Aerobic fitness and its influence in the mental stress response in army personnel

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ABSTRACT

Stress promotes human adaptation to different situations in high levels or, if kept for long periods, may produce consequences for the body, leading to several health conditions. Exercise practice as well as high cardiorespiratory fitness seems to protect the body against these undesired stress effects. The aim of this work was to verify the effect of aerobic physical fitness in the psycho physiological response to laboratory stressors in Brazilian Army Personnel. Four hundred and thirty-eight military individuals performed the 12-minute Cooper test in order to evaluate their cardiorespiratory fitness. After that, 28 subjects were selected among the ones who completed more than 3,200 m (estimated $\dot{V}O_{2max}$ of 63.01 ± 2.73 $ml.kg^{-1}.min^{-1}$) and less than 2,400 m (estimated $\dot{V}O_{2max}$ of 38.7 ± 1.68 $ml.kg^{-1}.min^{-1}$). These chosen subjects were divided in two groups called respectively superior fitness group (SUPG) and inferior fitness group (INFG). After an initial measurement in resting position, two consecutive laboratory stressors were applied in the subjects: cold-stressor and mathematical stressor, while their skin conductibility level (SCL) was measured. Previously to the stressors' beginning, the groups did not present differences from each other and concerning their application, the SUPG presented lower values of SCL than the INFG during the cold stressor (9.29 ± 0.06 µS and 9.40 ± 0.04 µS; p = 0.009, respectively) and during the mathematical stressor (9.29 ± 0.07 µS; p = 0.012, respectively). The results suggest that individuals with better cardiorespiratory fitness tend to present reduced patterns in anatomic response to stress, as shown by the behavior of the levels of conductibility on the skin.

Keywords: Exercise. Military personnel. Cardiorespiratory fitness. Stressor.

INTRODUCTION

Stress has been defined as a state of imbalance or threaten to homeostasis[1] whose original concept was proposed by Hans Selye in 1936[2] Nowadays, it has a remarkable position among the causes for known diseases. They go from cardiovascular[3-4] to psychological problems[5], including in this aspect, alterations in the immune system, which may trigger several other complications[6-7].

Many investigations which aim to measure the mental stress levels of an individual, do it in different ways, among them: cortisol level, which can be either blood[8] or salivary[9]; the measurement of some cardiovascular parameters[10], more noticeably heart rate and blood pressure, and besides these, the measurement of the skin conductance level[11], turn out of the increase of sudoresis promoted by the sweating glands in reaction to a 'fight or escape'[12].

Some research has pointed to a cardiorespiratory condition provided by aerobic physical exercise or recreational physical activity or even weight work as an efficient reducer of the stress levels[13-16]. Concomitantly, some professional categories are more prone to recurrent exposure to stress, such as nurses[17], firefighters[18] and military personnel[19]. In the latter case, it is worth mentioning the lack of work of this nature published with Brazilian Army personnel who, in the past years, have frequently participated in Peace Corps aiding the United Nations.

Therefore, the aim of this work was to verify the effect of aerobic physical fitness in response to stress in laboratory stressors in the Brazilian Army Personnel.

METHODOLOGY

All subjects involved in the research were previously submitted to medical examinations and signed the free and clarified consent form for participation in the study. All determinations from the National Health Committee (Law # 196/96) fulfilled the concerns about research in humans. The work has been approved by the Ethics Committee of the responsible institution.

An initial sample of 438 personnel from the Brazilian Army performed the 12-minute Cooper test[20] in order to predict the oxygen maximal intake. The test was performed in a flat track, marked at every 50 meters, having as result the last mark surpassed before the end of the time. The Cooper test was chosen due to its high correlation with maximal aerobic power (r = 0.897), as well as extensive experience from the part of the Brazilian personnel with it. Moreover, since the 12-minute test is used as one of the criteria for personnel promotion in the Army, maximal effort was guaranteed during its performance.

Considering the results obtained in this test and reaching the maximal level of the difference of fitness among the subjects, the personnel who completed more than 3200 m were initially included in the studied sample for the high level fitness group (HLFG) and the ones who completed less than 2400 m for the low level fitness group (LLFG). After that, 14 subjects were randomly chosen from each group to compose this research. The calculation for the maximal aerobic power prediction was performed through the equation proposed by Cooper[20], where the HLFG presented oxygen intake of 63.01 ± 2.73 $ml.kg^{-1}.min^{-1}$ and LLFG of 38.7 ± 1.68 $ml.kg^{-1}.min^{-1}$ (values expressed as mean ± standard deviation).

