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Estimation of changes of lower limbs reactivity among mountain cyclist under the influence of sauna treatment - abstract

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Abstract

Background: Elaborated system of neuromuscular connections gives to a human ability of body control, possibility to move and perform any complicated moves. The issue of neuromuscular conduction appears more frequently in physiotherapy, biological restoration or, widely perceived, sport training. Physiotherapists often wonder how sauna treatment, mainly used in biological restoration, influence on changes of its conduction and, on which level of a rehabilitation, training process or biological restoration should it be used. The aim of this paper was to check how an organism would react after methodically conducted sauna treatments in a form of whole body biological restoration.

Material/Methods: Competitors of cycling group GR AIRCO Team participated in research. Twelve men were classified and divided onto two age groups. On the basis of questionnaires personal details as well as basic antropometric parameters were collected. Tool used to measure reactivity was chosen to research method: Reactivity Measure MCZR/ATB 1.0.

Results: Analysis of variance of following measurements did not show any statistically crucial differences between the group under the age of 30 and over 30 ($p>0,05$). Results are shown respectively for right leg, left leg, both lower limbs tested simultaneously with the division onto age groups. Analysis of variance show increase of reactivity for all tested participants after sauna.

Conclusions: Sauna treatment among cyclist has impact on a rate of lower limbs reactivity tested simultaneously with impulse differentiation to an appropriate legs.

Keywords: steam bath, nervous system, muscles, neuromuscular condition, mountain cycling

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INTRODUCTION

Sauna is a physiotherapeutic treatment used in therapeutics, cosmetology and hygienic aims and most of all in a biological restoration for fast restitution after huge physical efforts. Sauna implementation is widely used in traumatic streaming as well as in morbidity units, as a supplementary treatment (Mills and Parker-Bennett, 2004; Fair, 2011).

Undressed person, using sauna, undergoes an influence of hot air with low humidity and, during brakes, of low temperatures (mostly cold water or chill air). In sauna, beside above mentioned changes of temperature and air humidity, variable intensity of magnetic field and lowered partial oxygen pressure occurs. Researches showed that during sauna treatment body temperature increase what results in metabolism rate acceleration. An increase of an oxygen consumption within bounds of 20% was noticed (Mills and Parker-Bennett, 2004; Crinnion, 2011).

Because of water lost by an organism and the same reduction of muscle flow slight metabolical acidosis can occur (lower blood pH, bicarbonate decrease, increase of partial pressure of CO2 in an artery blood) (Czarnowski and Górski, 1991; Kauppinen and Vuori, 1986). Additionally metabolical acidosis, which can be observed directly after treatment decrease rate of generation of maximal strength as well as muscle resistance, it reacts in diminishing of potassium concentration in muscle cells what leads to transient muscle strength reduction (Czarnowski and Górski, 1991; Pawłowski et al., 2015).

Sauna bath has positive impact on water-mineral balance. Similarly as during physical effort soda, potassium and chloride ions are emitted by sweat. It comes to declination of magnesium and calcium ions where scientists detect slowing down of synaptic conduction and the same reduction of nerves impulse noticed with an organism hyperthermia [Crinnion, 2011, Czarnowski and Górski, 1991]. During first few minutes in sauna breath slowdown is observed, then it comes to gradual breath shallowing and its acceleration to 24-36 breaths per minute. Lungs vital capacity increase as well as one-minute breath capacity, maximum expiratory flow, forced expiratory volume in 1 second. Increased ventilation leads to diminishing of CO2 blood partial pressure and growing of O2 partial pressure. All changes mentioned above are not considerable (to 10%) and recede quite fast after leaving sauna. When sauna treatment is repeated systematically these changes have positive impact on a gas exchange at tissue level. It influences on increase of endurance and muscle strength level (Czarnowski and Górski, 1991; Pawłowski et al., 2015; McArdle et al., 2004).

