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Director: Fernando Emilio Valladares Fuente

Email: fernando.valladares@upr.edu.cu

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Original article

Interval aerobic resistance training on physical tests performance of military personnel

Entrenamiento interválico de resistencia aeróbica en el rendimiento de las pruebas físicas del personal militar

Treinoamento de resistência aeróbica intervalo sobre o desempenho de testes físicos do pessoal militar

Darwin Bladimir Oña Caiza^{1*}  <https://orcid.org/0000-0003-1012-5467>

Héctor Manuel Caza Pulamarín¹  <https://orcid.org/0000-0001-5035-3187>

Calero Morales Santiago¹  <https://orcid.org/0000-0002-4702-331X>

¹University of the Armed Forces ESPE. Ecuador.

*Author for correspondence: dboac@espe.edu.ec

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ABSTRACT

Aerobic resistance is the capacity to perform physical activity for as long as possible, being a determining capacity for many sports and a need for active military personnel, for which specialized strategies are established for its enhancement such as the interval model application, considered a training based on the repetition periods of high intensity load. In this sense, the research objective is to promote aerobic endurance in soldiers of the Escuela de Infantería del Ejército (EIE) from a HIIT interval training. A descriptive-co relational investigation is implemented, analyzing 75 soldiers from the improvement course of the Escuela de Infantería del Ejército, evaluating their aerobic capacity, including the Body Mass Index before and after implementing interval training for 8 weeks. The average body mass index was 23.91kg (Normal; Pretest), and 23.38kg (Normal; Posttest), being significantly different ($p = 0.000$), while the average time in the 2-mile test was 13'39min / s (Pretest) and 12'48 min / s (Posttest), improving -51s. The $VoMax_2$ was 47.64 (ml / kg / min. Pretest) and 52.65 ml / Kg / min (Posttest), an increase of +5.01 ml / Kg / min, corresponding to a 10.51% increase of VO_2max . Interval training, emphasizing the extensive-medium and intensive-short, positively affects the development of short-term aerobic endurance, being an alternative to improve aerobic endurance indicators in soldiers with an age range between 23-28 years.

Keywords: VO_2max , Aerobic resistance, High Intensity Interval Training

RESUMEN

La resistencia aeróbica es la capacidad de realizar una actividad física en el mayor tiempo posible; esta es una capacidad determinante para muchos deportes y una necesidad para el personal militar activo, para lo cual se establecen estrategias especializadas en función de su potenciación como la aplicación del modelo interválico, considerado un entrenamiento basado en la repetición de periodos de trabajo de alta intensidad. En tal sentido, se planteó como objetivo de la investigación potenciar la resistencia aeróbica en soldados de la Escuela de Infantería del Ejército (EIE) a partir de un entrenamiento interválico HIIT. Se implementó una investigación descriptiva-correlacional. Se analizaron 75 soldados del curso de perfeccionamiento de la Escuela de Infantería del Ejército. Se evaluó su capacidad aeróbica e incluyó el índice de masa corporal antes y después de implementar un entrenamiento interválico durante ocho semanas. El promedio del índice de masa corporal fue de 23,91kg (normal; pretest), y de 23,38kg (normal; posttest). Se muestreó significativamente diferente ($p=0.000$), mientras que el tiempo promedio en el test de dos millas fue de 13'39min/s (pretest) y de 12'48min/s (posttest), se mejora, para un -51s. El $Vo_2máx$ fue de 47,64 (ml/kg/min. pretest) y de 52,65ml/Kg/min (posttest), un aumento de +5.01 ml/Kg/min, correspondiente a un 10,51 % de incremento del $VO_2máx$. El entrenamiento interválico, se enfatiza en el extensivo-medio e intensivo-corto e incide positivamente en el desarrollo de la resistencia aeróbica a corto plazo, indica que es una alternativa para mejorar indicadores de resistencia aeróbica en soldados con un rango etario entre 23-28 años.

Palabras clave: $Vo_2máx$; Resistencia aeróbica; Entrenamiento interválico de alta intensidad.

