, of the Cooper test

Parameter/test/group	GC pre-test	Post -test GC	GEX pre-test	GESX post -test
Average	2289	2464	2439	2789
Variance	96174.2	110246 ,0	96174.2	132555
Standard deviation	310.12	332,033	310.1	364.1
Minimum	1700	1900	1850	2200
Maximum	2750	3050	2900	3500
Coeff . of variation	13.55%	13.47%	12.71%	13.05%
Std. Skewness	-0.36	-0.10	-0.368212	0.15
Std. Kurtosis	-0.78	-0.98	-0.79	-1.01
Shapiro test) Wilks)	0.37	0.55	0.37	0.45

However, the normality tests showed a normal distribution with 95% confidence, since the kurtosis and asymmetry coefficients were within the range -2 and 2, and the probability values (p) were greater than 0.05.

The comparison of the results between the pre- and posttest of the GC and GEX, through the ANOVA test (table 5), yielded a probability value less than 0.05 (0.00); this demonstrated significant differences in the distances traveled between both groups, for a 95% confidence level, which corroborated the effectiveness of the physical conditioning protocol for SR.

Table 5. Results obtained with the ANOVA test.

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
Between groups	2.92531E6	3	975104	8.96	0.0000
Within groups	9.13814E6	84	108787		
Total (Corr.)	1.20634E7	87			



In the case of the Duncan multiple range test, its use allowed determining the difference in the results in the GEX post-test (Fig. 1), which confirmed an increase in the effectiveness of the protocol with respect to the traditional methodology, since the results obtained had differences, so the pre- and post-test interactions of both groups were significant.

In the first case, the Control Group subjects were influenced by training with the traditional methodology, and in the second case the contribution of resistance work associated with the designed SR physical conditioning protocol was demonstrated.

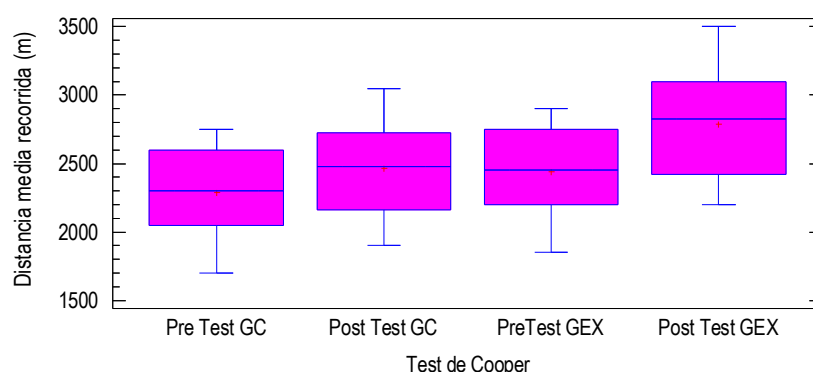


Figure 1. Confidence intervals.

In the evaluation of the resistance test, with the Cooper test, the results obtained in the pre- and post-test evaluations revealed that the GC increased its mean values in the 12-min test, with an improvement in 175 m and a 6.7% increase.

When comparing the results obtained against the evaluation scale of the 12-min Cooper endurance test, represented in (Table 6), the results of the national SR candidates were grouped below the scale of (three and two points), they did not reach the average aerobic resistance indices and only 9% were located close to the five-point scale. This regulation granted the status of national referee.

In the second stage, a slight improvement was noted, with 23% of the referees scoring above average (between five and six) on the evaluation scale. In this way, the regulations required to work as a national referee were met.



Table 6. Evaluation of the Cooper test resistance test.

Scale	Points	GC Pretest	%	Posttest GC	%	GEX Pretest	%	GEX posttest	%
3450	10	-	-	-	-	-	-	1	5%
3325	9	-	-	-	-	-	-	-	-
3262	8	-	-	-	-	-	-	-	-
3073	7	-	-	-	-	-	-	5	23%
2885	6	-	-	2	9%	2	9%	4	18%
2760	5	-	-	3	14%	2	9%	2	9%
2696	4	2	9%	2	9%	3	14%	1	5%
2508	3	5	23%	3	14%	-	-	1	5%
2319	2	3	14%	4	18%	7	32%	6	27%
2131	1	12	55%	8	36%	8	36%	2	9%
Totals		22	100%	22	100%	22	100%	22	100%

Meanwhile, the GEX that was trained with the physical conditioning protocol for SR designed at the first moment, in the resistance test (12-min Cooper test), only 18% was above the average on the five- and six-point scale, the remaining 82% was below the average (Table 6).