Under the impact of hot sauna bath haemoglobin level in erythrocytes increases, number of erythrocytes and a number granulocytic system hemocytes grows but the number of lymphocytes and oesinophils is reduced. Growth of haemoglobin level increases the level of oxygen in a blood circulation system – a phenomenon particularly acceptable in intensive efforts because it moves a boundary line of oxygen reaction what has an impact on higher body capability in an effort, and further regeneration is accelerated (Prystupa et al., 2009; Kauppinen and Vuori, 1986).

Sauna influences by an initial short-lived stimulating impulse on a sympathetic system after which comes strong sympathetic activation, what intensifies assimilating processes and accelerates rejuvenation after an effort. Systematic sauna baths lead to “parasympathicotonic body attitude” and in a result it contributes to growth of strength and muscle spasm rate and reduces time of parasympathicotonic overtraining occurrence. In case when strong impulse work overcome adaptation abilities of an autonomic nervous system then it comes to longer dysfunctions of this regulation. Increase of temperature in sauna over 100 C as well as prolongation of sauna bath over 12 minutes has negative impact on a work of neuromuscular system (Hannuksela and Ellahhma, 2011; Tomiyama et al., 2015).

Researches proved that after sauna bath a variety of endocrinological changes takes place, particularly among nonadopted people. Body reaction on hypothermia is activation of sympatho-adrenergic system and subthalamic and pituitary and adrenal axis 9Gieremek and Nowotny, 1989). In a result emission of catecholamine and cortisol increases and it involves further changes connected with its functioning, which are still not recognised till the end. Sauna bath reacts in 2-3 multicity of adrenaline concentration growth, what gives general nervous system stimulation (Kukkonen-Harjula and Kauppinen, 2006; Rhoades and Bell, 2009).

In hypothalamus rise content of a hormone realising corticotrophin what reacts in synthesis and adrenotropic hormone emission (ACTH). This occurrence is associated with intensified beta-endorphin emission which shows central anaesthetic reactions and, probably are responsible for wellbeing after sauna treatment (Jezova et al., 1985). Endorphins influence also on emotional stability what has direct influence on whole body regulation. Higher cortisol emission improves effort capacity and it is treated as a responsive measurement of thermal stress and heat toleration (Kukkonen-Harjula et al., 1989).

After sauna baths level of growth hormone among adult competitors grows (as an effect of higher central adrenergic stimulation what reacts in higher emission of growth hormone realising factor). Thanks to this phenomenon while trainings it comes to natural increase in muscle tissue as well as its mass and strength. Under the influence of body temperature

gamma motoneurons activity and activation of fibres of skeletal muscles are weaker. It results in lower motoneurons alfa activity causing weaker muscle tension skeletal muscle fibres relaxation. As a result of high temperature in sauna elasticity and stretchiness of a fibrous of an articular capsule and joint ligaments increase as well as hyperaemia but synovial viscosity decrease (Kauppinen and Vuori, 1986; Kukkonen-Harjula et al., 1989; Kukkonen-Harjula and and Kauppinen, 1988; Jezova et al., 1985).

In a literature dealing with sauna issue we cannot find any researches which unambiguously show prescription on its use in a rehabilitation process or training periodization in respect of real benefits and losts connected with changes occurred in an organism.

Authors of works, to which it was possible to reach while examining the issue of sauna influence on a human body, mainly pay attention to beneficial effect of its influence, however very often do not use specifically conducted researches particularly in regard to motor system and its reactivity, what determines psycho-motoric efficiency. There arise a question, what happens with an organism under the influence of sauna? Whether is it possible to answer this question on the basis of programmed researches process orientated on reactivity: Does a thermal bath influence on changes in a neuromuscular conduction and occurrence of motionally programmed muscle cramp?

In order to answer the questions researches were conducted on a group of sportsmen to observe how an organism reacts after methodically prepared sauna treatments, in a form of whole body biological restoration.