RESUMO



A resistência aeróbica é a capacidade de realizar uma atividade física no maior tempo possível; esta é uma capacidade determinante para muitos esportes e uma necessidade de pessoal militar ativo, para o qual são estabelecidas estratégias especializadas em termos de seu aperfeiçoamento, como a aplicação do modelo interválico, considerado um treinamento baseado na repetição de períodos de trabalho de alta intensidade. Neste sentido, o objetivo da pesquisa era melhorar a resistência aeróbica nos soldados da Escola de Infantaria do Exército (EIE) através do treinamento interválico HIIT. Uma pesquisa descritivo-correlacional foi implementada. Setenta e cinco soldados da Escola de Infantaria do Exército foram analisados no curso de treinamento avançado. Sua capacidade aeróbica foi avaliada e incluiu o índice de massa corporal antes e depois da implementação do treinamento interválico por oito semanas. O índice médio de massa corporal era de 23,91kg (normal; pré-teste), e 23,38kg (normal; pós-teste). A amostra foi significativamente diferente ($p=0,000$), enquanto o tempo médio no teste de duas milhas foi de 13'39min/s (pré-teste) e 12'48min/s (pós-teste), é melhorado, para um - 51s. O Vo_2max foi de 47,64 (ml/kg/min pré-teste) e 52,65ml/kg/min (pós-teste), um aumento de +5,01 ml/kg/min, correspondendo a um aumento de 10,51 % no VO_2max . O treinamento interválico, enfatizado no intensivo-médio e intensivo-curto e tem um impacto positivo no desenvolvimento da resistência aeróbica de curto prazo, indica que é uma alternativa para melhorar os indicadores de resistência aeróbica em soldados com uma faixa etária entre 23-28 anos.

Palavras-chave: Vo_2max ; Resistência aeróbica; Treinamento interválico de alta intensidade.

INTRODUCTION

The achievement of a mission in multifaceted institutions such as the army, is the result of the sum of multiple factors, so it is essential that the soldier possesses comprehensive preparation in all areas of professional development: cognitive, affective and physical. Physical capacity (PC) is an (Clavijo, Morales, & Cárdenas, 2016; Larrea & Calero Morales, 2017; Rivadeneyra Carranza, Morales, & Parra Cárdenas, H. A, 2017; Knox, Lugo, Helkala, & Sütterlin, 2019) unintelligible entity, in which three main mechanisms enter: energy creation such as aerobic and anaerobic, neuromuscular functions in the technical aspect and personal and labor psychological factors, which could be related to the conditional and coordinative physical capacities (Morales & González, 2015).

Marching long distances under stress, carrying equipment and weaponry, in hostile terrain and getting to fight effectively; driving, running and crawling for long distances, are activities typical of military tasks and, (Georgoulas-Sherry & Hernández, 2021) to perform optimally, the soldier must have outstanding physical competencies and performance, which must necessarily be trained and maintained throughout the military career.

According to (Nieto & Cárcamo, 2016, p. 2) states that, "Within the physical training of soldiers for the fulfillment of their mission, it should be noted the importance of the permanent evaluation of the physical condition for the performance of their tasks within the battlefield", so the military physical development for those who belong to the Ecuadorian Armed Forces, aims to expand, raise and maintain an optimal physical capacity consistent with the demands that this profession demands, regardless of the function or activity entrusted to be developed in the different military units and institutes of the country.



The Ecuadorian Army measures the *CF through the* biannual physical tests (PFS), an evaluation tool designed to accredit the common physical condition for all members of the institution, independent of their specialization and performance position, where tables differentiated by age ranges and gender are considered. These are: to measure physical capacity; running 3,219 meters (two-mile test), maximum number of elbow bends and abdominal bends (maximum in one minute and a half), military skills; swimming 200 meters crawl style and cape 5 meters, as stipulated by (Cevallos, 2018) The former Minister of Defense, in accordance with the Armed Forces physical culture regulations. However, the evaluation of the CF for organizations such as the Army cannot only be obtained through the PFS, and there must also be an instrument to measure and certify those physical performances inherent to each weapon or service, geographical scenario, type of mission and equipment of its members.

