Issue Rehabil. Orthop. Neurophysiol. Sport Promot. 2023; 45: 29–44. ISSN 2300-0767
DOI: 10.19271/IRONS-000198-2023-45

REVIEW ARTICLE

WHAT IS THE IMPACT OF COLD WATER BATHING AND SWIMMING ON HUMAN HEALTH? LITERATURE REVIEW

JAKI JEST WPŁYW MORSOWANIA I PŁYWANIA W ZIMNEJ WODZIE NA ZDROWIE CZŁOWIEKA? PRZEGLĄD LITERATURY

Jakub Langa[1], Maria Mitkowska[2], Michał Obrębski[3], Anna Wójcik[4], Jan Kościan[5], Justyna Chwiejczak[6], Aleksander Górny[7], Anna Seroka[8], Maria Rybicka[3], Julita Młynarska[9]
[1]Intern, Józef Struś Hospital, Poland
[2]Intern, HCP Medical Centre, Poland
[3]Intern, University Clinical Centre of the Medical University of Warsaw, Poland
[4]Intern, Warsaw Southern Hospital, Poland
[5]Intern, Independent Public Hospital them. prof. W. Orlowski Medical Centre of Postgraduate Educationl, Poland
[6]Intern, Memorial Bielański Hospital, Poland
[7]Intern, Prague Hospital of Lord's Transfiguration, Poland
[8]Intern, The National Institute of Medicine of the Ministry of Interior and Administration, Poland
[9]Intern, Saint Anna Hospital of Trauma Surgery, Poland

ABSTRACT

Introduction

Winter swimming has a long tradition that dates back to ancient times. In recent years, there has been an increase in interest in this activity in Poland and European countries.

Aim

The aim of this review is to present the positive and negative aspects of bathing and swimming in cold water.

Materials and methods

Our research involved freely accessible databases: PubMed, Google Scholar, ScienceDirect, using keywords such as: winter swimming, cold water bathing, hypothermia.

Results

The effect of increasing human immunity as a result of winter swimming is possible. Swimming has a slight influence on the fluctuations of hormone levels. The effect of cold water swimming on the circulatory system may be positive or negative, depending on the level of adaptation of the practitioner.

Conclusions

Regular cold water swimming by adapted individuals may have potential health benefits. There are health risks associated with such baths for unadapted people. The impact of cold water bathing and winter swimming should be further investigated.

Author responsible for correspondence:
Jakub Langa
Intern, Józef Struś Hospital, Szwajcarska 3, 61-285, Poznań, Poland
Email: mr.jakublanga@gmail.com
https://orcid.org/ 0009-0004-7700-1578

Authors reported no source of funding
Authors declared no conflict of interest

Date received: 04th April 2024
Date accepted: 23rd October 2024

Keywords: winter swimming, cold water bathing, hypothermia

STRESZCZENIE

Wstęp

Morsowanie to coraz bardziej popularny sposób na spędzanie wolnego czasu. Polega ono na kąpieli w jeziorze, rzece, morzu czy basenie, głównie w czasie okresu zimowego w zimniejszych i polarnych regionach.

Cel

Celem pracy przeglądowej jest zaprezentowanie pozytywnego i negatywnego wpływu morsowania i pływania w zimnej wodzie na funkcjonowanie szeregu układów i narządów.

Materiał i metody

Do naszych badań wykorzystaliśmy ogólnodostępne bazy danych: PubMed, Google Scholar, ScienceDirect, wykorzystując takie słowa kluczowe jak: winter swimming, cold water bathing, hypothermia.

Wyniki

Efekt zwiększenia odporności człowieka w wyniku morsowania jest możliwy. Morsowanie wpływa nieznacznie na wahanie poziomu hormonów. Wpływ pływania zimą na układ krążenia może być pozytywny lub negatywny, w zależności od stopnia przystosowania ćwiczącego.