MATERIAL AND METHODS

Tool used to measure reactivity was chosen to research method: Reactivity Measure MCZR/ATB 1.0. The apparatus is equipped with a program compliant with a PC class computer thanks to which registration of tests results directly to database and recording of particular tests results is possible.

Participants

Competitors of mountain cycling group GR AIRCO Team participated in researches. 12 men were classified and divided onto two groups (7 people under the age of 30 and 5 people over the age of 30). All participants being tested were informed about the aim of conducted researches and agreed on participation, marking that they can resign in any moment without giving a reason.

Measures

On the basis of questionnaires personal details as well as basic antropometric parameters were collected what allowed to count BMI. Moreover questionnaires gave information what is the average number of training hours per week and other forms of physical activity.

Procedures

Series of researches was programmed for 5 weeks period. By the period of first 4 weeks entrances to sauna were conducted with the appliance of full methodology of sauna baths. During the research project realization 5 measures of reactivity on luminous and sound impulses were programmed; following before the first sauna entrance and after it, next after 4^{th} and 8^{th} bath. The last research took place 7 days after last treatment series in sauna. The authors have followed the principles outlined in the Declaration of Helsinki.

Statistical Analysis

All obtained results were collected in a database and subjected to statistical analysis in Statistica 10.0. Statistical analysis was performed using U-Mann Withney Test. A one-way analysis of variance for repeated measurements was performed. For significant main effect the post hoc Tukey` test was performed. Following parameters were considered: age, height, BMI, training period, number of training hours per week and body mass

.

RESULTS

The characteristics of examined population is presented in table 1. After statistical analysis (U-Mann Withney Test), the homogeneity of age groups (below and under 30 years) was proved as for BMI, weight, height and number of trainings per week. In the younger group below 30 average age was 24 years and in the older group average age was 43 years.

Analysis of variance of difference between subsequent measurements without division onto groups did not show any crucial statistical changes in case of an average reactivity for right and left leg. Whereas analysis of variance for repeated reactivity measurements for both lower limbs showed that statistically there is crucial improvement of reactivity ($p = 0.036$). Analysis of variance of following measurements did not show any statistically crucial differences between the groups under the age of 30 and over 30 years.

Averaged results of reactivity are observed in the younger group show trend to increase of reactivity onto luminous impulses for a right leg. Analysis of variance does not estimate about the statistical significant of this change. Comparing average time of reactivity between the first and the last measurement growth up to 0.04 sec. and was noted among participants under the age of 30. Moreover the biggest difference in this group regarding to initial measurement was obtained after 4^{th} attempt (the last sauna bath) 0.0443 sec. Response time right leg on the luminous impulses in the older group do not show significant changes in this parameter (the largest increase after the first treatment 0.028 sec.).

Averaged results of reactivity in the left leg shown the similar trend like in the right leg. Comparing the average time rate of reaction between the first and last measurement in the left leg, it increased by 0.024 sec. The time obtained in this measurement was the best average response time in the research process for the left leg in the group under 30 years

Table 1. Characteristics of the examined population

Variable	Size	Average	Min	Max	Standard deviation
Age	12	31.92	21.0	60.0	11.77
Weight [kg]	12	75.42	62.0	94.0	10.97
Height [cm]	12	177.25	165.0	189.0	7.17
BMI	12	23.95	20.5	27.8	2.68
number of training hours per week	12	11.25	3.0	20.0	3.61
Training period [years]	12	4.75	2.0	10.0	2.96

