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Examination of the circulation and physiology of military personnel under extreme physical exercise

Author's review of the PhD dissertation

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1.PROPOSITION OF THE SCIENTIFIC PROBLEM

Soldiers are put through exceptional physical and psychological stress because of the new military concept, while partaking in NATO international tasks and in peacekeeping activity under the egis of the UNO. Working under extremes of climate (hot, dry climate around the tropic of cancer) the metabolic, water, electrolyte and acid-base balance in the body of personnel, thus ability to concentrate decreases and the incidence of cardiovascular events increases. The sum of these pathophysiological changes endangers not only the success of the military exercise, but also the health, or in severe cases the life of the soldier.

The increase and health hazards of global warming is under more scrutiny since the 1990s.This can be explained by the increase of morbidity and mortality due to heat stress. The adaptive capacity of the human body cannot adapt as fast as the climate changes occur. More and more heat injury (heat stroke, heat shock, sun damage, death due to higher temperatures) occurs due to the repeated and more intense heat waves and increasing global warming.

The military is also affected by the global warming. Not just the higher temperatures effect increased stress for the soldier, but also the combination of the following: military procedures in (warring and non-warring) cities, ("city heat island"),the humanitarian and support activity saving a great number of escapees due to the increasingly more common and more severe natural disasters, and the increased danger of the strange infectious diseases.

The constant level of the core temperature is necessary for the optimal fuctioning of the human body, which is only possible if the heat consumption equals the heat production and heat uptake. This mechanism is called heat regulation. The thermoreceptors located in the hypothalamus follow the change in core temperature, and start counter-regulation mechanisms. The body insures the even level of the core temperature by heat radiation, conduction, convection and evaporation. If this is combined with the high temperature and low humidity, then heat loss can only be accomplished by evaporation. With the activation of the sweat glands, the electrolytes get to the surface of the body together with water. The large amount of sweating in the absence of liquid and ion replacement causes severe water and electrolyte imbalance that can first lead to heat stress, low blood pressure, syncope, painful muscle cramps, heat exhaustion and in the most severe cases, heat stroke. The occurence of these conditions depends on the age, sex, physical endurance and fitness, moreover the accompanying illnesses and taken medications of the subjects.

2. GOALS OF THE INVESTIGATION

The international participation of the contract and professional soldiers makes it necessary to widen the range of the military fitness testing. During detailed and careful testing such circulatory and physiological functional disturbances can be found that are prognostic of unexpected caridovascular events that can endanger the successful completion of military exercises and task-performance.

The increased expectations, challenges and growing performance standards prompt us to work out safe standards of scientific exercise program and fitness level evaluation for soldiers. The role of military medicine is in the thorough knowledge of the adaptive mechanisms, metabolic changes, muscle work, the adaptation mechanisms of the circulatory and pulmonary systems, thus helping in preparation of the soldiers for the completion of exercises and for successful role assumption.

The goal of the investigation is to measure metabolic and hormonal changes during spiroergometry of fit soldiers under moderate and hot-dry climactic conditions.

We have searched for answers to the following questions:

1. What kind of changes occur in the cardiorespiratory system and hormone levels of the soldiers as a result of acute physical stress?
2. What kind of changes occur in the cardiorespiratory system and hormone levels in response to a two-week structured exercise program?
3. Is there a connection between the change in the hormone levels and cardiorespiratory parameters in response to extreme physical stress?
4. How do the hormone levels and cardiorespiratory parameters change in response to extreme physical stress?

3. MODES OF INVESTIGATION

The acclimation of the cardiorespiratory system to the physical and psychological stress under extremes of climate depends largely on the state of the circulatory and respiratory system, muscle mass, the capacity of the transport system and genetic aspects that determine the ability of the person to adapt. The metabolic and hormonal response given to exercise (depending on the type, intensity and time) depends on the fitness and above metabolic parameters of the subject.

Spiroergometry is able to determine the functional capacity of the soldier and recording the metabolic and physiologic changes in response to exercise.

We surmise that the metabolic and hormonal changes during exercise have prognostic value to determine the fitness and ability to acclimate of the soldier.

