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Winter swimming – is it possible to develop adaptation to cold temperature? A literature review

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Abstract

Introduction and purpose

Over the years winter swimming has gained popularity, becoming an eagerly practiced form of physical activity. This review aims to examine its influence on the human organism and explore the mechanisms of adaptation developed by winter swimmers.

Materials and methods

This work is based on the analysis of the materials obtained from "PubMed" and "Google Scholar" scientific databases using the key words selected based on their relevance to examining the matter in subject, such as: cold adaptation, cold water immersion, ice swimming, hypothermia, winter swimming

The state of knowledge

Investigated studies indicate that winter swimming influences human organism in various aspects, having a completely different impact depending on previous cold-water exposures, health status and individual adaptation. Winter swimmers tend to develop a wide range of compensatory mechanisms including hormonal, metabolic and immunological changes, improved thermoregulation and enhanced antioxidative protection. In contrast, for unadopted individuals cold water immersions may lead to severe complications including hypothermia and even fatal consequences.

Conclusions

Winter swimmers develop mechanisms of cold adaptation that enable them to perform and benefit from such activity. However, proper adjustment, following preventive measures and guidelines such as gradual, regular adaptation, warm-up exercises and being aware of individual health status are vital to minimize detrimental effects that concern especially inexperienced individuals.

Keywords: cold adaptation; cold water immersion; ice swimming; hypothermia; winter swimming

1. Introduction

Throughout recent years, the popularity of winter swimming among society has greatly increased (1). It has reached such a level of interest that several institutions dedicated to the development of this sport activity have been established such as, for instance, The International Ice Swimming Associations (IISA) and the International Winter Swimming Association (IWSA). Both of these associations convene individuals who share an affinity to the sport, for example by promoting the discipline and organizing championships based on strict and precise guidelines in order to provide safe and clear in terms of rules environment to compete (2)(3). However, beside a wide range of cold water swimming enthusiasts who participate in competitions, there are many individuals who practice winter swimming as a hobbyist, out of curiosity as well as desire to explore their endurance and potential health benefits of this sport discipline (4). They practice it individually or in groups which associate amateurs of cold water swimming, who claim that such sport activity influences their health not only regarding physical, but also mental aspects in a positive way, brings them joy, energy and is a form of body hardening (5) (6).

The aim of this literature review is to have a thorough insight into the matter of winter swimming regarding its influence on the human organism in winter swimmers, but also in unadopted individuals. In addition, the work aims to discuss particular mechanisms of adaptation developed by winter swimmers that enable them to preserve heat and benefit from such form of physical activity. In order to investigate the aforementioned aspects, thorough analysis of various scientific studies has been undertaken.

2. The state of knowledge:

2.1 Winter swimming – definition, general information, water temperature criteria

Winter swimming, also known as cold water swimming, is a physical activity which involves immersing in either cold, or ice cold water outdoors and may be performed in various kinds of water reservoirs such as, for example, river, lake, sea, swimming pool etc. during winter season or in the colder regions (7)(2). If the water temperature is below 5 Celsius degrees and there is a necessity of breaking the ice layer in order to expose the water and swim, the activity is referred to as ice swimming (7). Cold water immersions have far-reaching traditions and have been practiced since a long time especially in the northern countries such as for example Finland, Sweden and Estonia, or in places where weather conditions are favorable (7)(8)(9). What is interesting, for swimmers participating in championships, there have been specific requirements regarding water temperature distinguished and according to the criteria described in the official rules of World Championships held by IWSA there are 4 different categories depending on water temperature that include the following: category A – ice water of -2 to 0 Celsius degrees, B- freezing water which oscillates between 0 to 5 Celsius degrees, C- cold water that involves temperatures between +5 - +10 Celsius degrees and the last - category D including water temperature of +10 to +17 Celsius degrees (3).