Within the physical activity planning for the army infantry school, Tuesdays, Wednesdays and Thursdays are considered in rotating schedules, in which it is evident that the physical preparation is aimed at aerobic training, such as continuous jogging to different routes within the facilities of the Military Fort, but without technical direction and without considering the principle of gradual progression of loads. For such reason, it is necessary to implement a new methodology of intervallic training (HIIT) to improve aerobic endurance, since according to scientific sources such as (Fader, 2013 m pg 23). "It tells us that, in sedentary and active recreational individuals, HIIT (High Intensity Interval Training) improves endurance performance to a greater degree than that achieved with continuous training alone". Although it is considered that in order to be able to execute training loads through intervallic methods, it is necessary to have an aerobic base for the organism to adapt to this training methodology, which can generate better results.

The effectiveness of performing interval training at exercise intensities that enhance $\dot{V}O_{2\max}$ ensures the use of that training method as a great means to improve aerobic endurance (Vechin, Conceição, Telles, Libardi, & Ugrinowitsch, 2021; Runacres, Mackintosh, & Mc Narry, 2019; Oliveira, da Costa Mesquita, de Azevedo, & de Oliveira Rocha, 2018). Once the different metabolic adaptations that occur in the organism with this type of training are known, it can be pointed out that HIIT is perhaps an efficient training tactic, since in less time it can produce better adaptations with respect to continuous resistance training (Peroni & Goñi, 2019).

Regarding the maximal oxygen consumption ($\dot{V}O_{2\max}$) (Tschakert & Hofmann, 2013) point out in their study, that improvements in $\dot{V}O_{2\max}$ are mainly due to both adaptations of muscle oxidative potential, as well as the increase of mitochondria and mitochondrial enzyme activity. The study carried out on the increase of $\dot{V}O_{2\max}$ implies achieving improvements in all the organs and systems of the organism, which participate in the process of oxygen transport to the mitochondria, which is why $\dot{V}O_{2\max}$ is a fundamental variable for the cardiovascular fitness of the subject or health in general. In terms of body composition, it produces an increase in epinephrine and nor epinephrine that perform the function of catalyzing to enhance fat loss; the release of adrenaline and non-adrenaline perform lipolysis and are responsible for the release of subcutaneous and intramuscular fat to be used as a source of energy in exercise (Boutcher, 2011).

In this way, not only improvements in $\dot{V}O_{2\max}$ are determined, but also the progression of VAM (maximal aerobic speed) and PAM (maximal aerobic power), but also improves the oxidative, cardiovascular, metabolic, muscular and glycolytic environment. Currently, high intensity interval training (HIIT) is presented as a training alternative to



be employed in programs for significant improvement of maximal oxygen volume- $\dot{V}O_{max_2}$ and aerobic capacity, including in armed forces, (Kyröläinen, Pihlainen, Vaara, Ojanen, & Santtila, 2018; Machado, Miranda, Rica, Figueroa, & Bocalini, 2018) which is stimulated in the adolescent stage, where the oxygen consumption of the adult stage is ensured.

The intervallic method alternates loading phases with recovery phases as a fundamental part of training. Thus, it is determined by being established in work and pause, but with the complement that the pauses are incomplete, that is to say that a complete recovery is not reached between a load and a new load within the training session. The duration of the pauses is variable, according to the type and level of the athlete, the intensity of the work and the duration of the load. In general, the duration of the rest interval can be graded by heart rate.

The medium extensive interval method is characterized by the use of loads of duration between 1 and 3 minutes, with a medium to sub maximal intensity and with a high volume of work of 35 to 45 minutes and rests between 90 seconds to two minutes (Ospina & Trujillo, 2013). Therefore, due to the duration and intensity of the load increases the oxygen debt, so anaerobic processes are activated to a greater extent. Another important aspect to highlight in this type of training is the possibility of increasing the lactate production capacity of the slow fibers (ST). All this makes the aerobic capacity improve especially through the central factor and produces a greater tolerance to lactate, in addition to myocardial hypertrophy (Navarro, 1998), being used for the development of basic resistance II, medium duration resistance, and long duration resistance.

On the other hand, the short intensive intervallic method is identified by the execution of loads with a duration between 15-60 (20"-30") seconds, with a high intensity over 70-80 % of the maximum speed, with a recovery of 2-3 minutes, which is developed from 15 to 30 repetitions in groups of 3-5 repetitions. This type of training increases lactic anaerobic power by an increase in lactate production, increases lactic anaerobic capacity by increasing lactate tolerance, during the effort increases peripheral resistance, which promotes cardiac hypertrophy, also during recovery facilitates an increase in peripheral circulation; therefore, there will be an increase in $\dot{V}O_{max_2}$. Moreover, it is used in the development of basic resistance III, short and medium duration endurance.

