



Relationship between the level of the aerobic conditioning, performance on an obstacle course, and outcome in a shooting test

Adriano da Costa Dias¹, Estélio H.M. Dantas², Sérgio Bastos Moreira³ and Vernom Furtado da Silva²

ABSTRACT

The military preparation to the combat is based on military instructions that have as basis a representation of the battlefield. Among the main instructions are the obstacle course and the shooting performance. The purpose of this study was to verify the influence of the aerobic conditioning level on the outcome in the performance on an obstacle course, and performing a shooting test in soldiers of the Brazilian Army. Also, the aim of this study was to check the influence of the performance on an obstacle course versus the performance in a shooting test. The mentioned outcome was evaluated by the time of the execution on an obstacle course and the outcome in the shooting test (the SPI – performance in a shooting test was considered as the difference between the performance in the pre- and post-strength shooting test). The sampling was constituted by twenty-eight 19 to 20 years old soldiers. Initially, the individuals' $\dot{V}O_{2max}$ was estimated by means of the Léger-Boucher test. Later, the soldiers participating in the sampling performed a shooting test, an obstacle racing, and another shooting test. It was verified a significant difference between the pre- and post-strength shooting (43.79 ± 4.02 to 40.54 ± 4.10 points, $p < 0.05$). The outcomes obtained through the Pearson correlation were as follows: Obstacle Course and $\dot{V}O_{2max}$ $r = -0.612$ (significant); SPI and $\dot{V}O_{2max}$ $r = -0.403$ (significant), and pre-strength shooting $\dot{V}O_{2max}$ $r = 0.310$ (significant). It can be concluded that the level of the aerobic conditioning affects the performance time on an obstacle course, and there is a relationship between the level of the aerobic conditioning and the SPI. Nevertheless, it was observed no relationship between the outcome in the shooting test and the aerobic conditioning.

INTRODUCTION

The accomplishment of successive missions without an adequate resting time can compromise the combatant's performance. It is believed that the effects of the performance-induced fatigue in military tasks may be attenuated through a high aerobic conditioning. In order to search for an understanding on such effects, an obstacle course and combat shooting were used as instruments to induce and investigate the effects of the fatigue.

The obstacle course is a measured path where soldiers must progress and surpass several obstacles put in their itinerary. Among

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physical abilities used to perform an obstacle course, it can be pointed out the muscular power and the aerobic endurance. According to Bishop *et al.*⁽¹⁾, the level of the aerobic conditioning is highly connected to the time spent to run through an obstacle course. Those individuals with a better aerobic conditioning present a better performance than poor-conditioned individuals in the accomplishment of more complex physical tasks that demand a higher attention and concentration level⁽²⁾.

Soldiers must be prepared to shoot under physical and psychological stress conditions, since most of times, his survival will depend on such ability. The necessary ability for soldiers to achieve the efficiency in the combat shooting is acquired by means of learning the shooting fundamentals⁽³⁾. In order to the combatant to be an effective shooter, he must be in such a condition that allows him to discover a target and to get it. According to Grebot *et al.*⁽⁴⁾, the accomplishment of an endurance exercise before performing the shooting does not compromise the shooter's performance. Corroborating this, Evans *et al.*⁽⁵⁾ concluded that there is no relationship between the physical fitness and the outcome in the shooting. Nevertheless, Hoffman *et al.*⁽⁶⁾ observed that the performance in the shooting performance after the exercises decreases as the exercise intensity increases.

The purpose of this study was to verify the influence of the level of the aerobic conditioning on the outcome when running through an obstacle course and the performance in a shooting test. Also, it was aimed to verify the influence of running through an obstacle course after a shooting test.

METHODS

Sampling

The sampling was constituted by twenty-eight male soldiers, aging from 19 to 20 years old, incorporated to the 1st Group of Anti-Aerial Artillery (Military Organization pertained to the Brazilian Army). They were intentionally chosen observing some similar characteristics: gender, age, height, and fat percentage. All of them were volunteers, and they signed a Free and Informed Consent Term, in which the benefits and possible risks to the health associated to the trial were specified, besides the possibility to quit the research at any time. They were submitted to a medical evaluation, in order to check any counter-indication to the intense exercising with the same characteristics that it would be used in the present study. This work followed the Rules for the Regulations for Research Using Human Subjects, Resolution No. 196/96 from the National Health Council.