Wnioski

Regularne pływanie w zimnej wodzie przez osoby przystosowane może przynosić potencjalne korzyści zdrowotne. U osób nieprzystosowanych istnieje ryzyko zdrowotne związane z takimi kąpielami. Wpływ morsowania i pływania w zimnej wodzie powinien być dalej zbadany.

Słowa kluczowe: pływanie w zimnej wodzie, morsowanie, hipotermia

Introduction

Winter swimming and bathing are increasingly popular ways of spending free time. It involves swimming in a lake, river, sea or swimming pool, mainly during winter, in colder and polar regions. As a result, the entire body is exposed to the stressful effects of cold water, usually below 5°C (Lubkowska *et al.*, 2013) (Knechtle *et al.*, 2020). Initially popular mainly in Scandinavian countries, it now arouses interest among people all over the world (Knechtle *et al.*, 2020). Since 2020, we have noticed an increase in interest in this form of spending time (Kaniewska 2021). Popular opinion holds that this type of activity has a positive impact on the functioning of the body. Many scientific studies also suggest that swimming in cold water brings health benefits (Gibas-Dorna *et al.*, 2016), positively influencing, among others: on glucose and insulin metabolism, the immune system (Janský *et al.*, 1996), the hematopoietic system (Checinska-Maciejewska 2019) and the cardiovascular system (Manolis *et al.*, 2019).

Aim

The review aims to gather available data and summarize it to show the researched effects of cold water swimming and bathing on specific aspects of human health.

Material and methods

Our research involved freely accessible databases: PubMed, Google Scholar, ScienceDirect, using keywords such as: winter swimming, cold water bathing, hypothermia.

Results

Historical outline

The beginnings of the use of cold baths in medicine date back to around 2500 BC, when the inhabitants of ancient Egypt immersed their bodies in cool water for health purposes. Over time, for ancient peoples, bathing took on the form of an important spiritual rite, as well as one of the elements of social life, which contributed to the construction of widely accessible public baths by the citizens of ancient Rome (Wesołowski *et al.,* 2013). In 377 BC, Hippocrates described the effects of cold and the indications and contraindications for its use, according to which he recommended the use of low temperatures to reduce swelling, bleeding and pain (Tipton *et al.,* 2017). Methods of treating patients using low temperatures were used by Józef Strus, physician to King Sigismund Augustus. In 1578, doctor Wojciech Oczko published bathing regulations as well as indications and contraindications for their use in the treatise "Cieplice" (Wesołowski *et al.,* 2013). In 1808, the first seaside swimming pool was created in Poland in Brzeźno, which was open in the winter season. Nowadays cold baths have become more and more popular every year, which resulted in the creation of clubs bringing together enthusiasts of this form of group activity, practiced from autumn to spring. The oldest of them – the Gdańsk Walrus Club – was established in 1975, and since then over 100 clubs have been established throughout the country (Kaniewska *et al.,* 2021). The Polish name "morsowanie" as a term for short-term, cold baths in water in the open air comes from walruses, animals inhabiting the icy waters of the Arctic. In Russia, as in Poland, winter bathing enthusiasts are called walruses, in Finland seals, and in the United States polar bears (O morsach i morsowaniu. Obcy język polski 2020). The rapid increase in the popularity of winter swimming in Poland in recent years contributed to breaking the Guinness record for the largest number of people taking part in winter swimming at the same time 1.799 participants during the International Walrus Rally in Mielno in 2015 (Wesołowski *et al.,* 2013).

