SECTION – FUNDAMENTAL AND APPLIED KINESIOLOGY

DOI:

EFFECT OF WINTER SWIMMING AND TAKING IN A SAUNA ON THE BIOCHEMICAL PROPERTIES OF THE BLOOD IN "WALRUSES"

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Authors' contribution:

A. Study design/planning
B. Data collection/entry
C. Data analysis/statistics
D. Data interpretation
E. Preparation of manuscript
F. Literature analysis/search
G. Funds collection

Keywords: winter swimming, biochemical indicators, FT3, FT4, TSH, IgG, IgA, IgM, cortisol

Abstract

Study aim: The aim of the study was to examine the effect of winter swimming and taking a sauna on selected biochemical indicators of the blood.

Study material: The participating „Walruses" belonged to the Krakow Walrus club – "The Heaters". The study group consisted of 20 males, aged 30–45, 'walrusing' throughout the whole season from November to March. In order to examine the biochemical indicators of the blood, venous blood samples were drawn from the participants and the following were determined: immunoglobulin levels (IgG, IgA, IgM), the contents of thyroid hormones (FT3, FT4, TSH), and cortisol. On the test day, in November and March, one group of the studies "Walruses" (n = 10) took only cold baths bath for 5 minutes, and the second group of participating "Walruses" (n = 10), on the day of the study, went into a sauna for 10 minutes and took a cold bath for 5 minutes.

Study results: At the beginning of the winter swimming season in November, a statistically significant increase in cortisol concentration was found in a group that took the sauna as well as cold baths compared to the group that only took cold baths. A significant increase in IgM concentration at the end of the season in March was also noted for this group. No statistically significant changes in the level of TSH, FT3, FT4 or cortisol were noticed.

Conclusions: This study is the first combining the effects of winter swimming and taking a sauna on the level of immunoglobulin (IgG, IgA, IgM), thyroid hormones (FT3, FT4, TSH) and cortisol.

Introduction

Exposure to cold as well as high temperatures cause severe reactions of the organism. Under the influence of cold baths, activity of the sympathetic-adrenal system, adrenal secretion of norepinephrine, epinephrine and cortisol [1, 2] are stimulated. The released catecholamines activate the respiratory and cardiovascular centres in the medulla [3]. As a consequence of the activation of the sympathetic nervous system is-adrenergic receptor stimulation and strong vasoconstriction of the skin, which prevents the transfer of heat from the inside the body to the skin, and its further loss [4]. During cooling of the body, an increase in the secretion of the thyrotropin (TSH) and thyroid hormones can be observed. This results in an increase in metabolism non shivering thermogenesis and heat production [5, 6].

Taking a sauna effects the adrenergic system, endocrine glands, especially the adrenal glands stimulated both by the hypothalamic-pituitary, cerebral-adrenal and the renin-angiotensin-aldosterone system. Under the influence of being in the sauna, activation of the sympathetic nervous system also occurs. An increase in the production of the adrenocorticotropic hormone (ACTH) and cortisol levels along with their metabolites in blood or urine takes place. Another hormone, in which increased secretion is induced by thermal stress, is the growth hormone [7]. Passive heating of the body stimulates the secretion of this hormone to a greater degree than does a temperature increase of the body caused by physical activity [8]. Prolactin and β-endorphin levels also increase as a result of being in the sauna [9].

Sutkowy et al. (2015) confirmed that single exposure to extremely high and low temperatures is likely to cause the formation of reactive oxygen forms in healthy people, which interferes with antioxidant protection. Their research included 25 young males, who were divided into 2 groups. One used a sauna, the second was exposed to the cold (cryogenic chamber) [10]. After analyzing the results, they suggested that both long-term use of the sauna and the impact of cold on the body (cryogenic chamber) allows for gradual adaptation and toughening of the body. However, in "Walruses", regularly swimming in winter, increased immunity of the organism was found [11, 12, 13].

The aim of the study was to answer the question of impact the sauna and winter swimming has on biochemical indicators of the blood in "Walruses".