In the second measurement, the GEX transformed the situation with 55% above the average, with a percentage increase of 13.4%, which constituted a significant increase in the average endurance levels in the 12-minute test, with an improvement of 350 m . This placed them very close to the desired values for optimal performance, according to the parameters established by FIFA for referee performance.

In the Cooper test for maximum oxygen consumption, refereeing was considered as a predominantly aerobic activity due to its duration, with 81% of maximum oxygen consumption (VO₂max), as a reliable indicator of performance in intermittent sports. In this protocol for VO₂ max, of the SR, the 12-min indirect Cooper test was used (Table 7), which allowed to verify that approximately 82% of the members of the Control Group showed



indicators lower than three L/min, this condition allowed to infer limitations to delay the onset of fatigue.

Table 7. Assessment of VO2 max in L/min, of soccer referees, through the 12-min indirect Cooper test

Scale (L/min)	Assessment	GC pre-test	%	Post -test GC	%	GEX pre-test	%	GEX post -test	%	
4.5	E	0	0%	0	0%	1	5%	2	9%	
4.1	Very good	0	0%	0	0%	0	0%	0	0%	
3.75	B	0	0%	1	5%	1	5%	3	14%	
3.25	P	1	4.5%	4	18%	2	9%	7	32%	
2.75	BP	7	31.8%	8	36%	9	41%	6	27%	
2.25	P	7	31.8%	5	23%	6	27%	3	14%	
<	MM	7	31.8%	4	18%	3	14%	1	5%	
Totals		22	100%	22	100%	22	100%	22	100%	
Legend		excellent (E); very good (MB); good (B); average (P); below average (BP); bad (M); very bad (MM).								

In the GEX, where approximately 55% of the provincial referees exceeded 3.5 L/min, it was a favourable indicator, since a high VO2max delayed the onset of fatigue during the test, while helping to better recover from the efforts caused by the changes that arose during the test itself and was associated with behaviour during refereeing activity.

DISCUSSION

The elite level referee is exposed to physical demands similar to those presented by a soccer player in the game, for this reason his physical performance is interrelated with that of the players during the same match; so he must be able to cope with the game conditions imposed by the players, in order to control their behavior, apply the rules of the game and have a fair and impartial participation (Borja, et al., 2019), therefore, they must stay aware of the game at all times, to ensure optimal positioning in decision making.



During a soccer match, referees are required to have a high aerobic capacity, as they cover a distance of approximately 11-12 km per match. Of this, almost 1 km is covered in a constantly varying distance with short breaks at moderate and high intensities, since the predominant metabolic systems required are those of aerobic responses and a high participation of metabolic demands. These are similar to those found in endurance exercise, since most of the distance covered is covered at a moderate-low intensity (approximately 89%); on the other hand, considerable amounts of time are spent above the ventilation (45%) and anaerobic threshold (8%). These facts mean that the requirements to enter the world of refereeing are increasingly higher.

The control of the selected sample and its division into a GC and GEX allowed determining the aerobic capacity of the SR in training and provincials of Matanzas. Among the main findings, a statistically significant difference was evident between the GC and GEX when comparing the categories ($p < 0.05$), mainly due to the different variations and transitions in terms of dosage (distance/time), volume and intensity in the physical conditioning protocol for SR, designed. As a consequence, the participants in category A presented greater performance in aerobic capacity and pulmonary ventilation in this study compared to those in category B.

In relation to the prescription of the intensity of the effort, it was the load component that to a greater extent guided and conditioned the global aerobic work during the training, by indicating the intensity to which the volume of the specific endurance was adjusted; however, in this study a statistically significant difference was only evident with the referees subjected to the influence of the designed protocol, those recognized in category A, compared to those in category B who carried out the conditioning program for provincial referees.

The most experienced referees were able to reach the appropriate physical conditioning levels to cope with the demands of the matches, this was possible if they were subjected to adequate preparation programs, since in research carried out by Barros (2018), it was shown that inadequate training systems produced deficiencies in the development of physical attitudes, muscle fatigue and injuries; as well as poor professional performance of the SRs



in decision-making, this became evident when a marked decline in the physical and physiological responses of the SRs was observed at the end of the matches.

For their part, Flórez et al. (2021) confirmed that the percentages of physical demands that the referees made to perform well in a soccer match were high, which required a high level of effort and movements, both aerobic and anaerobic, to meet the demands of the game.

In this same order, Borja (2019) confirmed that the level of physical preparation of the SRs must have been optimal and a very important factor for their physical performance, which required aerobic and anaerobic exercises, due to the physical demands and the high demand in today's soccer, which enabled them to achieve a better position in the monitoring of events. In addition, an SR can make about 137 decisions during a match, without hindering its development and ensuring the maintenance of the correct position (Flórez, et al., 2021).