Impact on hematological and biochemical parameters of blood serum

Cold water swimming has a significant impact on the values of selected hematological parameters. The authors of one article noted that seven months of regular cold water swimming during the winter season results in increased serum EPO concentrations (Checinska-Maciejewska *et al.,* 2019) due to adaptive changes in response to transient hypoxia in the body, induced by reduced blood flow through the skin and kidneys, which is maintained a few minutes after immersion (Buemi *et al.,* 2010). Women are more susceptible to changes in serum EPO concentration (Checinska-Maciejewska *et al.,* 2019) due to the fact that the female body cools down more quickly (Gleyzer *et al.,* 2005). The previously described increase in EPO concentration due to cold stimulation leads to the stimulation of the hematopoiesis process. In people practicing cold-water swimming for half a year, blood counts showed increased concentrations of hemoglobin, hematocrit, erythrocytes, MCHC, MCV, MCH and decreased levels of platelets (Teległów *et al.,* 2015), with significant changes in platelet concentrations occurring mainly in women (Checinska-Maciejewska *et al.,* 2019). The described changes are also intensified by reduced plasma volume resulting from increased diuresis (Stocks *et al.,* 2004) and fluid shift due to increased sympathetic activity of the nervous system in the body's response to cold (Lubkowska *et al.,* 2013).

Subsequent authors noticed that regular exposure of the body to low temperatures in "walruses" also affects the immune system (Missau *et al.,* 2018), which is reflected in a decrease in WBC values and the levels of IgG, IgA and IgM immunoglobulins (Lubkowska *et al.,* 2013).

A case study by authors from Krakow showed that winter swimming may have an impact on laboratory results in the kidney

and liver profile, where after one 53-year-old swimmer left the water, a slight increase in AST, LDH and slight fluctuations in the level of electrolytes in the blood serum were observed – a decrease in the concentration of sodium cations and chloride anions and reduced urea concentration, suggesting that winter swimming may indicate the presence of other health problems of the swimmer (Ptaszek *et al.*, 2019).

Cold baths may also have a beneficial effect on cardiovascular risk – they cause a decrease in TG levels, homocysteine concentrations, and a lower Apo-B/ApoA-I ratio during the swimming season. The authors note, however, that the beneficial effect of cold bathing on cardiovascular risk factors may be gender-dependent; further research is therefore needed to draw accurate conclusions (Checinska-Maciejewska *et al.*, 2017).

Impact on the body's immunity and oxidative stress

If swimming in cold water has a positive effect on the functioning of the immune system, there should be noticeable changes in immune markers and health should improve during the swimming period. People bathing in cold waters reported fewer and less severe upper respiratory tract infections (URTI) compared to pool swimmers (Esperland *et al.*, 2022). This effect has not been precisely measured (Collier *et al.*, 2021). One study (Lombardi *et al.*, 2011) on a group of fifteen who attempted to swim 150 m in water at a temperature of 6 degrees Celsius may indicate a potential cause of such a phenomenon – the number of red blood cells, white blood cells and platelets increased significantly compared to the state before swimming. There was also a strong increase in the total number of neutrophils, lymphocytes and monocytes. Another study of ten people tried to measure the effect of winter swimming (three times a week for six weeks) on some components of the immune system and showed a small but significant increase in the proportion of monocytes and lymphocytes and increased TNF-α concentrations. An increase in plasma concentrations of some acute phase proteins, such as haptoglobin and hemopexin, was also observed. After 6 weeks of repeated immersions, an increase in the concentration of IL-6 in plasma and the total number of T lymphocytes (CD3), T helper lymphocytes (CD4), suppressor T lymphocytes (CD8), activated T and B lymphocytes (HLA-DR) was observed, and a decrease in the concentration was observed. alpha 1-antitrypsin in plasma. However, the researchers pointed out that the clinical significance of these observations remains to be clarified (Janský *et al.*, 1996).

Several studies have also tried to detect the effect of winter swimming on oxidative stress mechanisms (Lubkowska *et al.*, 2013) (Siems *et al.*, 1999) (Lubkowska *et al.*, 2019). Studies on rats immersed daily in water at a temperature of 5 degrees Celsius for several weeks have shown that females are better able to adapt to cold temperatures than males, as shown by an increase in the activity of erythrocyte superoxide dismutase (SOD) and the concentration of glutathione (GSH) in order to restoring the body's pro-oxidant balance (Lubkowska *et al.*, 2019). The study of 36 venous blood samples from people exposed to cold water baths compared to 40 people who had never practiced winter swimming suggests similar effects also in humans (Siems *et al.*, 1999).