We have examined 30 healthy and fit soldiers. After laboratory studies we have done a physical examination and echocardiography. Then we have performed spiroergometry on treadmill. During the exercise we have had continuous recording of EKG, breathing and gas exchange parameters. The exercise was preceded by the traditional spirometry, during which we calculated the maximal voluntary minute ventilation (MVV). The measurement of O2 and CO2 in each breath during exercise was done by gas sample analysis.

The soldiers exercised under two climactic conditions: 22C and 75% relative humidity, which is the equivalent of moderate climate, and 33C and 52% relative humidity, which is the equivalent of the hot and dry climate of the Middle Eastern countries. The exercises under the two conditions were separated by 2 weeks. In the 60 minutes preceding the exercise the subjects were kept NPO (nothing by mouth). We have continued the exercise until the subject reached the 80-100% of calculated maximal heart rate or exhaustion.

During the exercise, the following parameters were measured and compared: minute ventilation, oxygen consumption, respiratory quotient, anaerobic step, heart rate and blood pressure.

The lactate determination was done at the end of the exercise. Serum testosterone and cortisol levels were determined before and after the spiroergometry.

After collection and evaluation of data we have statistically processed them, analyzing the physiological responses under moderate and hot-dry conditions.

4. THE DESCRIPTION OF THE CHAPTERS

In the first chapter I describe the basic vocabulary, the physiological result of exercise, and the changes in the metabolism of the body in response to extreme conditions. I introduce the aerobic and anaerobic energy providing systems, describe the metabolism of carbohydrates, fats and proteins during exercise. I summarize the neuroendocrine regulation of exercise and intermittent training, and describe the principle of spiroergometry.

In the second chapter I explain the effect of the global warming on people, the economic and security political effects of climactic change. I describe in detail the mechanism of heat

regulation of the human body, the hormonal regulation of heat regulation, and the regulation of sustaining the core temperature. I introduce the change in metabolism and fluid balance in response to exercise in heat.

In the third chapter I describe the essence of acclimation, its mechanism, and the cellular consequences of exercise. I show the changes that are found in the skin, heart and circulatory system, respiration and volume state, in response to acclimation.

In the fourth chapter I summarize the factors that affect the physical ability, describe the metabolic changes during maximal and submaximal exercise. I define heat tolerance, the pathophysiology of heat stress, the types and cures of heat damage. I deal with the possibilities of raising exercise tolerance, and describe the biomedical parameters responsible for heat tolerance.

5. SUMMARY OF FINDINGS

The studies that were done to understand exercise physiology, the metabolic changes in the body due to extreme physical and psychological conditions, have been a great help in tailoring training programs. The pathological processes that are due to exercise done under unhospitable conditions are less likely to develop in those subjects that do regular aerobic exercise. During exercise biochemical regulatory mechanisms are put into play that organize those metabolic conditions that improve the capacity of the body.

Interval training causes morphological changes as part of adaptation. During this process the resting heart rate decreases, cardiac muscle hypertrophies, resting vagal tone increases, breath rate decreases, and skeletal muscle hypertrophies.

The hypothalamus-hypophysis-adrenal axis is activated in response to physical activity, this plays an important role in the regulation of the water and electrolyte balance, besides the catabolic and anabolic processes.

Endurance, performance diagnostics, and, among the medical diagnostics, spiroergometry is the most sensitive and specific diagnostic procedure. This is one of the best methods to determine aerobic capacity, the work of the cardiorespiratory system, metabolic rate and component respiratory gases.

Soldiers are exposed to greater heat stress in the past couple of years due to global warming and an active role in international activity. This causes an imbalance of metabolic activity, the fluid-electrolyte, acid-base balance, decreases the ability to concentrate and the rate of

cardiovascular events increases. The sum of these pathophysiological changes endangers to only the success of military goals, but the health, and in serious cases, the life of the soldier. The occurence of these pathological conditions decreases with adequate acclimation and fitness.

During adequate acclimation the secretion capacity of different hormones changes in the body, that guide the different anabolic and catabolic processes. These are basic in the optimal ergotropic switch. Monitoring these hormones is a sensitive marker of the fitness of the soldiers, which is baseline to successfully finish military procedures.

6. NEW SCIENTIFIC RESULTS

Our results, despite its deficiencies, shows that even after a 2 week structured exercise program we get data that predict the fitness and adaptability of the soldiers.