Four days after the Cooper test performance as well as the groups' division, the subjects were submitted to the experimental procedure in order to verify the stress levels during the laboratory stressors. The subjects would enter the evaluation room, which was quiet and refrigerated (21-24°C) and comfortably sit at a table.

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Ag/AgCl electrodes(Embramac®) were placed on the medium phalanges of the pointing and index fingers of the non-dominant hand and these were connected to a Biofeedback equipment (Bioeedback Systems, PE-020 model, Boulder, Colorado – USA), connected to a computer which measured the skin conductance level (SCL) of the individuals. The values measured were registered at every 0.1 second, in micro Siemens (µS). Two researchers in charge of the work stayed in the evaluation room with the research subject.

After being connected to the instrument and having received the explanation about the procedure's details, the study's volunteers had their conductance levels measured at one minute-rest, and during the application of two distinct laboratory stressors, one after the other. The first of them, named c*old stressor*[21], was applied during 1 minute and consisted of immersion of the left foot in an iced water solution, which was at a temperature between 2 and 4°C. This temperature was monitored before each subject was submitted to the experiment and, in case this solution presented temperature above the one mentioned before, it would have more ice added, in order to have all individuals submitted to the same treatment of the stressor agent.

The mathematical stressor[21] was applied immediately after the *cold stressor*. It consisted of the subtraction of the number '7' (seven) of a number of three figures, during a minute, with the responses being given out loud. The participants of the research were told that their answers should be correct as well as be given as fast as possible. Moreover, in three different occasions, the following phrases were told by the researcher who was applying the test: "go faster"; "you are slow"; "come on, hurry up"; these phrases were uttered respectively at 15, 35 and 50 seconds after the beginning of the test.

These stressors were chosen over others since they allow that necessary measurements could be performed with no interferences in the variable measured. Besides that, the situations previously described are not usual for most of the people, which could not cause any kind of adaptation to the agent[21]. It is still worth highlighting that the sequence choice, with no rest between the stressors, was performed in order to promote a maximization of the autonomous response, as performed in other studies[11-12]. In addition to that, for ethical reasons, the time of exposure to stress was not too extended, with a total of only two minutes.

Statistical treatment

Except for the $\dot{V}O_{2max}$, in order to characterize the sample, the differences between groups were calculated through *t*-tests for independent, bi-tailled samples. The t-test for independent, unitailled samples was used for the comparison of the $\dot{V}O_{2max}$ between HLFG and LLFG.

A 2x3 ANOVA with repeated measures was used in order to analyze the effects of the stressor agents as well as the aerobic fitness over the response to stress, being the level of physical fitness one factor and the situations of evaluation another.

The significance level adopted in all analyses was of $\alpha \leq 0.05$, being used for the calculations the *Statistica 6.0* program (StatSoft, Inc. Tulsa, OK – USA).

RESULTS

As can be observed in table 1, the groups presented identical profiles concerning age, weight, height and resting SCL variables ($p > 0.05$), being different only concerning the estimated maximal oxygen intake, with HLFG presenting a value significantly higher than LLFG ($p < 0.05$).

The analysis of the SCL behavior (figure 1) regarding the used stressors showed that regardless of the level of aerobic fitness of the groups, the *cold stressor* and mathematical stressor tests promoted a significant increase of this variable when compared with the initial resting levels ($F(2.52) = 349.9$; $p < 0.001$).

TABLE 1
Characteristics of the subjects (Mean ± SD)

Variables	HLFG	LLFG	*t* (26)	*p*-Value
Age (years)	29.6 ± 1.2	29.4 ± 1.0	–0.34	0.74
Weight (kg)	75.5 ± 2.6	81.5 ± 3.3	–1.42	0.16
Height (cm)	176.7 ± 0.02	178.4 ± 0.05	–0.76	0.45
$\dot{V}O_{2máx}$ (ml.kg^{-1}.min^{-1})[a]	63.0 ± 2.7	38.7 ± 1.7	28.52	0.000
SCL in rest (µS)[b]	8.85 ± 0.10	8.91 ± 0.12	–1.31	0.14

[a] Estimated by the Cooper protocol[20];
[b] Skin Conductance Level in rest.