Impact on hormonal balance

The reaction of the hormonal axes, when bathing at low temperatures, also seems interesting (Briganti *et al.*, 2023). One study examined the effect of long-term exposure to low temperatures on the concentration of adrenocorticotropic hormone (ACTH), cortisol, adrenaline and norepinephrine (Leppäluoto *et al.*, 2008) in the blood. The results showed that exposure to low temperatures did not suddenly disturb the functioning of the pituitary-hypothalamic axis – only a slight decrease in ACTH levels was noted, which may have resulted from the body's habituation. Plasma adrenaline levels also remained

unchanged relative to the control group. However, researchers found an increase in norepinephrine concentration each time after exposure to low temperature.

In another study (Smolander *et al.*, 2009), the researchers decided to check how cool baths affect the concentration of prolactin, thyroid hormones, thyroid-stimulating hormones and growth hormone (GH) in a group of six healthy women. During the 12-week study, only slight fluctuations in thyroid-stimulating hormones were observed, but they did not exceed normal values for a healthy population. No changes in plasma concentrations of other tested hormones were observed. On this basis, the researchers concluded that regular winter swimming does not cause any changes in the levels of the tested hormones in the blood of healthy women.

In turn, in another study on a group of 15 middle-aged people staying in cold water for 15 minutes regularly for 6 months, an increase in the level of parathyroid hormone (PTH), thyrotropin (thyroid-stimulating hormone – TSH) and a decrease in triiodothyronine (T3) and thyroxine (T4). The increase in PTH concentration also correlated with a decrease in systemic calcium concentration and an increase in phosphorus levels (Kovaničová *et al.*, 2020).

Cold water swimming may have a positive effect on insulin metabolism. The effect seems to be sex-specific (Gibas-Dorna *et al.*, 2016) (Gibas-Dorna *et al.*, 2016). For female and swimmers with lower body fat percentage, there was an increased insulin sensitivity as well as a reduction in insulin secretion and resistance in a six month field study (Kaniewska *et al.*, 2021).

There is a study of thermogenic brown adipose tissue (BAT) (Søberg *et al.*, 2021) (in experienced winter-swimming men performing brief dips in cold water with hot sauna sessions 2–3 times per week. The data suggests a lower thermal comfort state in the winter swimmers compared with controls. In response to cold, there was observed greater increases in cold-induced thermogenesis and supraclavicular skin temperature in the winter swimmers, suggesting both heat and cold acclimation in winter swimmers, and showcase winter swimming as a potential strategy for increasing energy expenditure.

Effects on the circulatory system

One of the main indicators of the condition of the cardiovascular system is blood pressure (BP). When it is too high, it is one of the most important factors increasing the risk of developing cardiovascular diseases. For these reasons, BP is a frequent target for research on the impact of winter swimming on the human body. One study conducted on a group of long-distance swimmers showed a significant decrease in diastolic blood pressure (DBP) after a few days of practicing this form of activity (Huttunen *et al.*, 2000). Another study conducted on seasonal winter swimmers showed that DBP increased slightly during bathing, but returned to normal four minutes after surfacing (Zenner *et al.*, 1980).

The ratio of lipoprotein B to lipoprotein A is reflected in the level of LDL and HDL. However, in a comparative study on a group of ten adapted winter swimmers and sixteen unadapted swimmers, although a reduced ratio of lipoprotein B to lipoprotein A was observed in the first of these groups, no statistically significant changes were noted in the values of other lipoprotein parameters (Kralova Lesna *et al.*, 2015).

Another important parameter are troponins, the level of which was significantly increased in swimmers covering distances from 500 to 1000 meters in winter competitions. The peak value of high-sensitivity troponins (hsTnI) occurred within 2 hours after the end of exercise. The concentration of the N-terminal fragment of brain natriuretic peptide type B (NT-proBNP) was also measured as a marker of heart failure. However, no statistically significant changes or connections between hsTnI and NT-proBNP levels were demonstrated (Broz *et al.*, 2017).