Every soldier of the sampling received at least a concept "Good" in a shooting test performed two months before the data collection, that is, each individual of the sampling were in conditions to perform the shooting fundamentals (stable positioning, shooting

1. Researcher for the Laboratory of the Human Motricity Bioscience – UCB, Rio de Janeiro, RJ.

2. Chair Professor of the *Stricto Sensu* Post-graduation Program in Human Motricity Science – UCB, Rio de Janeiro, RJ.

3. Researcher of the BIOSUAM – UNISUAM, Rio de Janeiro, RJ.

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Correspondence to: Rua General Savaget, bloco 9, apto. 202, Deodoro – 21610-390 – Rio de Janeiro, RJ. Phone: (21) 2450-8727. E-mail: adrieda@superig.com.br

constancy, breathing and triggering control) and to hit the target with an accuracy considered good in the Brazilian Army. The features of the individuals of the sampling are presented in table 1.

TABLE 1
Characteristics of the sampling

Description	Age (years)	Weight (Kg)	Height (cm)	Percentage of fat	$\dot{V}O_{2max}$ (ml.Kg ⁻¹ .min ⁻¹)
Mean	19.17	66.53	174.07	6.74	51.9
DP	0.39	7.59	6.90	2.45	3.53

Experimental design

In the previous week before performing the TME, the Léger-Boucher test⁽⁷⁾ was performed to estimate the $\dot{V}O_{2max}$ for each individual in the sampling. From this point on, the trial was divided in three phases. The first phase was constituted by the execution of the air-rifle (AR) shooting. The second phase was the performance on an obstacle course, and the third phase was once again constituted by the execution of the AR shooting test. Every phase was performed in a continuous way. The heart rate of every soldier was measured in each of the phases. In order to determine the relative cardiac cost of the work (CCReIT), it was considered the relationship between the relative cardiac cost (heart rate on the strength minus the resting heart rate) and the maximal heart rate.

While performing the TME, soldiers were using their combat uniform constituted by a helmet (1 kg), an open pack (suspender with the canvas equipments), and a 4,805 kg rifle. The military tasks studied were performed between 2 pm and 4 pm.

Léger-Boucher test to estimate the $\dot{V}O_{2max}$

To perform the Léger-Boucher test, the individual would have to continuously run through a path measured every 50 meters, always keeping the speed determined through sound signals that indicated when the individual would have to pass aside each mark. At the beginning, the issued signals were keeping the individual at a speed of nine km/h (equivalent to the Level 9). Each two minutes of the run, the running speed increased 1 km/h (new level) up to the moment the individual did not succeed in keeping the set speed (when he was starting to be late in successive marks, and he did not succeed to recover himself from such delay). When it was perceived that the individual reached this point, the test was terminated.

When the individual did not succeed in terminating the level set, it was this was considered the last terminated level, added by the fragmented portion performed by the individual when the test was interrupted. After determining the level attained, this was compared in a chart containing the estimated $\dot{V}O_{2max}$ for that level.

Obstacle course

The obstacle course is an instrument that seeks to simulate movement delaying situations that soldiers can face in the battlefield. The obstacle course consisted by an 1,200 meter length path, and it was composed approximately by eight obstacles 120 meters away one from another. In the first obstacle, called "Maximal and Minimum", the individual had to surpass three parallel logs, the first one on the top, the second below, and the third one above. The first and the third logs were 1.2 meters high, and the second log was 0.6 meters high. In the second obstacle, the "Pinguela"¹,

soldiers had to surpass a 10 meter length and 12 centimeters width log, one meter above the ground towards the course. In the third obstacle, "Passeio do Macaco"², soldiers had to surpass six vertically hung ropes with a 0.70 cm space one from another. In the fourth obstacle the "Escada"³ soldiers had to climb five steps (four meters), passing by the higher one, and going down on the other side; the fifth obstacle, the "Rastejo alto"⁴ is similar to the previous obstacle, with a difference in the height of the wire grating (50 cm above the ground). In the sixth obstacle, the "Passeio do Tarzan"⁵, soldiers had to surpass a two meter length water channel with the help of a rope. In the seventh obstacle, the "Fosso e tunel"⁶, soldiers had to get into a two meter deep hole, and surpass a ten meter length tunnel crawling on his fours.