2.2 Various organism responses to cold water exposure

Cold water swimming is an extreme sport that may influence human health in a wide range of various aspects, however according to the study by Kolettis et al. (6) it may present a different impact depending on the previous exposure to cold temperatures as well as individual adjustment. The study has discussed the hypothesis that unaccustomed individuals may be more vulnerable to harmful effects of cold water immersion, while in contrast, regular winter swimmers may benefit from such form of physical activity as far as their health is concerned. These findings correlate with the results of studies led by Vybiral et al. (10) who have investigated the process of thermoregulation in winter swimmers and have found that thermoregulatory functions differ between winter swimmers and individuals unaccustomed to cold temperatures. Another study discussing this issue, by Manolis et al. (5) also indicate that winter swimmers who regularly practice present a range of features that enable them to adapt to cold. Such organism adaptation occurs through several different mechanisms including, for instance, improved thermogenesis and adaptation of circulatory responses among the most important ones (6).

2.3 Different types of cold adaptation

There may be several adaptive types of acclimatization distinguished, all of which aim to improve heat preservation through decreased heat loss and increased heat production (5). According to some authors they include metabolic, insulative, hypothermic and mixed - insulative-hypothermic adaptation (5)(7)(11). However, the term "habituation" characterized by cutaneous vasoconstriction and blunted shivering is also frequently distinguished and may be developed via brief periodic cold exposures (5)(12). Taking into consideration particular types of adaptation, it is worth noting that metabolic adaptation involves an improved and intensified thermogenesis that is induced by cold exposures that are intense, however, not enough to provoke a considerable decrease in core temperature (5). In contrast, insulative adaptation is associated with cold exposures resulting in a significant decrease in core temperature. It is related to a decreased body temperature following cold exposure with invariable metabolic rates and it is influenced by increased vasoconstriction as well as redistribution of the body heat to the body integument that develops via regularly repeated cold exposures with a significant drop in a core temperature (5). Another type of adaptation, hypothermic one, is characterized by an enhanced tolerance to cold – in this type, the core temperature may drop more significantly before heat production mechanisms are induced, additionally in this type, thermal conductivity is decreased due to improved vasoconstriction as well as greater decrease in skin temperature (12).

2.4 Factors affecting the process of cold adaptation

Several factors have an impact on particular types of cold adaptation responses that include, for example, duration of the acclimatization period as well as duration of each cold water immersion, frequency of training and a degree of whole-body cooling during cold water exposure (5). Manolis et al. indicate that even short-time, few immersions foster the development of habituation and that metabolic adaptation tends to dominate if it can compensate the enhanced heat loss, while if not, insulative adaptation occurs. Moreover, the contribution of either metabolic or insulative type of adaptation to cold depends on the individual alternations and varies among humans (13). It may be determined by several contributing factors such as, for example, cold stress intensity, fitness, level of cold stress intensity, diet as well as content of the body fat, indicating that, for instance, obesity favors insulative responses, while increased metabolism is more frequent in a group of slim individuals (5)(11). Interesting observations regarding cold acclimatization and homeostatic responses to cold exposure were also made by Young (14) who concluded that three basic mechanisms of cold adjustments could be distinguished. The first one - habituation characterized by blunted shivering and cutaneous vasoconstriction was determined to be the most frequent one, initiated by exposure to conditions that led to superficial cooling of the body surface. In such a pattern, decrease of temperature in the acclimatized might be greater than in unacclimatized state. If exposure to cold was severe enough to provoke a decrease in core temperature, an insulative type of adaptation was observed to prevail. The third pattern of acclimatization - metabolic one was associated with a more significant increase in shivering and no shivering thermogenesis in comparison to the unacclimatized state. The author underlined that the process of adaptation to cold could be influenced by several factors such as nature of a cold stress, duration of the adaptation time, frequency of the exposure as well as individual factors.