In this sense, and taking into account the aforementioned theoretical basis, the purpose of the research is to enhance aerobic endurance in soldiers of the Army Infantry School (EIE) through HIIT training.

MATERIALS AND METHODS

A descriptive-co relational research was applied, since data were originally collected and by means of the pertinent tools it was possible to control, compare and arrive at integral conclusions.

The height and weight to determine the Body Mass Index (BMI) were measured using the Camry BR2016 scale; using the BMI as a simple indicator to identify overweight and obesity in the adults studied and the effects that indirectly could have the HIIT training



to be implemented. The BMI calculation was determined by using a template previously designed in Microsoft Excel 2019.

The time performed in the two-mile test was timed using a ULTRAK 496; applying this test to calculate the VO_{max_2} in a pretest and a posttest, thus determining the times and VO_{max_2} of each of the soldiers studied.

The two-mile test was applied according to the assumptions indicated:

- Two-mile test (3219mts): the test consists of running a linear distance of 3219 meters in the shortest possible time; the test concludes when the soldier crosses the finish line. For the calculation of VO_{max_2} the formula was used: $VO_{max_2} = 128.81 - (5.95 \times \text{times over the two miles in minutes})$, while the final times achieved in each test were recorded and analyzed.

The HIIT model implemented was applied according to the assumptions outlined above:

- HIIT application: the HIIT program was established in an eight-week macro cycle with 16 training sessions. Each training session was developed during the hour planned for military physical conditioning. The training place was in the facilities of the Atahualpa Military Fort, 75 soldiers (23-28 years old, male gender), selected from the Army Infantry School under a non-probabilistic intentional sampling, was studied.

The data were compared with the kolmogorov-smirnov test indicating normal distribution, for which the non-normal distribution of the data was evidenced for the results achieved in the two-mile test and VO_{max_2} , and a normal distribution for the BMI test. Being in all cases data for two related samples, the t-test for two related samples will be applied for the results of the BMI test ($p \leq 0.05$), and the Wilcoxon Signed Ranks test for the results obtained with the two-mile test ($p \leq 0.05$) and the maximal oxygen volume ($p \leq 0.05$).

RESULTS AND DISCUSSION

Table 1 shows the results achieved in the two-mile test in the two moments of the test, in which the final time data presented by the 75 soldiers studied are presented (Table 1).

Table 1. - Results of the two-miles test (time)



Tiempo en dos millas		
No	PRE TEST	POS TEST
1	15:01	12:48
2	12:22	11:20
3	14:06	13:11
4	15:43	14:02
5	13:06	12:16
6	12:40	12:01
7	12:58	11:55
8	14:29	13:25
9	13:25	12:42
10	14:22	13:38
11	12:36	12:03
12	14:18	13:00
13	13:46	12:53
14	12:57	11:59
15	13:25	12:40
16	14:04	13:05
17	14:22	13:31
18	12:52	12:01
19	12:31	12:01
20	12:27	12:07
21	12:33	11:56
22	13:16	12:24
23	13:27	12:37
24	13:06	11:28
25	12:51	11:29



26	15:23	14:31
27	12:02	11:42
28	13:03	12:23
29	15:19	14:38
30	13:56	12:56
31	14:44	13:44
32	14:15	13:15
33	14:56	13:56
34	15:03	14:23
35	14:26	13:26
36	13:39	12:51
37	13:27	12:25
38	13:49	12:47
39	14:05	13:06
40	13:11	12:05
41	15:34	14:12
42	14:39	13:58
43	12:43	12:00
44	12:18	11:33
45	13:18	12:50
46	12:53	12:03
47	13:02	12:42
48	13:26	12:41
49	12:38	12:01
50	12:32	12:19
51	14:51	13:21
52	14:38	14:01