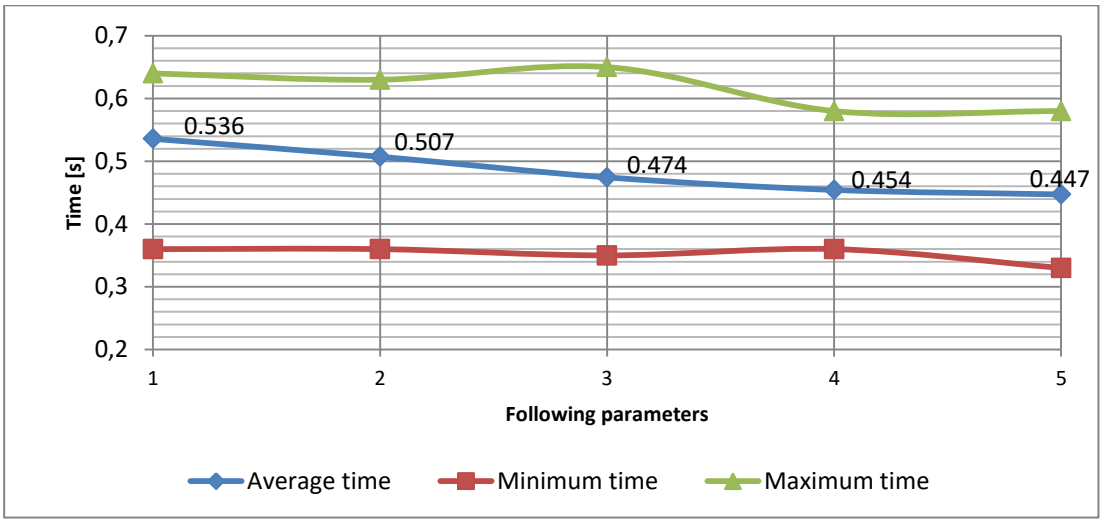

Figure 1. Averaged times of reactivity of right and left leg for group up to the age 30.

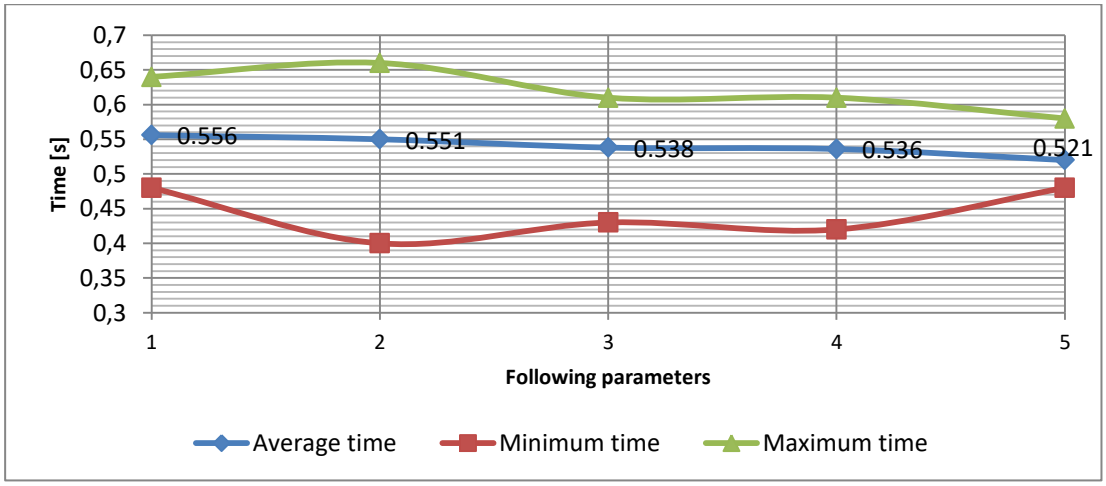

Figure 2. Averaged times of reactivity of right and left leg for group over the age 30.

Figures 1 and 2 present measuring results of right and left leg tested simultaneously. Analysis of variance show increase of reactivity with significant level p=0.035 for all tested participants. On the basis of Tukey`s Post-Hoc Test important changes between following parameters in groups were not stated.

In a younger group evident increase of tested parameter can be observed; difference between the first and the last measurement is 0.089 sec. and this is the highest average increase of reactivity obtained in measurements. However among participants over the age of 30 obtained difference of an improvement of reactivity is 0.036 sec. In both groups after first sauna treatment the reaction rate decreased.

