**ACCEPTED FOR PUBLICATION IN**
**Medical Hypotheses (2008) vol. 70, issue # 5, pp. 995–1001. Epub 2007 Nov 13.**

**THIS DOCUMENT IS IDENTICAL TO CORRECTED PROOF (FINAL PUBLISHED VERSION)**

http://www.sciencedirect.com/science/article/pii/S030698770700566X
http://pubmed.gov/17993252
doi: 10.1016/j.mehy.2007.04.052

# Adapted Cold Shower as a Potential Treatment for Depression

Nikolai A. Shevchuk, Ph.D.

Molecular Radiobiology Section, the Department of Radiation Oncology, Virginia Commonwealth University School of Medicine, 401 College St, Richmond, VA 23298, USA

Phone: +1 (202) 203-8901

Fax: +1 (804) 827-0635

E-mail: ~~nshevchuk@comcast.net~~ shevchook@ro.ru

Funding for this work was in part derived from Children's National Medical Center Fellowship at the George Washington University, Washington, DC, USA.

## ABSTRACT

Depression is a debilitating mood disorder that is among the top causes of disability worldwide. It can be characterized by a set of somatic, emotional, and behavioral symptoms, one of which is a high risk of suicide. This work presents a hypothesis that depression may be caused by the convergence of two factors: (A) A lifestyle that lacks certain physiological stressors that have been experienced by primates through millions of years of evolution, such as brief changes in body temperature (e.g. cold swim), and this lack of "thermal exercise" may cause inadequate functioning of the brain. (B) Genetic makeup that predisposes an individual to be affected by the above condition more seriously than other people.

To test the hypothesis, an approach to treating depression is proposed that consists of adapted cold showers (20 degrees Celsius, 2-3 minutes, preceded by a 5-minute gradual adaptation to make the procedure less shocking) performed once or twice daily. The proposed duration of treatment is several weeks to several months.

The following evidence appears to support the hypothesis: Exposure to cold is known to activate the sympathetic nervous system and increase the blood level of beta-endorphin and noradrenaline and to increase synaptic release of noradrenaline in the brain as well. Additionally, due to the high density of cold receptors in the skin, a cold shower is expected to send an overwhelming amount of electrical impulses from peripheral nerve endings to the brain, which could result in an anti-depressive effect. Practical testing by a statistically insignificant number of people, who did not have sufficient symptoms to be diagnosed with depression, showed that the cold hydrotherapy can relieve depressive symptoms rather effectively. The therapy was also found to have a significant analgesic effect

and it does not appear to have noticeable side effects or cause dependence. In conclusion, wider and more rigorous studies would be needed to test the validity of the hypothesis.

## INTRODUCTION

Depression is a common term for a group of depressive mood disorders, which includes major depressive disorder (the most severe form of depression), dysthymia, and bipolar depression among others [1]. It is estimated that depression is one of the leading causes of disability worldwide [2] and approximately 10% of the adult population suffer from a depressive illness in the United States [3]. Symptoms of depression affect body, mood and behavior and may include some or most of the following: persistent sad or empty mood; feelings of guilt, hopelessness, or helplessness; loss of interest in activities that were previously enjoyed; fatigue or being "slowed down"; thoughts or attempts of suicide (Table 1).

**Table 1.** Symptoms of depression [3].

- Persistent sad, anxious, or "empty" mood
- Feelings of hopelessness, pessimism
- Feelings of guilt, worthlessness, helplessness
- Loss of interest or pleasure in hobbies and activities that were once enjoyed, including sex
- Decreased energy, fatigue, being "slowed down"
- Difficulty concentrating, remembering, making decisions
- Insomnia, early-morning awakening, or oversleeping
- Appetite and/or weight loss or overeating and weight gain
- Thoughts of death or suicide; suicide attempts
- Restlessness, irritability
- Persistent physical symptoms that do not respond to treatment, such as headaches, digestive disorders, and chronic pain

The combination, severity and duration of symptoms vary among different depressive disorders and can vary within a given disorder as well [1]. Depression is considered to be a disorder of the brain and people suffering from depression cannot will their way out of this negative state or simply “pull themselves together” [3]. Depression affects productivity, school performance, relationships of the patient with other people and is among the top causes of suicide [1].