There have also been studies examining the impact of cold baths on the occurrence of arrhythmia. At the moment of immersion,

an "autonomous conflict" develops. Both the sympathetic and parasympathetic nervous systems are then activated. This results in the simultaneous induction of tachycardia or bradycardia. Therefore, the risk of arrhythmia increases and, in people with additional burden, it may even result in death. (Kovaničová *et al.*, 2020) (Shattock *et al.*, 2012) (Ishikawa *et al.*, 1992) (Wolf *et al.*, 1965).

Conclusions

Regular bathing in cold water may increase the concentration of erythropoietin and stimulate the hematopoiesis process, which is reflected in blood morphology parameters, mainly in women. Moreover, tests of other biochemical parameters in blood serum showed a slight anti-inflammatory effect and a beneficial effect on cardiovascular risk.

Tests of the levels of hormones: prolactin, cortisol, adrenaline, noradrenaline, triiodothyronine, thyroxine, under the influence of 12 weeks of observations, did not show any significant fluctuations. The researchers only observed increased levels of plasma norepinephrine concentration after exposure to low temperatures.

Cold water swimming may affect the number of white and red blood cells, but its direct impact on the increase in immunity and oxidative stress is a controversial issue that should be subjected to further research.

Bathing in cold water may also be important for the circulatory system. Practicing winter swimming by experienced people may cause positive changes, such as lowering blood pressure or lowering the ratio of lipoprotein B to lipoprotein A. In turn, the level of hsTnI may increase, as well as the risk of developing arrhythmia.

Summarizing the collected literature, it can be concluded that winter swimming may have many health benefits, but further research is necessary, especially on numerous groups, to clearly assess the impact of this activity on the human body.

Acknowledgments

We would like to thank prof. Kamila Grzywacz for proof reading of the final manuscript and language corrections.

REFERENCES

Briganti, G. L., Chesini, G., Tarditi, D., Serli, D., Capodici, A. (2023), *'Effects of cold water exposure on stress, cardiovascular, and psychological variables.'* Acta Physiol (Oxf); 239(4):e14056.

Broz, P., Rajdl, D., Racek, J., Zeman, V., Novák, J., Trefil, L. (2017), *'Relationship between cold water swimming and increased cardiac markers: A pilot study.'* Klin Biochem Metab; 25:27–31.

Buemi, M., Donato, V., Lupica, R., Cernaro, V., Lucisano, S., Buemi, A., Crasci, E., Lacquaniti, A. (2010), *'From oxygen to erythropoietin, as a protagonist of the skin-brain-kidney axis.'* G Ital Nefrol Organo Uff Della Soc Ital Nefrol.; 27(6):609–15.

Checinska-Maciejewska, Z., Miller-Kasprzak, E., Checinska, A., Korek, E., Gibas-Dorna, M., Adamczak-Ratajczak, A., Bogdanski, P., Krauss, H. (2017), *'Gender-related effect of cold water swimming on the seasonal changes in lipid profile, ApoB/ApoA-I ratio, and homocysteine concentration in cold water swimmers.'* J Physiol Pharmacol Off J Pol Physiol Soc; 68(6):887–96.

Checinska-Maciejewska, Z., Niepolski, L., Checinska, A., Korek, E., Kolodziejczak, B., Kopczynski, Z., Krauss, H., Pruszynska-Oszmalek, E., Kolodziejski, P., Gibas-Dorna, M. (2019), *'Regular cold water swimming during winter time affects resting hematological parameters and serum erythropoietin.'* J Physiol Pharmacol Off J Pol Physiol Soc.;70(5).

Collier, N., Lomax, M., Harper, M., Tipton, M., Massey, H. (2021), *'Habitual cold-water swimming and upper respiratory tract infection.* Rhinology; 59(5):485–7.

Esperland, D., de Weerd, L., Mercer, J. B. (2022), *'Health effects of voluntary exposure to cold water – a continuing subject of debate.'* Int J Circumpolar Health; 81(1):2111789.