DISCUSSION

Many authors, directly or indirectly, observed sauna influence on reactivity. Gieremek (1989) in his paper, in which he tested the influence of finish bath on nervous system reactivity, came to the conclusion that finish bath treatments diminish the reactivity.

The results of sauna influence on lower limbs reactivity on luminous impulses can suggest that there is no negative impact on this occurrence. This positive aspect is visible in a direct way in conducted researches from 15 to 60 minutes after the first sauna treatment. It is what attracts higher attention and is more noticeable among competitors in the younger group (<30). Further tests show that in the younger group, practically in case of all average times of reactivity on a given impulse, improvement of reactivity is visible.

It is also worth to analyse carefully the sauna influence on reactivity reviewing sport discipline of competitors who participated in researches. Surely a kind of tackled activity as well as its surrounding has meaning in better understanding of thermoregulation issues, homeothermal environment of a human or an organism adaptation to higher external and internal temperature.

Road or mountain cycling is a long-lasting physical effort which is characterized by higher body temperature even over 38 Celsius degrees and in extreme conditions it comes to 40 Celsius degrees. This knowledge allows to take a look on the researches result in a different way (Friel, 2010). Relevant decrease of reactivity is not noticeable in the first sauna treatment what can be expected and what is mentioned in majority of publications on this topic. This fact is surely connected with wide body tolerance on core body temperature changes and its possibility of effective work even with huge water-electrolyte changes and an occurrence of metabolic acidosis.

All competitors, who participated in tests, had monitored pulse and systolic as well as diastolic pressure after each entrance from sauna and after finished sauna bath. Changes of these parameters among majority of participants were definitely lower than it could be expected and rapidly came to norm. It proves that kind of cyclist`s activity adopts an organism to thermal body changes even in extreme conditions. This theory is confirmed in Chorąży and Kwaśny (2005) publication, who also attract the attention to the fact that higher training level is characterized by lower amplitude of pulse and blood pressure changes what indicated better body tolerance on thermal environment changes.

Between an organism and its surrounding heat is transferred in both directions by vaporization, radiation, convection and conduction. To keep constant body temperature in which all necessary biochemical transformations can proceed, efficient work of thermoregulation centres is necessary. They are distributed superficially (skin) and deeply (CNS). Main effectors of thermoregulation are: circulation system and perspiratory glands. The lasts react mainly on impulses coming from central thermo receptors but skin thermo receptors do not play any important role in this case. This is so called physical thermoregulation and discussed in this paper dry sauna treatment influence mainly on this thermoregulation and its efficiency gives possibility to perform physical effort in an extreme environment (McArdle et al., 2004; Prystupa et al., 2009; Hannuksela and Ellahham, 2011; Brouns, 1991; Costanzo, 2006).

Aspects called above in large measure explain changes in research group, particularly lack of decrease in reactivity after the first treatment. Training and body adaptation to interorganic changes caused by body overheating gave maintaining and even an improvement of reactivity after the first treatment. People who practice mountain cycling or other similar, according to performed activity, sport disciplines similar owe this positive result also body tolerance on displacement of the acid-base balance in direction of the acid reaction (Czarnowski and Górski, 1991). This crucial ability enables to maintain high physical efficiency particularly in long lasting activities. Sauna imitates this kind of effort reviewing changes in an organism. Summarizing people who have trained ability to work under the conditions of metabolic acidosis can also have undeterred reactivity and even its noticeable improvement, what is observed in case of obtained results.

All called examples having an influence on control of nerves conduction and, the same on reactivity, find reference in results interpretation and probably this is why do not find any confirmation in publication in which the author says that under the higher body temperature activity of gamma motoneurons and skeletal muscles fibres activation decline. In consequence activity of alfa motoneurons is decreased what results in weaker muscle tension and skeletal muscle relaxation (Prystupa et al., 2009; Podstawski et al., 2015; Mero et al., 2015; Sawatari et al., 2015).