Many researchers in the field admit that our current understanding of etiology of depression is rudimentary [1, 2]. No single gene has been shown to cause depression so far, although the existence of families with an extended history of depression suggests that a gene or a group of genes may be involved [1, 2, 4]. On the other hand, many cases of depression cannot be traced to a family history of the illness [1, 2]. The fact that depressive disorders are usually not congenital, but rather develop at some point in adolescence or much later, suggests that environmental and biomedical factors may play a role, and, indeed, some risk factors associated with occurrence of depressive symptoms have been reported (this association may not always be causal): cigarette smoking [5], medical causes such as a somatic illness (e.g. diabetes, cancer, endocrinopathies, anemia) [6] or use of certain medications (e.g. isotretinoin) [7], vitamin deficiencies (e.g. folic acid) [6], and stressful life events [8]. In most cases of diagnosed depressive disorders however, no clear causal factor can be identified [2, 8] and this work is an attempt to explore contributing factors of depression that, to my knowledge, have not been considered in the field to date.

One such contributing factor could be a lifestyle that lacks most of the physiological stressors that have been present throughout evolution of mammals and primates. These

stressors include frequent acute physical activity as well as frequent (temporary) changes in body temperature, for example, occasional forced swimming in cold water or hunting in very hot weather. A number of studies have shown beneficial effects of small amounts of otherwise stressful or harmful treatments on the lifespan of animals, for example: hypergravity, small amounts of toxic substances, heat shock and cold shock among others [9]. Closer to psychiatry, moderate amounts of electric shock have long been used to treat drug-resistant forms of depression (a procedure called electroconvulsive therapy or ECT [10]). This work examines hypothetical benefits of a stressor that may be related to ECT in its mechanism, but not necessarily in its effects, namely, brief whole-body exposure to cold water (cold shower). Since the density of cold receptors in the skin is thought to be 3 to 10 times higher than that of warm receptors [11, 12], simultaneous firing of all cutaneous cold receptors could be quite overwhelming and shocking for the brain, which may result in a positive therapeutic effect. In addition, exposure to cold has been shown: (i) to activate the sympathetic nervous system [13]; (ii) to increase the blood level as well as cerebral synaptic release of noradrenaline [14, 15], one of the key excitatory neurotransmitters in the brain [16]; and (iii) to increase production of beta-endorphin [17], which is known to produce the sense of well-being [18, 19].

## THE HYPOTHESIS

In view of the above, the hypothesis is that some depressive disorders may be caused by the convergence of two factors:

(A) A lifestyle that lacks sufficient physiological stressors, such as brief changes in body temperature, resulting in inadequate functioning of the central nervous system.

(B) Genetic makeup that predisposes an individual to be affected by the above condition more severely than other people.

## EVALUATION OF THE HYPOTHESIS

To test the hypothesis, an approach to treating depression is proposed that consists of adapted cold showers performed once or twice daily. A volunteer study among patients diagnosed with a depressive illness would be needed with a significant number of volunteers (30 to 100) plus a control group of patients who undergo a different kind of therapy. The effectiveness of cold hydrotherapy would be assessed by comparing the symptoms of the experimental group with symptoms of the control group after one week, after 3 weeks and after 3 months. Below is the rationale for choosing cold showers to test the hypothesis as well as some application notes.