2.5 Adaptation mechanisms in winter swimmers

2.5.1 Hormonal changes

Regular short time cold water exposure results in a considerable decrease in the levels of cortisol and ACTH hormones which is most probably associated with development of adaptive mechanisms and indicates that pituitary-adrenal cortex axis stimulation is not greatly affected by regular cold water immersions (15)(16). In comparison, while discussing the impact of cold water immersions on norepinephrine levels, there has been observed a considerable increase of its plasma concentration after each cold water exposure even after three months of regular training sessions, and it has been concluded that such increase indicates that the hormone might be significant with regard to several issues such as for example pain relief, insulative peripherial vasoconstriction, as well as improved tolerance to cold through non-shivering thermogenesis (15)(16) (17)(18)(19). Another interesting issue is the impact of regularly repeated cold water immersions on the levels of thyroid and parathyroid hormones. Kovaničová et al. (20) examined the influence of thyroid and parathyroid hormones on both acute and adaptive response to cold and observed that in a group of ice water swimmers, after 15 minutes of swimming, there was an increase in parathyroid hormone (PTH) and thyroid- stimulating hormone (TSH) level with simultaneous decrease in free fractions of T3, T4 hormones levels. In addition, the induction of nonshivering thermogenesis through cold exposure did not regulate PTH and free fraction of T4 and moreover, it resulted in a decrease in TSH as well as free fraction of T3. Furthermore, a positive correlation between an increase of PTH and systemic phosphorus level associated with ice water swimming was observed, while in contrast, in case of the level of calcium such correlation was negative. Taking into consideration a group of unadopted men, nonshivering thermogenesis induced by cold was associated with a decrease in PTH and TSH levels. All in all, the authors concluded that during exposure to cold, regulation of thyroid hormones and PTH was different depending on the intensity of cold stimulation and/or individual adaptation level. Another hormonal change that that should be taken into consideration regards leptin – an adipose tissue hormone responsible for preserving the proper homeostasis of the adipose tissue mass. In a study by Gibas-Dorna et al. (21) it was observed that cold water immersions resulted in a decrease of basal serum leptin concentrations. This stayed in correlation with the results previously concluded by Ricci et al. (22) who conducted research in order to investigate whether cold exposure had an impact on circulating leptin in women and concluded that it led to a decrease of the leptin level which was most likely associated with the activation of sympathetic nervous system.

2.5.2 Sympathetic nervous system activation

Body exposure to cold water is associated with hypothermic stress which contributes to stimulation of norepinephrine release from the sympathetic nervous system (1)(23). Johnson et al. (24) investigated this mechanism by measuring plasma norepinephrine concentration levels before, during and after an hour of immersion in water which temperature was 10 degrees Celsius. During their investigation, the researchers observed that after 2 minutes of immersion, norepinephrine concentration largely increased and rose gradually to reach a highest peak after 45minutes of immersion. Simultaneously, there was approximately triple increase in metabolic rate noted within the immersion time.

Another interesting observation during the investigation was that after rewarming in 40 Celsius degrees water there was a temporary peak in plasma norepinephrine concentration level noted, followed by a rapid decrease to baseline parameters after 30 minutes. Furthermore, in spite of sustained core temperature decrease, a reduction in the concentration of plasma norepinephrine was observed after 8 minutes of rewarming along with a rapid depression of metabolic rate and termination of both body shivering as well as sensation of feeling cold. All of these observations have led to conclusions that the response of sympathetic nervous system to cold is dependent on the skin temperature and moreover it may be either activated or suppressed within a short period of time.