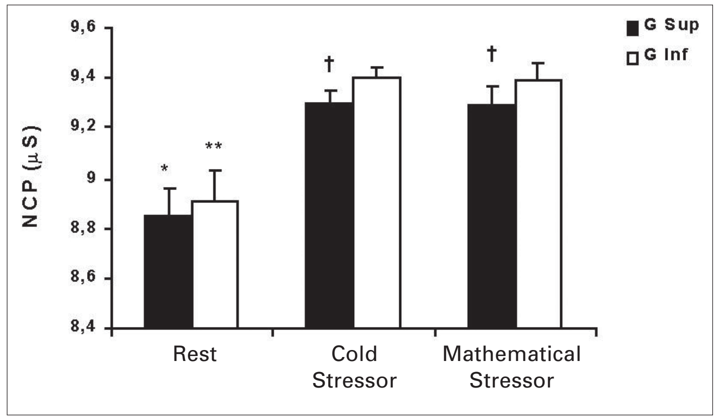

Figure 1 – *Mean (± SD) of the SCL values of the HLFG and LLFG groups in rest and during the stressors application. The SCL of the HLFG (* p < 0.001) and LLFG (** p < 0.001) were lower in rest than in the stressors. There was difference between the groups in the stressors application.(† p < 0.05).*

ANOVA also revealed a significant effect of the aerobic fitness over the SCL responses of the groups in each stressor applied, with the HLFG presenting values significantly lower than the LLFG ($F(1.26) = 16.4$; $p < 0.001$). The values presented by the groups in the different evaluation situations can be found in table 2.

TABLE 2
SCL results (Mean ± SD) obtained by the groups in the evaluations

	Rest (µS)	Cold Stressor (µS)	Mathematical Stressor (µS)
HLFG	8.85 ± 0.10	9.29 ± 0.06*	9.29 ± 0.07**
LLFG	8.91 ± 0.12	9.40 ± 0.04*	9.39 ± 0.07**

* p = 0.009
** p = 0.012

DISCUSSION

Generally, the obtained results have suggested that better aerobic fitness may mediate a reduction in the autonomous reactivity of the subjects during stress situations, when it is measured through the skin conductance levels.

Although the tasks chosen to verify the responses of the subjects to stress have significantly increased the SCL data in the two studied groups, a difference between the responses of the HLFG and the LLFG could be observed when they were submitted to both stressors. Such difference tends to reflect the diverse patterns of aerobic fitness between groups, highlighting the positive effect of a better cardiorespiratory aptitude in the stress response. In this context, one should consider one of the study's limitations, namely the estimation of the maximal oxygen intake through the Cooper protocol[20]; although, as mentioned before, both have a high correlation.

Another limitation, maybe the main of the study, is concerned with the outlining applied. Although the research's subjects have been randomly selected from the group of individuals who ran more than 3200 m and less than 2800 m in order to make the groups, which theoretically would eliminate any sample deviation, and the SCL of the groups in rest have been measured (no significant difference between them has been observed), this sample could for some reason favor one of the groups, once the reaction to stress of the HLFG and the LLFG under the stressors applied was unknown, if both presented identical aerobic fitness.

It is known that stress promotes deep physiological alterations in the human body, especially through the hormonal alteration triggered from it[22]. Although this hormonal imbalance is essential to promote the body's adaptation to a new situation, such condition should not constitute a long-term situation, since there is a possibility of more intense and serious damage to the body[2,23].

Although the stress action over the cardiac profile of an individual apparently is the most relevant factor and which calls the most attention, other effects should be mentioned. For instance, the results caused in the immune system[6], in the cognitive performance[24] as well as in the psychological disorders, especially in the cases of posttraumatic stress[5].

Concerning the interaction between stress and cardiovascular system, it seems clear that the attenuation of stress effects is benefic in order to guarantee better health. Moreover, the relationship between stress and some cardiocirculatory variables, especially blood pressure, has not been benefic[25], especially in work and social environments[26]. Within this context, aerobic fitness could be a protection and an aid of cardiovascular health of individuals.