### Rationale for adapted cold showers

The phenomenon of hormesis, whereby small amounts of a harmful agent can be beneficial for health and lifespan of animals, has been well documented [9]. The mechanism is not known precisely, but it is believed that triggering of one recovery mechanism also improves the functioning of other repair/recovery systems in a multicellular organism [20]. Moderate stressing agents other than the cold shower could theoretically also be used, for example: hypoxic stress (holding one's breath), oxidative stress (hyperventilation exercise), tickling sessions, and heat shock (sauna) among others, but they haven't been tested extensively by the author. The cold shower was chosen as a physiological stressor that might be beneficial in depression because:

1) It is expected to deliver a large-scale stimulus to the brain that may resemble electroconvulsive therapy (ECT), but without causing a seizure and side-effects such as memory loss. The density of cold receptors in the skin is thought to be 3 to 10 times higher than that of warm receptors [11, 12], and cold water also causes substantial vasoconstriction [21, 22] that could also activate pressure receptors [23]. In addition, thermal conductance of water is approximately 30 times greater than that of air [22]. For these reasons, whole-body exposure to cold water is expected to send a tremendous amount of electrical impulses from peripheral nerve endings to the brain (via sensory cortex [24]). Because this procedure may be too shocking a gradual adaptation period may be necessary.
2) Whole-body exposure to cold water was shown to increase the blood level of noradrenaline (norepinephrine) up to 4-fold in humans [14] and chronic exposure to cold was shown to enhance synaptic release of noradrenaline in locus ceruleus [15, 25] and hippocampus [26] in rats. Locus ceruleus is at the center of cerebral noradrenergic pathways [27, 28] and noradrenaline is one of the key excitatory neurotransmitters in the brain (along with serotonin) that is the target of many antidepressant drugs (the drugs are designed to increase the concentration of noradrenaline in brain synapses [16]). Noradrenaline can also penetrate the blood-brain barrier and can increase cerebral blood flow [29].
3) Local and whole-body exposure to cold has been shown to induce production of beta-endorphin [17, 30, 31] (up to 4-fold in blood [17]). This neurotransmitter is responsible for producing the sense of well-being and suppression of pain through opioid receptors [18, 19].

4) Whole-body exposure to cold has been shown to activate the sympathetic nervous system [13, 14], which is responsible for "priming" the body for action, for example during awakening [32, 33].
5) A cold shower is a physiological stress that may have a hormetic effect by forcing the body to recover normal core temperature after the cooling, which could have indirect beneficial effects on all systems and organs including the central nervous system [20].
6) Occasional transient changes in body temperature most likely have been present throughout most of evolution of mammals and primates due to a number of factors: absence of a heated or air-conditioned shelter, absence of clothes (somewhat compensated by body hair in primates and fur in other mammals), a mostly outdoor lifestyle and widely varying ambient temperature (intraday and seasonal); and a fairly frequent swimming or immersion in water of uncomfortable temperature in order to find food or escape predators. Even though humans are homeotherms (their body can maintain a constant core temperature of approximately 36.6°C) actual utilization of this sophisticated regulatory system controlled mostly by hypothalamus [34] is very low in modern life. Rapid disappearance of thermal stress from the lifestyle of humans in the last several thousand years compared to its presence in primates for millions of years before that could have some negative effects on human health because the thermoregulatory system (and the brain) does not get enough exercise.
7) Brief whole-body exposure to cold water (15-23°C) appears to be safe, and was not shown to have any significant side-effects either short-term or long-term [35,

36]; for example, the effect on core body temperature of healthy people is so negligible that hypothermia is hardly a concern [37, 38].

With respect to point #1, some discussion of ECT and other existing treatments of depression would be warranted. ECT is an old and effective therapy for drug-resistant depressive disorders [10]. Although the precise mechanism of its beneficial effect is still not entirely clear and is a matter of controversy [39], generally a dose of electricity is delivered to the brain that induces a large-scale generation of action potentials by brain neurons and causes a seizure for at least 15 seconds [39]. Therapeutic effects of ECT are not instantaneous and usually appear within one or two weeks of treatment [40]. Because ECT can cause such side effects as memory loss and cognitive impairment (a drop in intelligence quotient) [40], finding new methods of stimulating the brain would be beneficial. There are newer treatment strategies with electric devices such as transcranial magnetic stimulation, vagus nerve stimulation, deep-brain stimulation, and cranial electrotherapy stimulation, some of which have shown promise in clinical trials and have been approved by the FDA (Food and Drug Administration) for treatment of depressive and other disorders. There are also relatively newer classes of pharmacological agents such as selective serotonin reuptake inhibitors (SSRIs) which can cause remission of depressive symptoms in the majority of patients and have been approved by the FDA some years ago.