In the last obstacle, the "Muro de assalto"⁷, soldiers had to surpass a two meter height wall using free transposition. In order to measure the execution time of the course, it was used an electronic chronometer with hundredths of a second accuracy.

Militaries of the sampling started the course at the whistle-blowing, and from there, they should surpass ten obstacles set along the itinerary of the course. The time to pass through the course comprised the period between the whistle-blow and surpassing the arrival line.

Shooting test

The arming used to perform the shooting test was the AR, which is the gun used in the Brazilian Army to the shooting technique training sessions. The 4,050 kg and 4.5 mm caliber AR, with One-Shot shooting and a shot-to-shot loading capacity (to load the gun, the shooter has to act in the barrel in order to open and close the breech). The shooter was in the kneeled shooting position, and performed the shooting ten meter away, on a 6.3 x 9.4 cm target. Each soldier performed five shots, and each impact inside a three cm diameter circle was equal to ten points. Each time the diameter of the circle increased two centimeters, the equivalent points decreased (for instance, in a five centimeter circle, the soldier added nine points, in a seven centimeter circle, it was equal to eight points), and so on.

Cardiac Cost related to the Work (CCReIT)

During every phase of the trial, all soldiers had their heart rate measured for later calculation of the Relative Heart Cost of the Work (CCReIT). In order to calculate the mean CCReIT, the mean HR during the strength was used in all individuals for each activity: pre-strength shooting (CCReIT_{TR}), obstacle course (CCReIT_{PO}), and post-strength shooting (CCReIT_{TE}).

Statistical analysis

The significance level considered was of $p < 0.05$, which means 95% probability to the affirmatives and/or negatives demonstrated in the study. To the analysis of the shooting outcome, it was considered the difference between the pre- and post-strength shooting. The value found was called the shooting performance index (SPI). With the purpose to analyze the difference between the pre- and post-strength shooting, it was performed the T-Student test for the dependant sampling. Next, Pearson's correlation test was performed between the $\dot{V}O_{2max}$ variables, and the pre-strength shooting outcome; the $\dot{V}O_{2max}$ and SPI, and the time to pass through the obstacle course.

² "Monkey's Walk". (N.T.)

³ Staircase. (N.T.)

⁴ High Crawl. (N.T.)

⁵ Tarzan's Walk". (N.T.)

⁶ "Drain and tunnel". (N.T.)

⁷ "Attack Wall". (N.T.)

¹ Little bridge. (N.T.)

OUTCOMES

The time values to perform the shooting test and the mean punctuation of the pre- and post-strength shooting are shown in Table 2. Table 3 presents the mean time to execute the obstacle course. It can be observed in Table 2 that the performance time and the mean punctuation in the pre-strength shooting was higher than that after passing through the obstacle course.

TABLE 2
Outcomes in the shooting test

Description	Points	Time of execution
Pre-strength shooting	43.79 ± 4.02	02:33 ± 0.68 min
Post-strength shooting	40.54 ± 4.10* ¹	01:52 ± 0.51 min* ²
SPI	3.25 ± 5.64	-

*¹ p = 0.005; *² p = 0.001, related to the pre-strength shooting.

TABLE 3
Outcome in the obstacle course

Description	Time of execution in the obstacle course
Mean	8:49 ± 0.66 min

Table 4 shows the correlation between the obstacle course variables, SPI, $\dot{V}O_{2max}$ and pre-strength shooting. It is observed that there was a significant correlation in the relationship between the obstacle course and the $\dot{V}O_{2max}$ and between the SPI and the $\dot{V}O_{2max}$. On the other hand, it can be observed that there was no significant correlation between the $\dot{V}O_{2max}$ and the pre-strength shooting.