Study material and methods

Characteristics of the study group

"Walruses" are individuals who swim in the winter when the water temperature ranges from 1°C to 4°C. The participants belonged to the Krakow Walrus club – "The Heaters". In order to study changes in biochemical properties of the blood, venous blood samples were collected and tested twice for the study participants. The study took place at the Bagry lagoon, at the beginning at the beginning of the season on 18th November 2013 and at the end of the season on 30th March, 2013. The group consisted of 20 men, aged 30–45, 'walrusing' throughout the season from November to March. On the day of the test, in November and March, one research group (n = 10) took only cold baths and the second group of participants (n = 10) took a sauna as well as a cold bath.

Weather conditions on 18th November, 2013 (beginning of 'walrusing' season):
– water temperature 7˚C
– air temperature 4˚C
– humidity 55%
– wind speed 9 km/h

Weather conditions on 30th March, 2014 roku (end of 'walrusing' season):
– water temperature 7.5˚C
– air temperature 4˚C
– humidity 75%
– wind speed 5 km/h

On the day of the study (at the beginning and end of season), the time of a single cold bath in the first only 'walrusing' group was 5 min, however, for the second 'walrusing' and sauna taking group, the sauna stay lasted 10 min before immersion. Getting from the building with the sauna to the lagoon took about 3 minutes. Blood samples were drawn from the participants in the amount of 3 ml from the vein inside the elbow, on an empty stomach in the morning, after leaving the water. The samples were put into tubes with clot accelerator to obtain serum. Blood was drawn by a qualified nurse, under medical supervision. The study was approved by the Bioethics Committee at the Regional Medical Chamber in Krakow.

Study of biochemical properties

After the blood samples were drawn, they were transported to the M. Skłodowska-Curie Centre of Oncology in Krakow. There, the following parameters were marked: immunoglobulin content (IgG, IgA, IgM), the level of thyroid hormones (FT3, FT4, TSH) and cortisol.

Determining immunoglobulin concentration (IgG, IgA, IgM)

Marking IgG, IgA, IgM immunoglobulin concentrations was performed using the Siemens BN ProSpec apparatus. The assay required N antisera, i.e. liquid animal sera produced by immunizing rabbits with human immunoglobulin having a high degree of purity. Each of the N antisera was put into separate 2 ml vials. Next, the device automatically prepared serial dilution of the N reference protein and determination was performed. The results were based on the method assumption, by which the proteins present in the serum sample reacted with specific antibodies to form immune complexes. These complexes caused the beam of light rays passing through the sample to split, wherein the intensity of the scattered light was proportional to the concentration of the corresponding protein in the sample. For the marking, the immunosorbent ELISA test was used, which is derived from the RIA radioimmunoassay test.

FT3 thyroid hormone (free triiodothyronine) concentration assay

The test was performed using the Roche Diagnostics e411 cobas analyzer. The assay was carried out using the competitive method in the blood serum. The results were read from the calibration curve based on the two-point calibration.

Cortisol concentration assay

The test was performed using the Roche Diagnostics e411 cobas analyzer. The total time of serum assay was 18 minutes. The results were read from the calibration curve based on two-point calibration. For the assay, the immunosorbent ELISA test was used, which is derived from the RIA radioimmunoassay test.

Statistical analysis

Data are presented as mean values and standard deviation. Normality of distribution was verified using the Shapiro-Wilk test. Variables with normal distribution were compared using the Student's t-test for dependent samples, in the case that the given assumptions were not met using the t-test, the Wilcoxon test was used.

Differences between groups were analyzed using the t-test for unpaired variables. In the case that the given assumptions were not met using the t-test, the Mann-Whitney U test was performed. In analyzes, the assumed level of significance was $\alpha = 0.05$. Analyses were performed using the Statistica 10 packagge (StatSoft®, USA).

Results

1. Analysis of results in group 1 – only winter swimming.

Considering changes in IgA [g/L], IgG [g/L], IgM [g/L], TSH [mU/L], FT3 [pmol/L], FT4 [pmol/L] and cortisol [nmol/L] concentrations at the beginning and end of the season, no statistically significant differences were noted (Tab. 1).