In the present study, the results found corroborate the ones found in other experimental work[13,27-30]. In that research, different methods of stress evaluation were used: questionnaires, hemodynamic responses (heart rate and blood pressure); skin conductance levels; and hormonal variables, especially cortisol, adrenaline and noradrenaline. In all variables analyzed the trained individuals or the ones with the best performances in the cardiopulmonary tests presented attenuated responses during the stressors applied, in comparison with the non-trained ones, or with the ones with the lowest fitness levels.

Nevertheless, other authors did not find the same results. In studies conducted by Geus *et al.*[31-32], for instance, differences between the well and badly-conditioned subjects were not stated in the hemodynamic responses to stress. Perhaps, because in them, the discrepancies in the oxygen intake between the evaluated groups have not been high enough in order to produce the same results of this work. In the research by Geus *et al.*[31-32], the differences of $\dot{V}O_{2max}$ between the badly and well-conditioned subjects were of 10.0 and 5.2 $ml.Kg^{-1}.min^{-1}$, respectively, while in the present study, it was higher than 24 $ml.Kg^{-1}.min^{-1}$. This hypothesis of difference of reactivity based on different levels of maximal oxygen intake also finds support in a research developed by Steptoe *et al.*[29], in which groups which presented low breadth of variation of $\dot{V}O_{2max}$ did not demonstrate significant difference in the majority of the variables measured for stress evaluation. They became evident as the discrepancies in aerobic fitness were higher.

Within this context, the choice not to measure other parameters indicators of stress, such as measurement of cardiovascular and hormonal variables, could be pointed as a limitation to our work. It is worth mentioning that although the evaluation of the skin conductance levels is a widely used and validated variable in papers already published in international journals[11-12], it has been receiving little attention in Brazil, with few papers with reference of the use of such instrument, which is non-invasive and of easy application. In one of the studies mentioned above, Jacobs *et al.*[12] showed that the activation of the sympathetic response to stress performed in the sweating glands, which would eventually be the responsible for the increase of conductance on the skin, was more stable under the action of different stressors than the cardiovascular variables already mentioned before. Besides the exposed data, it is believed that the use of other parameters, more notably heart rate and blood pressure, could suffer the influence of the stressors applied in the study, especially the *cold stressor*, according to what Steptoe *et al.*[21] report and that, despite providing a broader and more detailed physiological response, could also provoke the distortion of some result.

A possible physiological explanation for the lower stress levels found by the Army personnel with better conditioning may be the lower activation from these subjects of the sweating glands, which suffer a concentrated sympathetic action, mainly on the feet soles and palms of the hands[33]. Another explanation would be possibly due to the fact that individuals with higher maximal oxygen intake have sharper vagal tonus[16], which is a characteristic of more trained and better fit individuals[34].

Moreover, the LLFG despite presenting a $\dot{V}O_{2max}$ lower than the HLFG, did not have bad cardiorespiratory fitness, which is typical from sedentary individuals, being the mean value of its members classified in the percentile 40 of its age group, according to the ACSM[35]. This fact denotes that high aerobic fitness may effectively provide an attenuation of the stress levels.

Further investigation should be conducted in order to evaluate for instance whether better-conditioned individuals, from the aerobic point of view, when under stress, will present lower aggression to the cardiovascular system, through the measurement of cardiovascular variables, better immune responses, better cognitive performance and better protection against the posttraumatic syndrome. Moreover, the role of physical activity and fitness in these interactions should be better defined as well as from what moment on this fitness optimally acts. Finally, the physiological mechanisms presented here are probably the responsible ones for the found results.

CONCLUSION

In this study, we can conclude for the sample and conditions used that better aerobic fitness minimized the effects caused by the laboratory stressors applied and that were measured through the skin conductance levels.

This study shows that the obtained outcomes found support in the literature, despite the disagreement with some investigations previously mentioned here. Therefore, further investigations on this issue should be conducted, since in our modern society the disturbs caused by stress are ever increasing. In addition to that, since the sample consists of Army personnel who occasionally may be submitted to stressing situations, the need for a physical training which guarantees good cardiorespiratory fitness as a protective agent against deletereal effects derived from these possible situations.

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