Although the existing therapies are effective, they appear to largely deal with symptomatic treatment and do not seem to adequately address the question of etiology of depression. For instance, it has been established that depressed mood can be caused by a dimin-

ished concentration of a neurotransmitter called serotonin in brain synapses [41], but little attention seems to be devoted to what may have caused this imbalance. If depression was not congenital, then it is possible that some environmental or lifestyle factors caused the neurochemical imbalance to develop at some point in a patient's life. Sometimes a causal factor or factors can be identified and if corrected, the symptoms would be expected to go away as well, as is the case with stressful life situations, certain somatic medical conditions and medications, substance abuse or vitamin deficiencies (in these cases diagnosis of depression is usually not made despite the presence of symptoms) [1, 8]. On the other hand, if the cause of depression cannot be easily determined and a hidden causative factor stays with the patient for the rest of his or her life, then focusing all efforts on treatment of depressive symptoms and not searching for the primary cause of the problem can leave the patient with a sad prospect of lifetime dependence on a costly treatment and possibly lifetime side effects, as well as a painful realization that he or she is probably an abnormal individual, who needs treatment unlike "normal people." While treatment of symptoms without knowing the cause is often the only available option and is better than not treating symptoms and not knowing the cause, this paper attempts to draw more attention to the search for possible lifestyle or environmental causes of depression.

As mentioned above, it is hypothesized that one of the contributing factors of depression could be the lack of thermal stress, which has been present through millions of years of evolution, and the proposed cold shower procedure is supposed to deliver this kind of stress. Just as the lack of physical exercise is widely recognized as a risk factor for many somatic illnesses, this work offers a hypothesis that the lack of "thermal exercise" could be a contributing factor of depression.

### Application of adapted cold showers

Personal experience shows that a sudden cold shower is indeed very stressful and quite uncomfortable during the first few seconds and, therefore, the proposed procedure would include a 5- to 7-minute adaptation period to make it less shocking. The proposed adaptation method is gradual expansion of the area of contact with cold water from the feet up. The temperature of the water would be 20°C and the whole-body shower can last 2 to 3 minutes, the whole procedure being performed once or twice a day (morning and afternoon). A cold bath is an option as well but it takes more time to prepare, control of the temperature is problematic, and submerging the head is not very convenient. 20°C was chosen empirically, because it appears to be sufficiently cold for the skin, yet comfortable. In the experience of the author, temperatures of water approaching 10°C and lower can cause a notable sensation of pain in the skin and muscles.

## EMPIRICAL DATA

The proposed method of cold hydrotherapy appears to be effective at alleviating depressive symptoms in approximately 2 years of experience of the author and two people that he knows (longer experience for them). This is a statistically insignificant sample given that there was no questionnaires, no systematic records, no consistent methodology, and this was not a volunteer study per se because those people were using cold hydrotherapy for their own reasons and were kind enough to share their observations with the author on the condition of anonymity. None of the “observed” people was diagnosed with depres-

sion, but they did experience some symptoms listed in Table 1 on at least one occasion. All statements in this section are based on these limited unpublished data.

**Effects of adapted cold showers**

In the experience of the author, a cold shower with an adaptation period is still shocking enough to produce beneficial effects on mood. The most notable effects of a cold shower are (a) it is energizing (invigorating), (b) it produces a sense of optimism and well-being, and (c) it alleviates fever and physical pain if they are present. Therapeutic effects of a cold shower appear to be instantaneous and lasting from hours to days. A sudden cold shower also has beneficial effects but it is difficult to perform on a regular basis. There are two possible negative effects of the cold shower:

(1) If it is taken after 7 p.m. it can cause insomnia, or, to be more precise, it can disrupt a sleep schedule. If necessary, a cool shower can be used instead in the evening (30°C, also with gradual adaptation, 2-3 minutes). The cool shower with an adaptation period, in the author's experience, does not have the energizing effect of the cold shower, but it does improve mood and promote relaxation, so it could be beneficial at night.