53	12:33	12:01
54	12:13	12:02
55	13:25	13:02
56	13:44	13:04
57	13:01	12:31
58	12:54	12:01
59	15:56	14:16
60	14:22	13:42
61	13:06	12:36
62	13:43	12:43
63	13:30	12:50
64	12:59	12:09
65	13:02	12:02
66	12:39	12:39
67	15:21	14:01
68	14:21	13:51
69	12:55	12:05
70	12:40	12:00
71	15:19	14:09
72	12:07	12:07
73	14:34	13:34
74	12:57	12:07
75	15:14	14:10
□	13:39	12:48



The comparison of the means determines differences between the pretest (13:39) and the posttest (12:48) in favor of the latter (Table 1). There was a decrease in the time required to complete the two-mile test with an improvement of 51" during the eight weeks of intervallic training applied to the soldier personnel of the Army Infantry School improvement course. The Wilcoxon Signed Ranks test showed significant differences in favor of the posttest ($p=0.000$), presenting a higher average rank, with 73 negative ranks or soldiers who decreased the time to complete the two-mile test, with 0 positive ranks and two ties.

The body mass index was also checked at the two moments of implementation of the intervention proposal (Table 2), the results were measured in a pretest and a posttest for each BMI of the 75 soldiers under study (Table 2).

Table 2. - Body mass index

I.M.C (kg/m ²)		
No	PRE TEST	POS TEST
1	25,21	24,16
2	25,26	24,22
3	23,80	23,42
4	22,96	22,96
5	26,67	25,91
6	22,31	21,94
7	23,51	23,14
8	25,34	24,24
9	19,23	19,23
10	26,30	25,26
11	22,21	22,21
12	24,22	23,53
13	22,06	22,06
14	24,22	23,88
15	24,42	23,81
16	24,02	23,67
17	20,32	20,32
18	24,31	23,59



19	23,03	22,68
20	22,68	22,32
21	22,77	22,77
22	21,77	21,77
23	22,39	22,05
24	24,09	23,71
25	20,58	20,58
26	23,80	23,42
27	21,55	21,55
28	25,82	24,74
29	22,23	22,23
30	23,60	23,26
31	25,77	24,67
32	22,58	22,58
33	23,03	22,68
34	27,51	26,03
35	22,68	22,68
36	26,77	25,65
37	23,80	23,42
38	23,74	23,38
39	24,09	23,74
40	22,86	22,86
41	22,04	22,04
42	21,26	21,26
43	26,29	25,15
44	21,16	20,80
45	24,68	23,95



46	25,16	23,74
47	24,51	24,51
48	22,76	22,41
49	22,10	22,10
50	23,23	22,86
51	28,39	27,04
52	29,07	27,34
53	26,42	25,43
54	23,94	23,60
55	23,11	22,76
56	21,26	21,26
57	24,91	24,17
58	23,66	23,66
59	23,36	23,36
60	25,71	24,61
61	25,82	24,74
62	24,38	24,02
63	21,31	21,31
64	24,54	24,17
65	22,79	22,46
66	26,15	25,18
67	25,26	23,18
68	24,38	24,38
69	23,95	23,59
70	24,80	24,80
71	25,54	24,58
72	23,38	23,03



73	22,48	22,48
74	22,65	22,31
75	29,41	25,26
<input type="checkbox"/>	23,91	23,38

As shown in Table 2, BMI values decreased as part of the posttest (23.38), being lower than the mean obtained in the pretest (23.91), for which the Student's t-test for related samples determined the existence of significant differences ($p=0.000$) in favor of the posttest as it presented a lower mean.

On the other hand, the analysis of VO_{max2} is shown as part of Table 3, where this indicator is obtained at two moments of the preparation, comparing the results (Table 3).

Table 3. - V_{max2} results

Vo2 Max(ml/kg/min)		
No	PRE TEST	POS TEST
1	39,46	52,65
2	55,23	61,38
3	44,92	50,37
4	35,3	45,31
5	50,87	55,82
6	53,44	57,31
7	51,66	57,91
8	42,63	48,98
9	48,98	53,25
10	43,33	47,69
11	53,84	57,11
12	43,73	51,46
13	46,9	52,15
14	51,76	57,51