2. Analysis of results in group 2 – sauna and winter swimming.

Considering changes in IgA [g/L], IgG [g/L], IgM [g/L], TSH [mU/L], FT3 [pmol/L], FT4 [pmol/L] and cortisol [nmol/L] concentrations at the beginning and end of the season, no statistically significant differences were noted (Tab. 2).

3. Comparison of groups 1 and 2 at the beginning and end of the winter swimming season (group 1 – only winter swimming and group 2 sauna and winter swimming).

Comparing groups 1 and 2, no statistically significant changes in IgA [g/L], IgG [g/L], IgM [g/L], TSH [mU/L], FT3 [pmol/L] and FT4 [pmol/L] concentrations were found at the beginning or end of the winter swimming season (Tab. 3, Tab. 4). The only statistically significant increases observed were in cortisol concentration [nmol/L] at the beginning of the season in November (Tab. 3, Fig. 1), and IgM concentration [g/L] at the end of the season in March (Tab. 4, Fig. 2) for the sauna and winter swimming group.

Table 1. Mean values ± standard deviation of indicators assayed in group 1 performing winter swimming

Parameter	n	Initial measurement (November) $\bar{x} \pm SD$	Final measurement (March) $\bar{x} \pm SD$	p
IgG [g/L]	5	13.26 ± 2.09	14.30 ± 2.77	0.1152
IgA [g/L]	5	2.92 ± 0.66	2.98 ± 0.90	0.7948
IgM [g/L]	5	0.80 ± 0.57	0.62 ± 0.28	0.3134
TSH [mU/L]	5	2.41 ± 1.58	2.69 ± 1.45	0.4343
FT3 [pmol/L]	5	5.39 ± 0.67	5.11 ± 0.27	0.3089
FT4[pmol/L]	5	17.07 ± 3.40	15.11 ± 1.72	0.1430
cortisol [nmol/L]	5	432.72 ± 166.56	469.58 ± 199.68	0.7660

Table 2. Mean values ± standard deviation of indicators assayed in group 2 using a sauna and performing winter swimming

Parameter	n	Initial measurement (November) $\bar{x} \pm SD$	Final measurement (March) $\bar{x} \pm SD$	p
IgG [g/L]	6	11.93 ± 1.81	12.13 ± 1.34	0.5673
IgA [g/L]	6	2.85 ± 0.92	2.90 ± 0.92	0.7558
IgM [g/L]	6	1.27 ± 0.51	1.25 ± 0.43	0.9178
TSH [mU/L]	6	2.70 ± 1.39	2.45 ± 1.32	0.5000
FT3 [pmol/L]	6	5.54 ± 0.64	5.25 ± 0.59	0.3454
FT4[pmol/L]	6	18.00 ± 1.56	16.78 ± 1.22	0.2262
cortisol [nmol/L]	6	651.13 ± 146.67	536.68 ± 176.94	0.2980

Table 3. Comparison of initial measurements (November) in the only winter swimming group with the sauna + winter swimming group

Parameter	Only winter swimming $\bar{x} \pm SD$	Sauna + winter swimming $\bar{x} \pm SD$	p
IgG [g/L]	13.26 ± 2.09	11.93 ± 1.81	0.2882
IgA [g/L]	2.92 ± 0.66	2.85 ± 0.92	0.8898
IgM [g/L]	0.80 ± 0.57	1.27 ± 0.51	0.1864
TSH [mU/L]	2.41 ± 1.58	2.70 ± 1.39	0.7518
FT3 [pmol/L]	5.39 ± 0.67	5.54 ± 0.64	0.7188
FT4[pmol/L]	17.07 ± 3.40	18.00 ± 1.56	0.5652
cortisol [nmol/L]	432.72 ± 166.56	651.13 ± 146.67	**0.0459**