(2) Excessive use of cold showers (e.g. twice a day for many months) can result in symptoms of hypomania. In this case, the frequency of cold showers should be reduced to 1-2 times per week.

The duration of treatment with cold hydrotherapy can be several weeks to several months and the expected long term results are: (d) increased capacity for work; (e) increased

speed of psychomotor processes without increased agitation; and (f) an enjoyable neutral or slightly positive emotional state as opposed to an overly positive state (mania) or negative one (depression). Table 2 summarizes the expected effects of cold hydrotherapy on major symptoms of depressive disorders [8] based on personal experiences and observations of the author (N.A.S. has about 2 years of experience with almost daily cold showers, plus the observations reported by others, who used them regularly or occasionally, that go back approximately 19 years).

**Table 2.** Expected effects of daily cold showers on symptoms of depressive disorders.

*Legend:* "+" means an expected positive therapeutic effect; "+ –" means a limited or no expected effect; "–" means no expected effect.

| Symptoms | Effect of adapted cold showers |
|---|---|
| (1) Depressed mood nearly every day | + |
| (2) Decreased interest/pleasure in almost all activities nearly every day | + – |
| (3.a) Noticeable weight loss without dieting, or | + |
| (3.b) weight gain (an increase of 5% of body weight or more within a month), or | – |
| (3.c) decrease in appetite or | + |
| (3.d) increase in appetite (nearly every day for *c* and *d* ) | + – |
| (4.a) Insomnia nearly every day or | – |
| (4.b) hypersomnia nearly every day | + |
| (5.a) Psychomotor agitation nearly every day or | – |
| (5.b) psychomotor retardation nearly every day | + |

| | |
|---|---|
| (6.a) Pain symptoms nearly every day or | + |
| (6.b) Loss of energy nearly every day | + |
| (7.a) Feeling of worthlessness or | + – |
| (7.b) Inappropriate or excessive guilt (could be delusional) | – |
| (nearly every day for *a* and *b*) | |
| (8.a) Decreased ability to think or | + |
| (8.b) to concentrate* | + – |
| (8.c) or indecisiveness | + |
| (nearly every day for *a, b,* and *c*) | |
| (9) Recurrent thoughts about suicide without a | + |
| plan, or a suicide attempt (or a plan) | |

*The ability to concentrate on reading and writing is not expected to be improved significantly, while the ability to concentrate on easier tasks, such as listening to a lecture or watching a movie may be improved.

In summary, based on the limited evidence, cold hydrotherapy appears to cover many of the symptoms that are used for diagnosis of depressive disorders; however, the method may not be effective for some symptoms, such as “markedly diminished interest in previously enjoyed activities”, “weight gain and an increase in appetite,” and “diminished ability to concentrate” (in relation to reading and writing). This suggests that some other factors play a role and a healthy diet according to the latest nutritional science [42] and sufficient exercise could potentially fill these gaps, which could be a subject of future research.

## CONSEQUENCES OF THE HYPOTHESIS AND DISCUSSION

As mentioned above, rigorous, statistically significant volunteer studies would be needed to test the validity of the present hypothesis. If the therapy is proven to be effective and safe, it could become a viable treatment option for some depressive disorders, especially for childhood and adolescent depressive disorders where therapeutic options are rather limited [1]. Psychological counseling and/or cognitive behavioral therapy most likely would be beneficial in combination with the proposed method. It can be speculated that, with respect to treatment of manic episodes of bipolar depression, cold showers may not be beneficial because they appear work in the direction of more activity and more optimism; the author has no empirical data in this regard.