Gibas-Dorna, M., Chęcińska, Z., Korek, E., Kupsz, J., Sowińska, A., Krauss, H. (2016), *'Cold Water Swimming Beneficially Modulates Insulin Sensitivity in Middle-Aged Individuals.'* J Aging Phys Act. Oct;24(4):547–54.

Gibas-Dorna, M., Checinska, Z., Korek, E., Kupsz, J., Sowinska, A., Wojciechowska, M., Krauss, H., Piątek, J. (2016), *'Variations in leptin and insulin levels within one swimming season in non-obese female cold water swimmers.'* Scand J Clin Lab Invest; 76(6):486–91.

Gleyzer, N., Vercauteren, K., Scarpulla, R.C. (2005), *'Control of mitochondrial transcription specificity factors (TFB1M and TFB2M) by nuclear respiratory factors (NRF-1 and NRF-2) and PGC-1 family coactivators.'* Mol Cell Biol.;25(4):1354–66.

Huttunen, P., Lando, N.G., Meshtsheryakov, V.A., Lyutov, V.A. (2000), *'Effects of long-distance swimming in cold water on temperature, blood pressure and stress hormones in winter swimmers.'* J Therm Biol; 25(1):171–4.

Ishikawa, H., Matsushima, M., Nagashima, M., Osuga, A. (1992), *'Screening of children with arrhythmias for arrhythmia development during diving and swimming-face immersion as a substitute for diving and exercise stress testing as a substitute for swimming.'* Jpn Circ J. ;56(9):881–90.

Janský, L., Pospísilová, D., Honzová, S., Ulicný, B., Srámek, P., Zeman, V., Kamínková, J. (1996), *'Immune system of cold-exposed and cold-adapted humans.'* Eur J Appl Physiol.; 72(5–6):445–50.

Kaniewska, P., Ossowska, L. (2021), *'Fenomen morsowania w Polsce.'* Zesz Nauk Wydz Nauk Ekon.;1(25):79–96.

Knechtle, B., Waśkiewicz, Z., Sousa, C. V., Hill, L., Nikolaidis, P. T. (2020), *'Cold Water SwimmingBenefits and Risks: A Narrative Review.'* Int J Environ Res Public Health. bDec;17(23):8984.

Kovaničová, Z., Kurdiová, T., Baláž, M., Štefanička, P., Varga, L., Kulterer, O. C., Betz, M. J., Haug, A. R., Burger, I. A., Kiefer, F. W., Wolfrum, C., Ukropcová, B., Ukropec J. (2020), *'Cold Exposure Distinctively Modulates Parathyroid and Thyroid Hormones in Cold-Acclimatized and Non-Acclimatized Humans.'* Endocrinology. ;161(7):bqaa051.

Kralova Lesna I., Rychlikova, J., Vavrova, L., Vybiral, S. (2015), *'Could human cold adaptation decrease the risk of cardiovascular disease?'* J Therm Biol; 52:192–8.

Leppäluoto, J., Westerlund, T., Huttunen, P., Oksa, J., Smolander, J., Dugué, B., Mikkelsson, M. (2008), *'Effects of long-term whole-body cold exposures on plasma concentrations of ACTH, beta-endorphin, cortisol, catecholamines and cytokines in healthy females.'* Scand J Clin Lab Invest; 68(2):145–53.

Lombardi, G., Ricci, C., Banfi, G. (2011) *'Effect of winter swimming on haematological parameters.'* Biochem Medica;21(1):71–8.

Lubkowska, A., Bryczkowska, I., Gutowska, I., Rotter, I., Marczuk, N., Baranowska-Bosiacka, I., Banfi, G. (2019), *'The Effects of Swimming Training in Cold Water on Antioxidant Enzyme Activity and Lipid Peroxidation in Erythrocytes of Male and Female Aged Rats.'* Int J Environ Res Public Health; 16(4):647.