TABLE 4
Pearson's correlation

Crossing	Pearson's r	p	Outcome
Obstacle course and $\dot{V}O_{2max}$	-0.612	0.014	Significant
SPI and $\dot{V}O_{2max}$	-0.403	0.033	Significant
$\dot{V}O_{2max}$ and pre-strength shooting	0.310	0.109	Non-significant

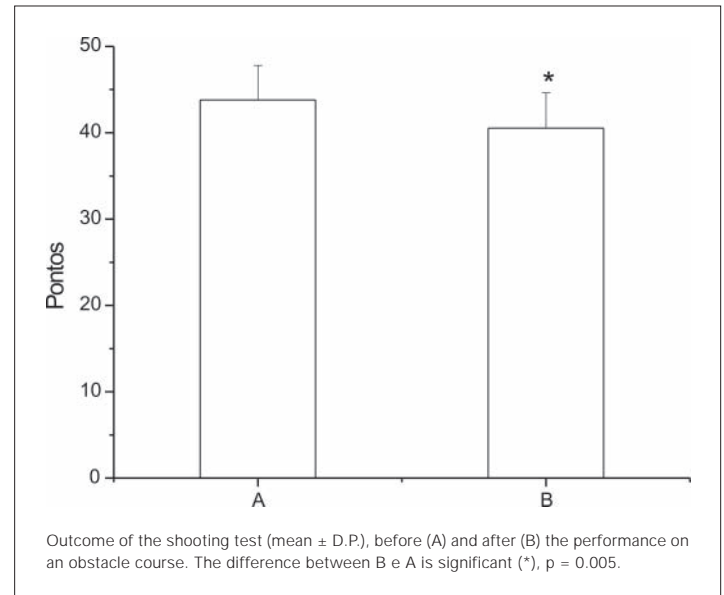
DISCUSSION

The aim of this study was to construct experimental simulation of progressive combat situations (shooting, obstacle courses, shooting), in order to study the impact of the aerobic conditioning on the TME performance. The obstacle course and the combat shooting were the instruments used to supply comprehension of the physiological effects of the combat stress and its impacts on the combatant's performance.

Initially, the aim was to verify the effects of the obstacle course performance on the shooting test performance, for later evaluation of the influence of the aerobic conditioning has on these variables. Graphic 1 presents the difference in the punctuation between the pre- and post-strength shooting.

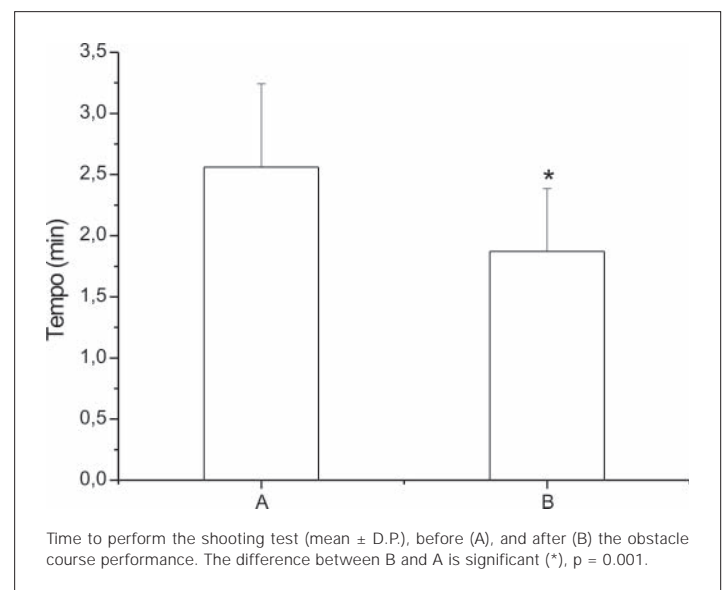
There was a significant difference between the outcome of the pre- and post-strength shooting tests. These outcomes indicate that there was a 7.42% reduction in the post-strength test outcome compared to the test performed before passing through the obstacle course. It is believed that such variation may be due to the muscular fatigue caused by the performance in the obstacle course. It makes difficult the shooter's body balance and gun stabilization, causing an impaired aim. Physiological changes (such as ventilatory response, changes in the muscular biochemistry, the contraction and development of the static tension) may also have affected the shooting outcome, once they make difficult to keep a