It is worth mentioning that cold hydrotherapy has not been reported to cause dependence or noticeable side effects [35, 36]. A legitimate question would be the potential for developing respiratory problems due to daily exposure to cold water (there is a popular

belief that exposure to cold can cause a cold or the flu). Long-term use of cold hydrotherapy does not appear to increase either the frequency or severity of respiratory infections ([35, 36] and N.A. Shevchuk, unpublished data), but more studies would be needed to prove that this is the case. Negative effects of prolonged hypothermia have been well documented [22, 43], but brief cold showers and even cold baths of up to 1 hour long do not appear to cause a sustained decrease in core temperature sufficient to cause the known negative effects in healthy people and animals [35, 36, 38] due to remarkable efficiency of the thermoregulatory system [37]. In the elderly or people who are prone to hypothermia due to a metabolic disorder, a warm shower or other warming techniques may be necessary after a cold shower [22]. Additionally, abrupt discontinuation of daily cold showers does not appear to cause symptoms of withdrawal (the author had at one point stopped taking them for 6 weeks after about 1.5 years of almost daily procedures, without noticeable problems), although the capacity for work may return to an average level from an above average level. For prophylaxis, a cold shower once a week possibly would be sufficient. The most important factor in preventing recurrence of depressive symptoms is probably a healthy lifestyle with sufficient physical activity and a healthy diet [42]. In conclusion, the proposed treatment of depression appears to be promising, but will need rigorous testing to prove its effectiveness.

## ACKNOWLEDGMENTS

The author thanks Stephan Ladisch for providing critical comments about cold hydrotherapy, and Yevgeniya A. Nusinovich for critical comments about the manuscript.

## REFERENCES


[1] Bhatia SK and Bhatia SC. Childhood and adolescent depression. Am Fam Physician 2007;75:73-80.

[2] Gelenberg AJ and Hopkins HS. Assessing and treating depression in primary care medicine. Am J Med 2007;120:105-8.

[3] National Institute of Mental Health, Bethesda, MD, USA. *Depression,* 2007. *URL: www.nimh.nih.gov/publicat/depression.cfm* Last accessed 03-26-2007.

[4] Hariri AR, Mattay VS, Tessitore A et al. Serotonin transporter genetic variation and the response of the human amygdala. Science 2002;297:400-3.

[5] Warner V, Weissman MM, Mufson L, and Wickramaratne PJ. Grandparents, parents, and grandchildren at high risk for depression: a three-generation study. J Am Acad Child Adolesc Psychiatry 1999;38:289-96.

[6] National Institute of Mental Health, Bethesda, MD, USA. *Depression in children and adolescents: a fact sheet for physicians,* 2006. *URL: www.mental-health-matters.com/articles/article.php?artID=320* Last accessed 03-26-2007.

[7] Wysowski DK, Pitts M, and Beitz J. An analysis of reports of depression and suicide in patients treated with isotretinoin. J Am Acad Dermatol 2001;45:515-9.

[8] American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders, 4th ed., text revision.,* 2000.

[9] Leslie M. How can we use moderate stresses to fortify humans and slow aging? Sci Aging Knowledge Environ;2005:nf49. doi:10.1126/sageke.2005.26.nf49.

[10] Ishihara K and Sasa M. Mechanism underlying the therapeutic effects of electro-convulsive therapy (ECT) on depression. Jpn J Pharmacol 1999;80:185-9.

[11] Iggo A and Iggo BJ. Impulse coding in primate cutaneous thermoreceptors in dynamic thermal conditions. J Physiol (Paris) 1971;63:287-90.

[12] Woodworth RS, Schlosberg, H. *Experimental Psychology*. 1965. New York: Holt, Rinehart and Winston; 347pp.

[13] Nakamoto M. Responses of sympathetic nervous system to cold exposure in vibration syndrome subjects and age-matched healthy controls. Int Arch Occup Environ Health 1990;62:177-81.

[14] Jansky L, Sramek P, Savlikova J, Ulicny B, Janakova H, and Horky K. Change in sympathetic activity, cardiovascular functions and plasma hormone concentrations due to cold water immersion in men. Eur J Appl Physiol Occup Physiol 1996;74:148-52.