2.5.3 Immunological adaptation

The impact of cold water immersions on the immune system has been investigated by Jansky et al. (25) who have stated that if repeated regularly, such form of physical activity may result in a slight activation of the immune system. They have observed that in a group of study subjects, after six weeks of regular cold water immersions – three times a week, for one hour in 14 Celsius degrees water - there has been an increase in plasma concentration of IL6, as well as in the amount of T helper cells (CD4), total T lymphocytes (CD3), T suppressor cells (CD8) and activated B and T lymphocytes with simultaneous decrease of alpha 1-antitripsin concentration in plasma. Furthermore, during the period of six weeks of regular cold water immersions, there has been a slight yet significant increase in the plasma concentrations of several acute phase proteins such as, for example, hemopexin and haptoglobin. Additionally, an increase in the proportions of monocytes and lymphocytes with expressed IL2 receptors has been noted. Nevertheless, the authors have stated that whether those changes are biologically significant needs to be further determined. The correlation between cold water immersion and an increase in the level of IL-6 has been also observed by Pawłowska et al. (26) who have investigated the impact of a short-term cold water immersion on the inflammatory state before and after aerobic exercise. The activation of the immune system has also been discussed by Dugue et al. (27) who have concluded that habitual winter swimmers show an increase in the concentrations of plasma interleukin 6, leukocytes and monocytes in comparison to inexperienced individuals. Another interesting study by Kormanovski et al. (28) focusing on immunological response in open water swimmers during long distance swimming in temperatures oscillating between 18 - 21 Celsius degrees was based on analysis of salivary and serum antibody concentrations. Observations at the end of six months of regularly performed exercises showed a significant decrease in the average levels of serum immunoglobulin IgG, IgA, IgM as well as salivary IgA before training. Furthermore, suppression of preexcercise serum and salivary antibody levels were noted, yet those changes had no impact on the resistance to respiratory infections in a group of swimmers.

2.5.4 Improved antioxidant protection

Oxygen free radicals which may be found in neutrophilic granulocytes serve as important components of immune defense mechanisms as they are involved in the process of phagocytized pathogens destruction (6). However, their concentration needs to be maintained at a proper level by reducing enzymes, as if certain circumstances are provided, oxygen free radicals may contribute to adverse effects on human health and to the development of a range of diseases such as for example arthritis, immunodeficiencies and cardiopulmonary complications (29). A study conducted by Siems et al. (30) has indicated that when the human body is exposed to cold temperatures, oxidative stress of medium degree may be induced and if such process is repeated regularly, it may result in adaptation through preconditioning which provides an enhanced protection against oxidative stress. Such mechanism might be speculatively responsible for body hardening as well as improved organism's preparation for exposure to stress factors (5)(31)(32). According to the results of an investigation conducted by Siems et al. (30) who have analyzed potential improvement in antioxidant protection in winter swimmers, a form of protection against tissue damage initiated by free radicals has been observed, as in comparison to controls, in a group of winter swimmers exposure to cold water has resulted in an increase of basal levels of reducing enzymes such as peroxidase-dismutase, peroxidase, glutathione and catalase, and moreover in lower increase of oxidized glutathione. Another interesting observation during this study has indicated that in a group of winter swimmers the increase of 4-hydroxynonenal which is a marker of free radical production has not been associated with changes in the levels of potassium, glucose, creatine kinase, globulins, alkaline phosphatase, aspartate aminotransferase or γ-glutamyl transferase. Scientific research led to the conclusion that repeated exposure to oxidative stress may result in an organism's adaptation and therefore improved tolerance to detrimental effects such as stress and diseases (32).

2.5.5 Mental health and psychological aspects

Physical activity is proposed as an alternative way of treatment for major depressive disorder (33). Despite winter swimming being an extreme form of physical activity associated with a huge stress for the organism, it has become a very popular sport, which enthusiasts find it joyful and beneficial in a wide range of ways including mental health (5)(17). An interesting study was conducted by Shevchuk et al. (34) who proposed an intriguing hypothesis that, as over the course of evolution, exposures to physiological stressors such as, for example, changes in body temperature related to cold swims were commonly experienced by primates, lack of those certain stressors might lead to improper brain function. He stated that cold water exposure might be beneficial in terms of anti-depressive influence, due to the observations that stress associated with cold water exposure induced activation of sympathetic nervous system, increase of blood levels of beta-endorphin and noradrenaline as well as synaptic release of noradrenaline within brain. Moreover, stimulation of cold receptors located within the skin during cold water exposure could result in intense afferent input to the brain by sending a great deal of electrical impulses from peripheral nerve endings to the brain which therefore could have an anti-depressive effect.