Striking is the fact than an increase of reactivity up to 0,09 sec was obtained in case of the younger group. It is possible that the measuring device to test lower limbs reactivity influences on this fact because

of its construction which needed to work out appropriate movement technique, what could have an impact on occurrence of measuring error and lower research reliability. However, what was visible in the last test series, in some measurements it came to worsening of reactivity. It is why it can be deducted that the size of this error did not influence importantly on an average time of reaction but only on a minimum time, what is not analysed directly in the measurement course.

In publication on the process of chosen psychomotor tests and associated changes under the influence of sauna authors widely tackle its impact on emotional changes of hyperthermal environment on psychomotor test. Particularly this kind of test all research process of this paper was planned and, surely, impact of emotions also played an important role in reactivity changes (Gieremek and Kwaśny, 1994).

On the result of emotional activation influence sauna and its thermally extreme character. Undoubtedly hormonal changes, and in case of sauna there is a wide range of them, attest to changes in psyche. It is shown i.a.: in changes of blood hormone concentration even as adrenaline, noradrenalin and increase of adrenocortycotropic hormone secretion, cortisol, angiotensin II, so the hormones playing an important role in a mechanism of creation of vegetative psychomotor component. On the basis of changes of these hormones secretion Gieremek, in his publication, proves that sauna positively influences an organism as a kind of emotional training because, as he supposes, it influences adaptable mechanism activation. According to the author these factors improve psychomotor efficiency (Rhoades and Bell, 2009; Sawatari et al., 2015; Gieremek and Kwaśny, 1994).

Obtaining improvement of psychomotor efficiency and paying attention on nervous control rate of any movements in other researches confirm conclusions arising from measurements of lower limbs reactivity. Noticeable improvement, as shown, can be widely explained what is still do not comprehensive enough in this issue and requires further researches.

Worth attention is also the fact that obtained improvement of answers on given impulse is maintained also after the end of the sauna treatments cycle. It proves that an organism as a result of used methodology has adopted changes in movement initiation rates. It is possible that this change is not constant. Obtained in some results the fact of lower rate of reaction, after one week break from the last test, gives an evidence on that. Unfortunately this changes are not sure because demented level of relevance was not achieved, only certain trend was observed what needs a control among larger research group.

It cannot be said for 100% that existed changes are positive and that sauna in the appropriate mean to obtain a progress in rehabilitation, biological renovation or sport training. For sure it can be said that methodologically conduced treatments are recommended not only reviewing neuromotor control but for whole organism (Fair, 2011). Positive physiological aspects are mainly associated with regular sauna treatments. Influence on thermoregulation, circulation, respiratory system, metabolism, nervous system and movement organ presents sauna as a treatment which regulates whole organism, what definitely has a reflection in tests results over the rate of reaction (Hedley et al., 2002; Smolander and Louhevaara, 1992; Kanji et al., 2015; Stanley et al., 2015; Tomiyama et al., 2015).

We cannot forget that this parameter consists of great number of factors starting from an impulse interpretation and suitable activation of upper motor neuron finishing on suitably coordinated muscle control. Influence on this complicated mechanism, which can be easily disturbed with the use of not controlled or to intensive impulses, in case of well suited sauna treatment is beneficial. This fact illustrates its influence on reactivity.

CONCLUSION

1. Sauna among cyclist has impact on a rate of lower limbs reactivity tested simultaneously with impulse differentiation to an appropriate lower limb.
2. It has no statistically significant influence on increase of lower limbs reactivity rates among cyclist tested separately, however trend which gives an evidence on sauna influence on this parameter is visible.
3. Age has no influence on lower limbs reactivity rate after sauna treatment. In the group up to the age of 30 this treatment explicitly improves this parameter what cannot be clearly stated in the older group.
4. Change of reactivity rate is maintained after the end of sauna treatment cycle, however it slow decline is noticeable.

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