[15] Jedema HP, Finlay JM, Sved AF, and Grace AA. Chronic cold exposure potentiates CRH-evoked increases in electrophysiologic activity of locus coeruleus neurons. Biol Psychiatry 2001;49:351-9.

[16] Nutt DJ. The neuropharmacology of serotonin and noradrenaline in depression. Int Clin Psychopharmacol 2002;17 Suppl. 1:S1-12.

[17] Vaswani KK, Richard CW, 3rd, and Tejwani GA. Cold swim stress-induced changes in the levels of opioid peptides in the rat CNS and peripheral tissues. Pharmacol Biochem Behav 1988;29:163-8.

[18] The Columbia Encyclopedia, 6th ed. *Endorphins,* 2007. *URL: www.bartleby.com* Last accessed: 03-26-2007.

[19] Encyclopaedia Britannica Online. *Endorphin,* 2007. *URL: www.britannica.com/eb/article-9032621* Last accessed: 03-26-2007.

[20] Arumugam TV, Gleichmann M, Tang SC, and Mattson MP. Hormesis/preconditioning mechanisms, the nervous system and aging. Ageing Res Rev 2006;5:165-78.

[21] Drummond PD. Immersion of the hand in ice water releases adrenergic vasoconstrictor tone in the ipsilateral temple. Auton Neurosci 2006;128:70-5.

[22] McCullough L and Arora S. Diagnosis and treatment of hypothermia. Am Fam Physician 2004;70:2325-32.

[23] Schmidt RF (ed.). *Fundamentals of Sensory Physiology*. 1978. New York: Springer-Verlag; 286pp.

[24] Encyclopaedia Britannica Online. *Brain,* 2007. *URL: www.britannica.com/eb/article-9016178* Last accessed: 03-26-2007.

[25] Jedema HP and Grace AA. Chronic exposure to cold stress alters electrophysiological properties of locus coeruleus neurons recorded in vitro. Neuropsychopharmacology 2003;28:63-72.

[26] Nisenbaum LK, Zigmond MJ, Sved AF, and Abercrombie ED. Prior exposure to chronic stress results in enhanced synthesis and release of hippocampal norepinephrine in response to a novel stressor. J Neurosci 1991;11:1478-84.

[27] Encyclopaedia Britannica Online. *Human Nervous System (section: autonomic pathways),* 2007. *URL: www.britannica.com/eb/article-9110704* Last accessed: 03-26-2007.

[28] Wikipedia, the Free Encyclopedia. *Norepinephrine,* 2007. *URL: en.wikipedia.org* Last accessed: 03-26-2007.

[29] Edvinsson L, Hardebo JE, MacKenzie ET, and Owman C. Effect of exogenous noradrenaline on local cerebral blood flow after osmotic opening of the blood-brain barrier in the rat. J Physiol 1978;274:149-56.

[30] Suzuki K, Maekawa K, Minakuchi H et al. Responses of the hypothalamic-pituitary-adrenal axis and pain threshold changes in the orofacial region upon cold pressor stimulation in normal volunteers. Arch Oral Biol 2007:[E-pub. ahead of print].

[31] Mizoguchi H, Narita M, Kampine JP, and Tseng LF. [Met5]enkephalin and delta2-opioid receptors in the spinal cord are involved in the cold water swimming-induced antinociception in the mouse. Life Sci 1997;61:PL81-6.

[32] Wikipedia, the Free Encyclopedia. *Sympathetic nervous system,* 2007. *URL: en.wikipedia.org* Last accessed: 03-26-2007.

[33] Encyclopaedia Britannica Online. *Autonomic Nervous System,* 2007. *URL: www.britannica.com/eb/article-9011379* Last accessed: 03-26-2007.

[34] Encyclopaedia Britannica Online. *Hypothalamus,* 2007. *URL: www.britannica.com/eb/article-9041829* Last accessed: 03-26-2007.