His study indicated that cold hydrotherapy might promote resolution of depressive symptoms rather efficiently, however author emphasized that further, more meticulous and strict studies conducted on a greater group of individuals ought to be undertaken to confirm such hypothesis and explore the matter thoroughly. The issue of the impact of cold water exposure on depressive disorder was also discussed in a case report by Van Tulleken and al. (33) that concerned a woman suffering from intractable depression and anxiety since the age of 17. Postpartum, she desired to be medication-free and symptom-free. The alternative therapy protocol involved weekly cold water swimming and resulted not only in instant mood enhancement after each swim, but also in permanent and progressive decrease of depressive symptoms which ultimately led to reduction and finally termination of medication intake. What was important, the patient was still off medication after a year follow-up. Huttunen et al. (4) investigated the impact of four months regular, four times a week, winter swimming on general well-being. Medical individuals were asked to complete two questionnaires - one on the "Profile of Mood States" that involved the assessment of mood in terms of fatigue, depression, confusion, tension, vigor and hostility as well as the second one on the "Subjective Symptoms" that determined subjective factors of memory and mood factors, the quality of sleep, general vigilance and somatic symptoms. The authors observed improvement in mood and memory in winter swimmers, reduction of tension and fatigue and furthermore noted that winter swimmers felt more vigorous, lively and had more energy in comparison to controls.

2.5.6 Thermoregulation changes after cold exposure

Among the most important adaptative mechanisms in winter swimmers improved thermogenesis as well as circulatory responses adaptations should be distinguished (6). There may be two fundamental components of the thermoregulatory system distinguished including both thermosensory neurons responsible for the control of local temperature not only from the skin, but also from deeper localized structures such as for example, spinal cord and hypothalamus, as well as a control circuit within the hypothalamic preoptic area (POA) which aim is to induce thermoeffector responses in order to maintain constant temperature (35). POA consists of the central thermoregulatory center which obtains thermal information from the skin as well as from internal organs, and transmits signals that induce specific somatic, hormonal, behavioral as well as autonomic responses (5). An exposure of the organism to cold temperature initiates a wide range of various mechanisms responsible for saving the heat such as, for example, cutaneous vasoconstriction and piloerection with subsequent appearance of thermogenic mechanisms that are responsible for resisting temperature changes (5). Those thermogenic mechanisms are controlled by several endocrine regulators such as, for instance, thyroid hormones, glucocorticoids, insulin and leptin (35)(36). After exposure to cold, firstly, skeletal muscle shivering occurs, resulting in ATP hydrolysis that generates the heat, however if the exposure to cold maintains, nonshivering thermogenesis develops that involves muscles, blood vessels, adipocytes and beta-adrenergic receptors of the heart (5)(36).

What is intriguing, studies show different reactions to cold exposure depending on the habituation to cold indicating that in controls, cold water immersion leads to a rapid increase in metabolism resulting in thermogenesis with emphasis that this mechanism becomes weary and after some time (about 40minutes) reaches a plateau which leads to shivering thermogenesis, (6) comparison, in winter swimmers increase in metabolism occurs later after cold water immersion and continues even after the activity is terminated (6). According to Vybiral et al. (10) such mechanism may find its explanation in differences in thermoregulatory centers located in hypothalamus which become less sensitive to alternations in skin temperature and respond slower, yet longer to core temperature alternations. Therefore, it may be concluded that in winter swimmers, the mechanism of nonshivering thermogenesis seems to be better developed and within the first hour after cold water immersion it serves as a main mechanism in the process of thermal energy production (6)(10)(37). It needs to be underlined though, that specific mechanisms of nonshivering thermogenesis have not been completely discovered, nevertheless most probably its mechanism involves participation of beta-adrenergic stimulation of skeletal muscle or/and white adipose tissue (6)(38).