constant aim. These outcomes are in accordance to what Tharion *et al.*⁽⁸⁾ found upon their observation of soldiers after a four hour march at a 3.5 miles per hour speed, and carrying a 45 kg stuff. They observed that there was a worsening in a shooting test outcome. Evans *et al.*⁽⁵⁾ observed a decrease in the shooting performance after passing through an obstacle course caused by the muscular fatigue in the upper limbs.



Graphic 1 – Outcome of the Pre- and Post-Strength Shooting Test

The results found in the present investigation suggest that the execution on an obstacle course may impair the shooting performance. Oppose to such idea, Grebot *et al.*⁽⁴⁾ observed that elite biathletes (sky and shooting) had no decrease in their shooting performance after performing an endurance exercise (1,000 meter sky).



Graphic 2 – Time to Perform the Pre- and Post-Strength Shooting Test

Graphic 2 presents the mean time in performing the pre- and post-strength shooting test. It is observed that the mean time to accomplish the shooting test after the strength was lower than the one performed before the strength. Such difference in the time can be one of the factors which help to find a decrease in the

performance of a post-strength shooting test. The performance in the shooting test is based on the shooting fundamentals, and among these, it is the aim and triggering performance. When individuals performed the shooting test at a lower time, it is possible that the test was performed having the same concern related to two both fundamentals, and consequently, there was a decrease in the shooting performance. Upon the knowledge that a physical exercise stimulates the catecholamine secretion, it is believed that these substances may have caused an increase in the stimulation of the individuals of the sampling, and as consequence, they performed a faster shooting test. Another explanation would be that the physical discomfort individuals experienced would stimulate them to look for terminating that situation in the quickest time possible.

After checking the effects of the performance in the obstacle course against the shooting performance, the aim was to set a relationship between the aerobic conditioning and the TME. The performance on an obstacle course is associated to a series of factors, and among them, it is pointed out the aerobic conditioning.

Searching for a better understanding on the influence of the aerobic conditioning on the performance on an obstacle course, the correlation between both variables was performed (table 4).

There was a significant correlation between the $\dot{V}O_{2max}$ and the time to pass through the obstacle course. Such relationship suggests that the higher aerobic conditioning, the lower will be the time of the performance on an obstacle course. A possible explanation for such relationship is that individuals with best aerobic conditioning would run in-between distances in a faster speed, thus canceling a possible difficulty to surpass some obstacles due to a reduced strength in the upper limbs. Soeiro *et al.*⁽⁹⁾ observed that there was no relationship between the outcome on an obstacle course and the strength in the upper limbs in Brazilian Army soldiers. On the other hand, Pandorf *et al.*⁽¹⁰⁾ observed that individuals with bigger muscular mass had more easiness to perform a march and on an obstacle course with no load. Corroborating this idea, Jetté *et al.*⁽¹¹⁾ observed that ten individuals presenting best outcomes on an indoor combat course had 141% higher muscular endurance than ten individuals with poorest outcomes. It is suggested that such outcome is associated to the extent of the course (approximately 200 meters), the high number of obstacles (total 19), and the short distance in-between (approximately 10 meters) that could benefiting those individuals with higher muscular endurance. On the contrary, in the present study, the extent of the course was of 1,200 meters, and the distance in-between obstacle was approximately 110 meters. So, individuals with higher aerobic conditioning could be benefited.

Opposed to this finding, the course in the present study was 1,200 meters long, and the distance between obstacles was approximately 110 meters. Nevertheless, individuals with higher aerobic conditioning could be benefited.