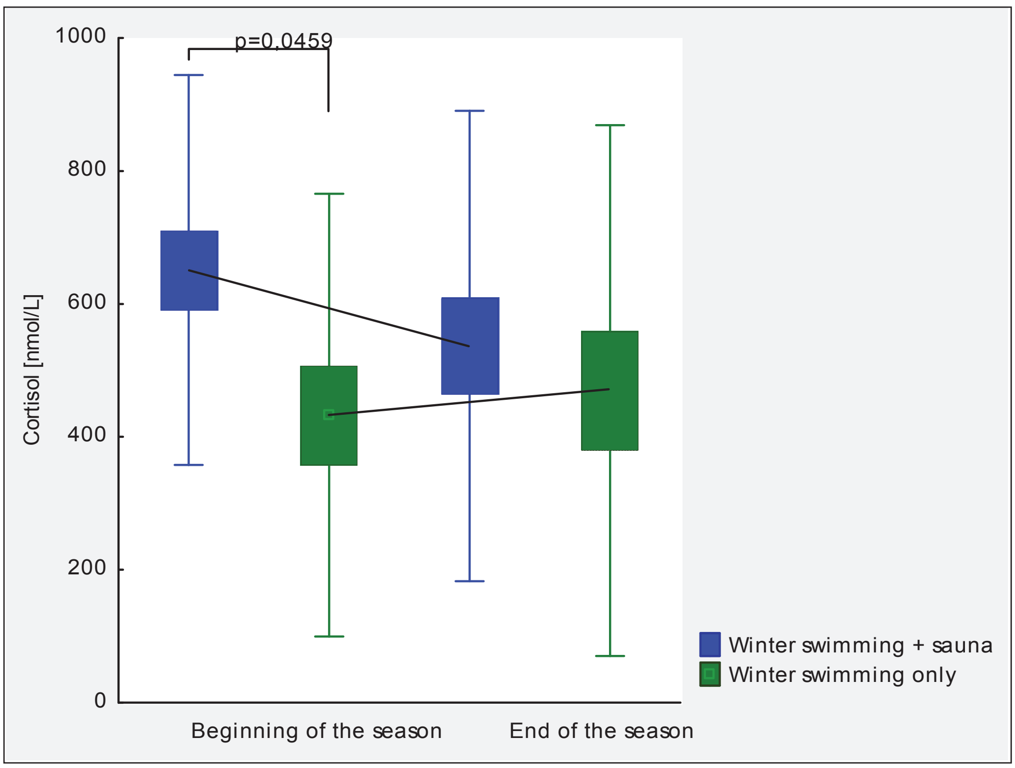

Figure 1. Changes of the average cortisol concentrations [mmol/L] between the beginning and the end of the season in the 'winter swimming + sauna group' and 'winter swimming only' group

Table 4. Comparison of initial measurements (March) in the only winter swimming group with the sauna + winter swimming group

Parameter	Only winter swimming $\bar{x} \pm SD$	Sauna + winter swimming $\bar{x} \pm SD$	p
IgG [g/L]	14.30 ± 2.77	12.13 ± 1.34	0.1209
IgA [g/L]	2.98 ± 0.90	2.90 ± 0.92	0.8877
IgM [g/L]	0.62 ± 0.28	1.25 ± 0.43	**0.0207**
TSH [mU/L]	2.69 ± 1.45	2.45 ± 1.32	0.7771
FT3 [pmol/L]	5.11 ± 0.27	5.25 ± 0.59	0.6538
FT4[pmol/L]	15.11 ± 1.72	16.78 ± 1.22	0.0936
cortisol [nmol/L]	469.58 ± 199.68	536.68 ± 176.94	0.5688