2.5.7 Thermal insulation and heat loss

Thermal insulation plays an important role while discussing the adaptative mechanisms in winter swimmers. It occurs via decreased blood flow to the skin while swimming (30)(39) as a result of an increased vasoconstriction within the skin, as well as lower heart rate and therefore cardiac output (4)(5). However, the role of adipose tissue and subcutaneous fat as an insulator for heat ought to be also discussed. A study by Hayward et al. (40) has been conducted in order to examine the role of subcutaneous fat and thermoregulatory reflexes in developing the capacity to maintain steady body core temperature. It has been indicated that it is different depending on certain areas of the body. Overall body insulation per unit surface area has been determined by mean subcutaneous fat thickness assessed by ultrasounds, irrespective of variations of this fat placement among genders. Evaluation of the heat loss after stabilization of body temperature in cold water, has indicated trunk to be the body area mostly responsible for heat loss emphasizing that subcutaneous fat has been responsible for most of the internal insulation there. In comparison, in muscular parts within the limbs subcutaneous fat has accounted for less than a third of insulation and for less than 3 % of insulation in the area of feet and hands.

2.6 Indications for winter swimmers to avoid adverse effects from cold water immersions: As cold-water swimming has become popular physical activity that is commonly practiced, it is important for winter swimmers to take into consideration several guidelines in order to prevent detrimental effects and avoid illnesses:

Table 1. Indications for winter swimmers to prevent adverse effects related to cold water immersions (5)(41):
• **Maintaining a healthy lifestyle including regular physical activity and nutritious diet**
• **Warm-up activity before cold water immersion**
• **Gradual, slow adjustment to lower water temperatures**
• **Gradual extension of swimming period from 5min to 30minutes per session (longer exposure enhances the risk of hypothermia)**
• **Regular trainings**
• **Keeping swimming during the whole time of cold-water immersion period as muscular activity contributes to heat production**
• **Avoiding hypoglycemia as it impairs shivering and enhances the risk of hypothermia**
• **Avoiding training while sleep deprived, ill, under the influence of alcohol/drugs or suffering from diabetes, neuropathies renal failure or CAD disease due to increased risk of complications such as e.g hypothermia, drowning**
• **Changing into warm, dry clothes when swimming session is complete**
• **Performing rewarming activity, seeking a warm environment indoors, or having a warm drink after training session**
• **Following up-to-date information regarding weather conditions before and during training session**
• **Adjusting training to own limits and monitoring of individual well-being**

2.7 Harmful effects of cold water swimming in non-cold-adapted individuals

Cold water swimming is an extreme sport activity that may be a source of detrimental consequences regarding health depending on the level of coldness and duration of exposure, especially when performed by inexperienced individuals (5). Among the greatest risks related to cold water exposure by unadjusted individuals neurogenically activated cold-shock respiratory responses should be mentioned, as cold water immersion provokes inspiratory gasp and subsequently hyperventilation that is unrestrained and may result in respiratory alkalosis, as well as hypocapnia (5)(42). Another health hazard associated with cold water immersions that should be discussed is hypothermia, decrease of core temperature with cardiovascular and neurophysiological implications that may result in severe complications including even fatal consequences (6)(39)(10). According to Manolis et al. (5) when unadopted individuals are exposed to cold water immersion, the risk of death is associated the most commonly with the initial neurogenic cold-shock response, hypothermia or progressive decline in swimming performance as such activity becomes more arduous in cold environment (5)(39)(43).