Another research corroborating the outcomes found in this study was performed by Hawking *et al.*⁽²⁾, that upon the observation of individuals performing an aerobic training for ten weeks noted a better outcome to performing the military tasks. Corroborating this, Silva and Gomes⁽¹²⁾, observing the behavior of soldiers after performing specific tasks (such as 24 km march, arm flexion on the horizontal bar, and a 12 minute running) verified that individuals with higher aerobic ability obtained a higher outcome in those tasks compared to individuals presenting a lower aerobic ability. Another study performed by Pandorf *et al.*⁽⁹⁾, they observed a strong correlation between the $\dot{V}O_{2max}$ and the time to perform a 3,200 meter afoot march, and passing through an obstacle course.

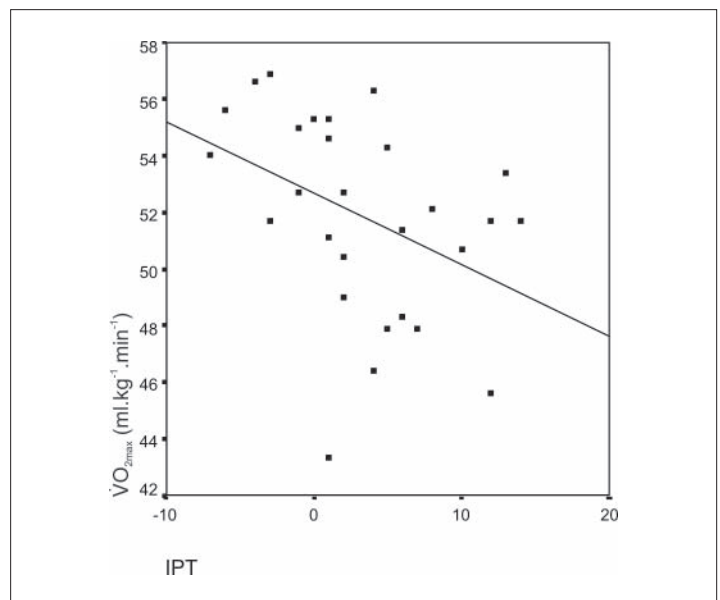
There was a significant correlation between the SPI and the $\dot{V}O_{2max}$. This outcome suggests that the higher aerobic conditioning, the lower will be the SPI, that means, individuals with better aerobic conditioning presented little difference in the post-strength shooting performance compared to the pre-strength shooting,

while individuals with poor aerobic conditioning trended to present a worsening in their post-strength performance. Probably, individuals with better aerobic conditioning that presented a lower recovery time after performing exercises had more easiness to perform the shooting test. The outcomes found in the present study confirm the Evans *et al.*⁽⁵⁾ findings, who reported a strong correlation between the physical ability and the outcome in the shooting test after passing through a course simulating urban combat.

Aiming to check if the aerobic conditioning has a relationship with the performance in a shooting test, it was performed a comparison of the outcome in a shooting test before passing through an obstacle course, and this allowed to observe the shooting behavior without being influenced by the fatigue (table 6).

It was observed that the correlation was not significant, suggesting that there is no influence of the aerobic conditioning on the shooting performance before passing through the obstacle course, that means, individuals with better aerobic conditioning not necessarily will present a better shooting ability.

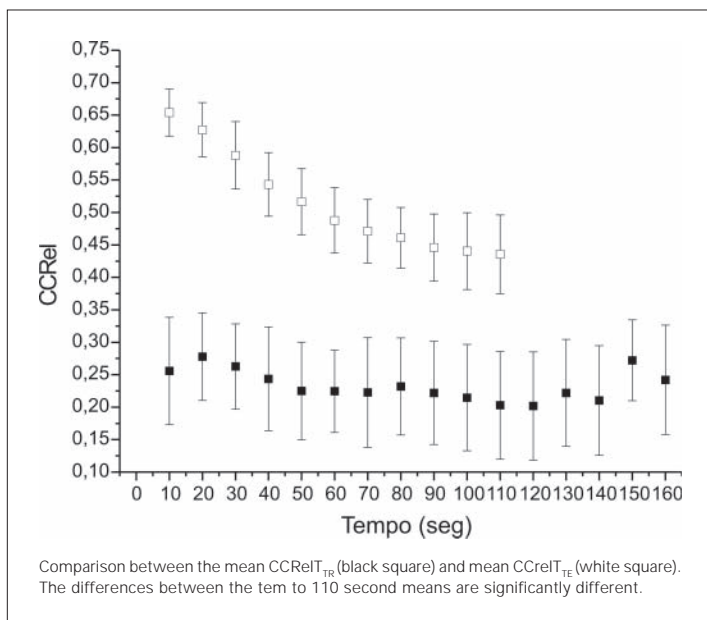
Searching for a better visualization of the relationship between variables, it was set the graphical representation. Graphic 3 presents the data dispersion in relation to the regression straight line of the $\dot{V}O_{2max}$ and SPI.