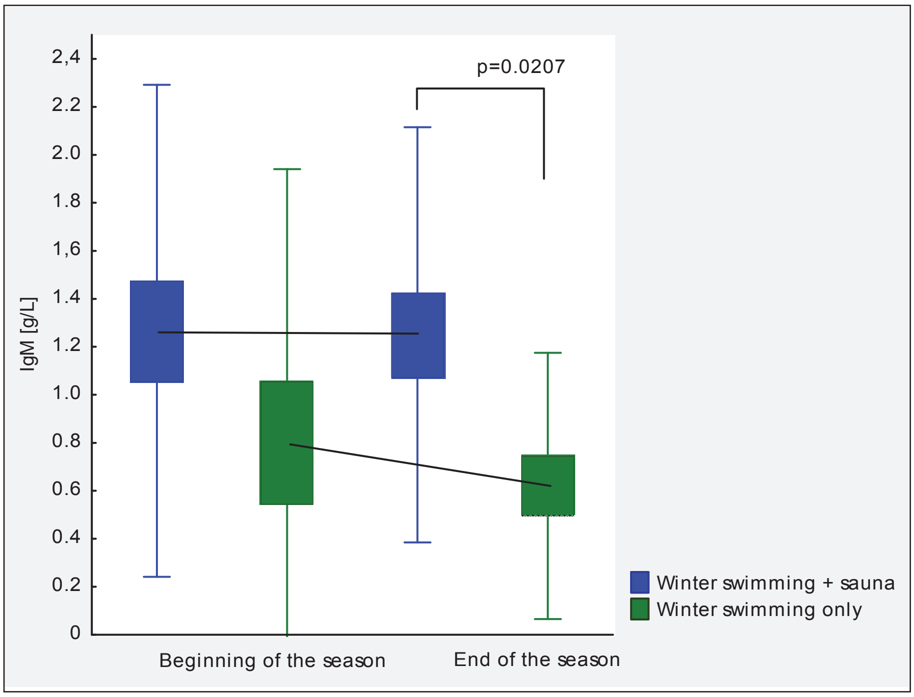

Figure 2. Changes of the average IgM concentrations [g/L] between the beginning and the end of the season in the 'winter swimming + sauna group' and 'winter swimming only' group

Discussion

The tests within the framework of this study were performed in order to answer the question - what is the impact of taking a sauna and winter swimming on the biochemical indicators of the blood in "Walruses"? Although there are reports on the impact of being in a sauna or winter swimming on the human body, there are no studies which simultaneously combine exposure to low and high temperatures in "Walruses".

In conditions of severe heat loss, an increase occurs in the secretion of hormones stimulating metabolism. Hermanussen et al. (1995) conducted a study in a group of 11 healthy students. The participants went for winter swims at least once a week for 2 to 10 minutes for 2.5 months. After analyzing the results of TSH in both groups (both untraining and training in the cold), the levels increased by about 48%, and the level of cortisol by approximately 34% [14]. In a review paper, Teległów et al. (2008) described how cortisol secreted by the adrenal cortex modulates many physiological responses in reaction to cold. It elevates resting energy consumption, inhibits vasodilatation, increases the availability of free fatty acids and affects the operation of the sympathetic nervous system. Cortisol secretion is regulated by the adrenocorticotropic hormone (ACTH). The increase in cortisol levels during exercise in cold water seems to depend on changes in the internal temperature of the body [4]. As reported by Plich et al. (2013), Vescovi (2000) and Ježová et al. (1994) changes in cortisol concentration levels under the influence of being in a sauna are similar [15, 16, 17]. Plich et al. (2013) conducted an experiment to investigate the effects of taking a sauna on cortisol concentration in 9 runners and 9 men not related to sports. Both groups participated in 15-minute sessions in a sauna with a 2 minute break for a cold shower at a temperature of 19–20°C. After analyzing the results, a statistically significant increase in cortisol concentration levels were noted in both groups, but higher in untrained men [15]. Ježov et al. (1994) performed studies in 8 men and 8 women, who spent 20 minutes in a sauna at a temperature of 80°C. The study showed a biphasic response of cortisol concentration in the plasma. Its level decreased during the initial phase (15 minutes), however, it later increased, the highest value recorded 15 minutes after leaving the sauna. Hyperthermia caused stronger activation of the neuroendocrine system in women compared to men [16]. Kauppinen et al. (1989) carried out a study in which 9 men participated. They took a sauna and were subjected to low temperatures (immersion in freezing water and showers at 15°C). An increase in cortisol levels was observed. The authors suggested that the tendency to secrete ACTH, cortisol and an increase in activity of the sympathetic nervous system caused by a stay in the sauna and cold baths, can cause elevation of the pain threshold and develop tolerance to cold [17]. Debt and Leppanem (2000) conducted a study which involved 11 women, aged 25–52 and 9 men, aged 19–64. The experiment took place in Finland. The volunteers spent 15 minutes in a sauna heated to 95°C, with a humidity of 30-50%, and then walked to the lake (about a minute), which was located 50 m away. The air temperature was between –5°C to –15°C. The subjects swam in the freezing water for about half a minute. After getting out of the lake, they returned to the building with the sauna. The study was conducted four times during late winter. After testing, a significant increase in the cortisol level was noted, i.e. 61% [18]. Also, an increase in the concentration of interleukin-6 (IL-6) was observed, which is indicative of adaptation of the immune system [18].