Regarding the specific physical demands related to endurance and performance of the SR, elements such as VO₂max and the work with oxygen that the body could absorb, transport and consume in a given time were associated. In another order, the anaerobic threshold associated with the moment in which fatigue appears and the way of obtaining it was predominantly without oxygen, the energy efficiency to expend the least energy at a certain constant speed throughout the entire match, which allowed the plays to be followed closely and the anaerobic capacity and power.

The terms used to define these were anaerobic capacity, defined as the ability to sustain a predominantly anaerobic effort for a period of time; and anaerobic power, as the ability to generate a lot of energy per unit of time through the anaerobic pathway. In SR these terms were used when performing demanding and continuous changes of pace, when the teams carried out several rapid counterattacks from goal to goal during a match, which the referee had to follow closely with hardly any rest.

Due to the characteristics of modern soccer, which is increasingly faster, there was so much emphasis on the development of aerobic capacity and power that the method of high-intensity intermittent training was indicated, aimed at enhancing it. In this sense, Castillo et



al. (2021) developed a 10-week program where referees performed a HIIT that allowed them to significantly improve their ability to repeat sprints, accompanied by maintaining submaximal cardiovascular variables.

The inclusion of a 12-week training program based on HIIT delayed the onset of neuromuscular fatigue during matches; although performing high-intensity series and repeating sprints for eight weeks reported significant improvements in the yo-yo test, an intermittent recovery test.

According to Bravo & Bravo (2021), a better execution of high-intensity game actions could be achieved with the development of the repeated sprint skill, although the execution of the game actions were covered by the production of energy through the aerobic pathway where it was recognized that in about 70 of the sprints carried out by the referees, with distances between 1.5 m of high intensity with recovery intervals of 20 s, the mechanism called anaerobic pathway was used, this type of training in the HIIT method had a positive impact on the fatigue index.

The present protocol demonstrated, like the study carried out by Bravo-Gutiérrez & Bravo-Navarro (2021), an effectiveness in reducing accumulated fatigue during RSA tests, which also improved low-intensity aerobic capacity. In contrast, the designed protocol was organized into three shorter periods of only two and three weeks, because the participants were not full-time SR, as they performed other activities.

Unlike the designed protocol, which involved training at faster paces that required strength training, the SR fitness program considered high-paced training in aerobic endurance work, although with the onset of fatigue the same distance was continued, stride length was reduced, and this led to two results: the frequency increased and the running pace was maintained; the same frequency was maintained, and the pace decreased.

In both situations, the result was similar. In the first case, where stride frequency was increased, training focused on the hip muscles; although these were important for running, they did not contribute as much to the economy of the muscle as the gastrocnemius and



soleus muscles; in the second case, the shortening of the stride meant that the fast muscles (which allowed the use of the spring mechanism of the Achilles tendon) were insufficient and involved the intervention of the slow muscles to help with the push, which generated less power and for this reason the strides were shorter.

The motor patterns showed that 48% of the total time of the match, the Premier League SRs were in the low-intensity jogging phase. The second motor action that predominated in the motor pattern was, in the high-intensity phase, short periods of time (6-8 s), and speeds above 13-15 km/h. These parameters determined, in a global way, the physical demands of the game on the referees.

The experiment sought to incorporate three HIIT training sessions into the weekly activities carried out by referees, as specific training to be able to move up or simply obtain an initial category. In this way, specific aerobic capacity training protocols could be established to delay the onset of fatigue during matches; this favoured a better positioning of the referees that contributed positively to decision-making during the matches, especially at the end of them.

This study was not without limitations, although the internal and external load for the development of aerobic capacity was quantified, with three training variants at different times, it would have also been interesting to extend this protocol to the rest of the capacities strength, speed, coordination, for greater consistency to the study.

CONCLUSIONS

With the findings of this study, it was concluded that there were statistically significant differences in the distances covered between the GC and GEX, in pre- and posttest, of the Cooper test, for a confidence level of 95%. In this way, it was highlighted that the SRs who had more experience, belonging to the provincial category, had an optimal performance of the aerobic capacity that favored the success of the arbitration.



Based on the data determined in this study, related to work in the mixed aerobic-anaerobic zone, the planning and control of aerobic capacity training with SRs belonging to the other categories was started, based on the use of the HIIT training method.

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The author declares that there are no conflicts of interest.

Author's contribution:

The author is responsible for writing the work and analyzing the documents.



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