Tipton et al. (39) have stated that there are 400-1000 deaths connected to cold water swimming reported annually in Britain, most of which occur within the first minutes after immersion and are associated most frequently with cerebrovascular or cardiac causes secondary to malignant arrhythmias related to sympathetic activation, or to haemoconcentration and subsequent thrombus formation (6)(39). It is also important to highlight that age plays an important role in potential winter swimming implications, as according to Inoue et al. (44) who have investigated organism reactions to cold exposure in a group of nine young (20-25) individuals and ten older (60-71) ones, the older individuals are more exposed to negative consequences of lower temperatures. Moreover, individuals suffering from either evident or occult underlying cardiovascular conditions are more susceptible to detrimental effects of cold water swimming related to provocation or aggravation of arrythmias and other severe cardiovascular complications (43). For instance, patients suffering from congenital long QT syndrome or with history of such condition should not practice cold water swimming due to enhanced risk of cardiac arrhythmic event leading to a risk of drowning in consequence (5)(45). What should be highlighted is that proper adaptation process enables to minimize the risks of adverse effects such as, for example, hypothermia therefore it is of the utmost importance to follow indications facilitating the process of the adjustment (5).

Table 2: Additional indications facilitating cold water adaptation (5):
• **Medical examination preceding the activity in order to be aware of one's health status**
• **Warm up exercise before cold water immersion**
• **Choosing safe, familiar environment and practicing in company rather than alone**
• **Beginning adaptation in waters oscillating between 10-16 Celsius degrees and gradually adjusting to lower temperatures**
• **Avoiding extremely cold, windy or snowy days (obtaining up-to-date information regarding weather)**
• **Gradual, slow immersion**
• **Initiating immersion from the body rather than from head and avoiding diving straight away**
• **Withholding swimming for the first two-three minutes (cold shock period), until breathing is normalized and after that time proceeding with practicing, as swimming and body movement produces heat as well as distributes it equally)**
• **Exiting the water in case of struggling, beginning to shiver, feeling tired or not well**
• **Beginning adaptation by brief cold water immersions and gradual elongation of swimming period**
• **Following regular training program for example twice a week**
• **At the beginning plan to exercise beyond the end of summer into the fall (moderate cold) and progressively into winter months (severe cold)**
• **Post-swimming exercise in dry clothes**

- **Paing attention to post-swimming period in order to restore and maintain body warmth**

3. Conclusions:

Throughout the years, winter swimming has gained significant popularity, becoming a physical activity, that is eagerly practiced not only professionally, but also for leisure purposes. Enthusiasts of this sport assert that despite being considered extreme, it is beneficial in a wide range of various health-related aspects. Indeed, it improves tolerance to stress and diseases, serves as a form of body hardening as well as enhances the mood, memory and general well-being by inducing energy increase. However, the influence of such physical activity on health, depends to a large extent on individual adjustment to cold, previous exposures to cold water, proper adaptation process, as well as individual health status. Examined studies indicate that winter swimmers develop adaptation mechanisms in order to improve heat preservation that involve, for instance, metabolic, hormonal, immunological changes, as well as improved thermoregulation and antioxidant protection. Nevertheless, it is crucial for winter swimmers to respect and follow preventive measures and guidelines regarding cold water immersions. Among such indications warm-up exercises, regular training adjusted to individual limits, as well as avoiding immersions while sleep deprived, under the influence of drugs or alcohol, ill or not feeling well should be distinguished. Furthermore, investigated studies indicate that for unadopted individuals, winter swimming poses significant risk of severe health complications such as, for example, hypothermia, arrhythmias as well as decrease in swimming ability and effectiveness due to shivering and enhanced muscle fatigue. Such complications may result in fatal consequences, therefore it is of the utmost importance for novices to respect and follow the process of slow, gradual adaptation to cold water exposure and to undertake all the preventive measures that facilitate the process of adaptation. In addition, it ought to be emphasized that medical examination preceding training in order to be aware of individual health status and exclude conditions that may increase the risk of detrimental complications is also vital. All in all, it is imperative to undertake adequate preparation prior to engaging in such an extreme physical activity as winter swimming in order to develop adaptation and reap the benefits rather than risks.

Disclosure:

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