We can only satisfy the increasing expectations of the modern army by scientifically proven exercise programs and training. The goal of military medicine is to help this.

I have made four new scientific statements in my study:

1. The serum testosterone and cortisol levels significantly increase in fit soldiers, that did spiroergometric exercise until exhaustion.
2. A two-week structured exercise program causes enough adaptation in otherwise fit soldiers to successfully finish tasks under extreme conditions.
3. Exercise under extreme conditions does not change the ratio of anabolic/catabolic processes in fully adapted, fit soldiers.
4. The decrease of the ratio of testosterone/cortisol during extreme stress mirrors the increase in the catabolic processes, and that shows in turn the ineffective adaptation of the soldier.

7. THE PRACTICAL USE OF THE SCIENTIFIC RESULTS

The goal of my study is to find reasonable indicators to evaluate the fitness and adaptability of soldiers, and the metabolic and hormonal changes due to extreme physical exercise. The detailed and exact knowledge of these processes helps to develop practically usable diagnostic procedures.

Our results help bettering training and exercise programs developed for the soldiers, thus

improving the efficacy of military and peacekeeping activity.
Knowing this information we can choose those soldiers safer that can do their job safely under extreme physical conditions.
The spiroergometry, the pre- and post-exercise serum testosterone and cortisol levels safely predicts the response of the soldiers to exercise, their physical fitness and prognosticates the level of adaptation.

8. GUIDELINES

1. I suggest that soldiers on special military duty should undergo spiroergometry combined with pre- and post-exercise serum testosterone and cortisol levels, and calculating the testosterone/cortisol ratio.
2. Afer a minimum of 2 week structured exercise training I suggest a repeat spiroergometry combined with pre- and post-exercise serum testosterone and cortisol levels, and calculating the testosterone/cortisol ratio.

I would like to share the results of my scientific study with those military decision makers whose goal is to choose the fittest soldiers from the Hungarian Army to finish tasks in especially extreme physical conditions.

9. LIST OF PUBLICATIONS

1. Consequences and solutions to extreme physical and psychological stresses among disaster relief military personnel. AARMS Vol. 6, 2007/1, 3-8
2. The aerobic capacity and fitness of Hungarian soldiers. AARMS Vol. 6, 2007/4, 687-697
3. Stress tolerance of military personnel during exercise in hot, dry climates- the physiology. AARMS Vol. 7, 2008/1, 35-45
4. Stress tolerance of military personnel during exercise in hot, dry climates- the prevention and treatment. AARMS Vol. 7, 2008/2, 301-307
5. A rendszeresen sportoló katonák aerob kapacitása. Kard és toll. 2006/2, 173-180
6. Katonák aerob kapacitásának és állóképességének a vizsgálata. Honvédorvos, LVIII, 2006/3-4, 171-182

7. Az endotel diszfunkció: az atheroszklerózis prediktora. PPT presentation, Balatonfüred, 2005.03.17.
8. Pitvarfibrilláció kezelése. PPT presentation, Veszprém, 2005.05.19.
9. Dyslipidaemia és a vasculáris remodelling. PPT presentation, Várpalota, 2005.10.18
10. Fizikai aktivitás szerepe az egészség megőrzésében. PPT presentation, Balatonfüred, 2005.11.04.
11. Az anaerob szint változása rendszeres tréning hatására. PPT presentation, Székesfehérvár 2006.11.21
12. A metabolikus szindróma mint a koszorúsérbetegség kockázati tényezője. PPT presentation, Balatonfüred, 2006.03.23
13. Lipid célértékek változásai metabolikus szindromában. PPT presentation, Veszprém. 2006.04.26
14. A rendszeresen sportoló katonák aerob kapacitása. PPT presentation, Budapest. 2006.06.14
15. A hőártalom sürgősségi ellátása operatív feladatokat végrehajtó katonánknál. PPT presentation, Budapest. 2007.10.16.

10. CURRICULUME VITAE

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Education

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1978 – 1984	State University of Uzsgorod, Faculty of Medicine

Place of work

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Skills and medical qualities

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Hobbies

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Budapest, 2008-08-25 ……

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