Lubkowska, A., Dołęgowska, B., Szyguła, Z., Bryczkowska, I., Stańczyk-Dunaj, M., Sałata, D., Budkowska, M. (2013), *'Winter-swimming as a building-up body resistance factor inducing adaptive changes in the oxidant/antioxidant status.'* Scand J Clin Lab Invest.;73(4):315–25.

Manolis, A. S., Manolis, S. A., Manolis, A. A., Manolis, T. A., Apostolaki, N., Melita, H. (2019), *'Winter Swimming: Body Hardening and Cardiorespiratory Protection Via Sustainable Acclimation.'* Curr Sports Med Rep.;18(11):401–15.

Missau, E., Teixeira, A., Franco, O., Martins, C., Paulitsch, F., Peres, W., Silva, A., Signori, L. (2018), *'Cold water immersion and inflammatory response after resistance exercises.'* Rev. Bras. Med. Esporte. 24:372–6.

O morsach i morsowaniu. **Obcy język polski**. (2020) Available from: https://obcyjezykpolski.pl/o-morsach-i-morsowaniu/.

Ptaszek, B., Marchewka, J., Andrzej, M., Patrycja, P., Sylwia, P., Paulina, R., Kabata-Piżuch, A., Teległów, A. (2019), *'Assessment of blood morphology, electrolyte level as well*

as kidney and liver function before and after exiting the water in winter swimmer during the entire winter swimming season – a case study.

Shattock, M. J., Tiptonm M. J. (2012), *'Autonomic conflict: a different way to die during cold water immersion?'* J Physiol.; 590(Pt 14):3219–30.

Siems, W. G., Brenke, R., Sommerburg, O., Grune, T. (1999) *'Improved antioxidative protection in winter swimmers.'* QJM Mon J Assoc Physicians; 92(4):193–198.

Smolander, J., Leppäluoto, J., Westerlund, T., Oksa, J., Dugue, B., Mikkelsson, M., Ruokonen, A. (2009), *'Effects of repeated whole-body cold exposures on serum concentrations of growth hormone, thyrotropin, prolactin and thyroid hormones in healthy women.'* Cryobiology; 58(3):275–278.

Søberg, S., Löfgren, J., Philipsen, F. E. *et al.* (2021), *'Altered brown fat thermoregulation and enhanced cold-induced thermogenesis in young, healthy, winter-swimming men.'* Cell Rep Med; 2(10):100408.

Stocks, J. M., Taylor, N. A. S., Tipton, M. J., Greenleaf, J. E. (2004), *'Human physiological responses to cold exposure.'* Aviat Space Environ Med.75(5):444–457.

Teległów, A., Marchewka, J., Tabarowski, Z., Rembiasz, K., Głodzik, J., Scisłowska-Czarnecka, A. (2015), *'Comparison of Selected Morphological, Rheological and Biochemical Parameters of Winter Swimmers' Blood at the End of One Winter Swimming Season and at the Beginning of Another.*Folia Biol (Praha).63(3):221–228.

Tipton, M. J., Collier, N., Massey, H., Corbett, J., Harper, M. (2017), *'Cold water immersion: kill or cure?'* Exp Physiol.;102(11):1335–1355.

Tipton, M. J., Kelleher, P. C., Golden, F. S. (1994), *'Supraventricular arrhythmias following breath-hold submersions in cold water.'* Undersea Hyperb Med J Undersea Hyperb Med Soc Inc; 21(3):305–313.

Wesołowski, R., Gackowska, M., Woźniak, A., Mila-Kierzenkowska, C., Jurecka, A. (2013), *'Oddziaływanie zimna na organizm człowieka – morsowanie jako forma rekreacji ruchowej'.* 39–49.

Wolf, S. (1965), *'The Bradycardia of the Dive Reflex – A Possible Mechanism of Sudden Death.'* Trans Am Clin Climatol Assoc.;76:192–200.

Zenner, R. J. (1980), *'Blood-pressure response to swimming in ice-cold water – The Lancet.'* Available from: https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(80)90605-4/fulltext.

Authors reported no source of funding.
Authors declared no conflict of interest.