15	48,98	53,44
16	45,11	50,96
17	43,33	48,39
18	52,25	57,31
19	54,34	57,31
20	54,73	56,72
21	54,14	57,81
22	49,87	55,03
23	48,78	53,74
24	50,87	60,58
25	52,35	60,48
26	37,28	42,44
27	57,21	59,2
28	51,16	55,13
29	37,68	41,74
30	45,91	51,86
31	41,15	47,1
32	44,02	49,97
33	39,96	45,91
34	39,26	43,23
35	42,93	48,88
36	47,59	52,35
37	48,78	54,93
38	46,6	52,75
39	45,01	50,87
40	50,37	56,91
41	36,19	44,32



42	41,64	45,71
43	53,15	57,41
44	55,63	60,09
45	49,68	52,45
46	52,15	57,11
47	51,26	53,25
48	48,88	53,34
49	53,64	57,31
50	54,24	55,53
51	40,45	49,38
52	41,74	45,41
53	54,14	57,31
54	56,12	57,21
55	48,98	51,26
56	47,1	51,06
57	51,36	54,34
58	52,06	57,31
59	34,01	43,92
60	43,33	47,3
61	50,87	53,84
62	47,2	53,15
63	48,49	52,45
64	51,56	56,52
65	51,26	57,21
66	53,54	53,54
67	37,48	45,41
68	43,43	46,4



69	51,96	56,91
70	53,44	57,41
71	37,68	44,62
72	56,72	56,72
73	42,14	48,09
74	51,76	56,72
75	38,17	44,52
□	47,64	52,65

The maximal oxygen volume presented a lower mean in the pretest (47.64ml/kg/min) compared to the mean obtained as part of the posttest (52.65ml/kg/min), indicative of an improvement in maximal oxygen consumption in favor of the posttest, such improvement being significantly different ($p=0.000$) in favor of the posttest. The highest average range prevailed in the study, with 73 positive ranges, 0 negative ranges and two ties, indicating that the majority of the studied military personnel presented a better maximal oxygen volume after implementing HIIT training.

Aerobic performance is fundamental in the physical preparation of the soldier (Clavijo, Morales, & Cárdenas, 2016; Larrea & Calero Morales, 2017; Rivadeneyra Carranza, Morales, & Parra Cárdenas, H. A, 2017). Military training includes prolonged physical activities, normally using stimuli at low intensities, as defined by Kyröläinen, *et al.*, (2018), an aspect that requires superior training methods to improve and optimize the overall physical performance of soldiers, as would be the variation of the physical stimulus, an aspect that can be achieved by correctly applying the interval method and its variants such as HIIT. For the present research, it is corroborated that HIIT training indirectly improves BMI in soldiers, in addition to directly improving VO_{max2} and the average time required to complete an aerobic endurance test, as evidenced by other authors cited for the specific case of armed forces personnel, as is the case of Morocho, Tulcanaza, & Guerrero, (2021), where it is confirmed that the application of high-intensity intervallic training can increase VO_{max} in third-year cadets of the Eloy Alfaro Military High School, or work of high-intensity intervallic training can increase VO_{max} in third-year cadets of the Eloy Alfaro Military High School. Guerrero, (2021) where it is confirmed that the application of high intensity intervallic training can increase VO_{max2} in third year cadets of the High Military School *Eloy Alfaro*, or the work of Tornero-Aguilera *et al.*, (2019). In this context, by combining two resistance HIIT sessions oriented to solve military tasks, a significant decrease in BMI was found, along with an increase in muscle strength in the lower extremities, an improvement in aerobic and anaerobic performance, resilience. The existence of stress tolerance and psychological flexibility are also added; therefore, HIIT can provoke a psycho physiological response similar to real combat maneuvers, demonstrating, as stated by Tornero-Aguilera *et al.*, (2021), to be an optimal stimulus approach/intervention for the specific physical preparation of the soldier.



For the improvement of the present research, it is recommended to carry out a quasi experimental research in the future, generating at least two independent groups where a HIIT proposal as the one designed in the present research is applied to the experimental group, and a traditional training model to the control group, showing the real potential of each intervention model.

CONCLUSIONS

Once the results of the present research work have been described, it is concluded that the intervallic training, mainly the medium extensive and short intensive, effectively affects the development of aerobic endurance, after a period of 8 weeks of training. The intervallic training gave favorable results, demonstrating that it helps the development of aerobic endurance, assuming that it is possible to change the usual methods of conditioning in military units under certain objective and subjective assumptions.

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