Graphic 3 – Relationship between $\dot{V}O_{2max}$ and the SPI

It can be observed in graphic 4 that the CCR_{IT} is increased when compared to a mean resting CCR_{el}. According to Tremayne and Barry⁽¹³⁾, the HR during the shooting performance is followed by mental processes associated to the experience. Instead of simple physical changes associated to the rising of the gun, the pressure on the trigger or the retrocession and the noise of the fire, the authors suggest an increasing vigilance status related to an active state of focusing on external stimuli. Kontinen and Lyytinen⁽¹⁴⁾ has mentioned another explanation in their study on the HR behavior during a rifle shooting contest, and they concluded that the variations in the HR were associated to the athletes' attempts in finding a stable position of the rifle.

Graphic 4 shows that the performance in the pre-strength shooting was characterized by a mean CCR_{IT} lower than the shooting performed after passing through the obstacle course. It must be considered that the variation in the HR is associated to several physiological changes. Some authors have mentioned that before or during the shooting, shooters experience a reduction in the HR^(14,15).



Graphic 4 – Mean CCRelT of the Pre- and Post-Strength Shooting

Nevertheless, it must be considered that these authors used a sampling constituted by well-trained-soldiers. The present study used a sampling composed by just enlisted soldiers to perform the shooting test. Experienced shooters seek to be relaxed to reach a slower breathing status and in order to decrease the arch of movement. Probably, less experienced shooters dwell their attention on the basic techniques to perform a good shooting (stable positioning, triggering, breathing, and aiming control) without any concern on how they may improve these fundamentals.

So, it can be concluded that soldiers with better aerobic conditioning presented a better performance on an obstacle course, that is, the level of the aerobic conditioning affects the outcome on an obstacle course. It was observed that the better aerobic conditioning is associated to a lower variation in the post-strength shooting outcome compared to the pre-strength shooting. It was observed no significant relationship between the aerobic conditioning and the pre-strength shooting test, thus suggesting that the aerobic conditioning has few influence on the shooting performance.

It is pointed out that the main insight found in this study was to observe a significant decrease in the outcome and in the time spent to perform the post-strength shooting test compared to the pre-strength test of about 7.42% and 26.6%, respectively. With this, it can be mentioned that the performance on an obstacle course impairs the soldiers' performance in the accomplishment of a shooting test performed just after the obstacle course is finished.

The outcomes found in this study bring important contributions to the Army, and it can be used as input to develop physical education programs upon the consideration of specific physical qualities for the military activity, such as creating a military instructional plan aiming to qualify soldiers to shoot under physical and mental

stressing situations, and based on the outcomes found, it can be divided in small portions, thus allowing to leveling those fractions aiming to attain a major homogeneity.

For further studies, it is recommended to divide the groups according to the aerobic conditioning level, as this could help the search for other interpretations on the performance of highly and poorly conditioned individuals in the TME performance. The measurement could be performed other variables associated to the fatigue, once this is a complex process involving several variables.

The use of the Light Automatic Rifle would be another interesting suggestion, once the AR does not simulate the characteristic recession or noise of the LAR, and it is believed that both variables may interfere in the soldier's performance. Also, it could be adopted other shooting positioning, searching for an analysis of the shooter's arch of movement. One suggestion for this analysis would be a laser gun sight. At last, it is believed that it would be interesting to analyze the HR for each shot performed by the shooter, in order to attain a more detailed analysis for this variable.

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