In our study, only at the beginning of the season in November did we observe a statistically significant increase in cortisol in the sauna and winter swimming group compared with the only winter swimming group. This demonstrates that the combination of high and low temperatures was a stronger stimulus at the beginning of the winter swimming season compared with the impact of only the low temperature of the water.

Maintaining the thyroid at a resting, constant level depends on the cooperation of the TSH and TRH thyroid hormone feedback loops. Adaptation to changing environmental conditions, mediated by TRH, is expressed by an increase in thyroid hormone secretion due to cold [19, 20, 21, 22] and a reduction in their synthesis when exposed to heat [23, 24]. *Štrbák* et al. (1987) performed a study to investigate the impact of taking a sauna on thyroid function parameters. The participating males, aged 20–25, spent 30 minutes in the sauna. There was an increase in TSH level in the plasma [25]. Leppäluoto et al. (1986) conducted a study which involved 10 healthy men and 7 women. They used the sauna at a temperature of 80°C. The session lasted for one hour, twice a day for seven days. The level of cortisol, TSH and thyroid hormones was assayed only for men. There were no significant changes in the concentration of the thyroid hormone serum or TSH, however, cortisol levels decreased [26]. Plich et al. (2007) conducted a study involving 10 healthy female students, aged 19–21. The volunteers spent 40 minutes in the sauna, with a 5 minute break for a 2 minute cold shower at the temperature of 20–22°C, and a 3 minute rest in a lying position. The average temperature in the sauna, measured 1.5 m above the floor level, was 80°C and the humidity equalled 5–27%. Blood tests were performed on first and fourteenth day of the experiment. A statistically significant decrease in cortisol concentration was noted, while the concentration of the thyroid hormones (FT3, FT4, TSH) did not change [8].

In this study, there was no statistically significant changes in the levels of TSH, FT3 or FT4, which confirm the results of the study conducted by Pilch et al. (2007) [8].

The reduced incidence of various diseases in people toughened by exposure to cold water is connected to higher levels of IgA in the plasma [12, 27]. Banafi et al. (2009) studied the effects of systemic cold (cryogenic chamber), inter alia, the immunological parameters of athletes (IgM, IgG, IgA). The obtained results showed no change compared with the baseline measurements [28]. Based on the results of our research, similarly, no statistically significant changes in the levels of IgG and IgA immunoglobulin were found. Only at the beginning of the season in March, a statistically significant increase in IgM concentration in the sauna and winter swimming group could be found. IgM is a gamma-globulin produced by plasma cells constituting 5% of the immunoglobulin fraction. Due to the reason that an increase in IgM levels can be observed in inflammation states, the combination of cold and heat factors may have resulted in a strong reaction in "Walruses" after the whole season.

Although studies have already been conducted regarding the impact of cold and taking a sauna on biochemical indicators, so far, this study is the first combining the effects of 'walrusing' and a sauna on the levels of immunoglobulin (IgG, IgA, IgM), thyroid hormones (FT3, FT4, TSH) and cortisol.

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Word count: 4.022
Tables: 4
Figures: 2
References: 28

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