[35] Holloszy JO and Smith EK. Longevity of cold-exposed rats: a reevaluation of the "rate-of-living theory". J Appl Physiol 1986;61:1656-60.

[36] Jansky L, Pospisilova D, Honzova S et al. Immune system of cold-exposed and cold-adapted humans. Eur J Appl Physiol Occup Physiol 1996;72:445-50.

[37] Doufas AG and Sessler DI. Physiology and clinical relevance of induced hypothermia. Neurocrit Care 2004;1:489-98.

[38] Tikuisis P. Heat balance precedes stabilization of body temperatures during cold water immersion. J Appl Physiol 2003;95:89-96.

[39] Takano H, Kato M, Inagaki A, Watanabe K, and Kashima H. Time course of cerebral blood flow changes following electroconvulsive therapy in depressive patients--measured at 3 time points using single photon emission computed tomography. Keio J Med 2006;55:153-60.

[40] Sackeim HA, Prudic J, Fuller R, Keilp J, Lavori PW, and Olfson M. The cognitive effects of electroconvulsive therapy in community settings. Neuropsychopharmacology 2007;32:244-54.

[41] Iversen L. Neurotransmitter transporters and their impact on the development of psychopharmacology. Br J Pharmacol 2006;147 Suppl. 1:S82-8.

[42] Harvard School of Public Health, Cambridge, MA, USA. *Food Pyramids,* 2007. *URL: www.hsph.harvard.edu/nutritionsource/* Last accessed: 03-26-2007.

[43] Day MP. Hypothermia: a hazard for all seasons. Nursing 2006;36:44-7.

**THE TEXT BELOW IS THE AUTHOR'S UNPUBLISHED NOTES**

Here are some studies of various cooling methods (cooling suit, cold showers, winter swimming and swimming in a public pool [weak cooling]).

**Cooling elevates normal mood:**

Huttunen P, Kokko L, Ylijukuri V: **Winter swimming improves general well-being**. *Int J Circumpolar Health* 2004, **63**(2):140-144.

Berger BG, Owen DR: **Mood alteration with swimming--swimmers really do "feel better"**. *Psychosom Med* 1983, **45**(5):425-433.

Rymaszewska J, Bialy D, Zagrobelny Z, Kiejna A: **The influence of whole body cryotherapy on mental health**. *Psychiatr Pol* 2000, **34**(4):649-653.

Hirvonen J, Lindeman S, Matti J, Huttunen P: **Plasma catecholamines, serotonin and their metabolites and beta-endorphin of winter swimmers during one winter. Possible correlations to psychological traits**. *Int J Circumpolar Health* 2002, **61**(4):363-372.

Lindeman S, Hirvonen J, Joukamaa M: **Neurotic psychopathology and alexithymia among winter swimmers and controls--a prospective study**. *Int J Circumpolar Health* 2002, **61**(2):123-130.

Flensner G, Lindencrona C: **The cooling-suit: case studies of its influence on fatigue among eight individuals with multiple sclerosis**. *J Adv Nurs* 2002, **37**(6):541-550.

Kelly JS, Bird E: **Improved mood following a single immersion in cold water.** *Lifestyle Med* 2022, **3**(1): e53.

Massey H, Kandala NI, Davis C, Harper M, Gorczynski P, Denton H: **Mood and well-being of novice open water swimmers and controls during an introductory outdoor swimming programme: A feasibility study**. *Journal of Lifestyle Medicine* 2020, doi:10.1002/lim2.12.

Trylińska-Tekielska E, Drewnik M, Włostowska K, Borowska M: **Cold water immersion in Poland during the COVID-19 pandemic - motivating factors.** *Journal of Physical Education and Sport* 2022, **22**(7)1772-1778.

Yankouskaya A, Williamson R, Stacey C, Totman JJ, Massey H: **Short-term head-out whole-body cold-water immersion facilitates positive affect and increases interaction between large-scale brain networks.** *Biology (Basel)* 2023, **12**(2):211.

Miller NM, Gabitova E: **"It's the experience, it's not exercise": Blue Therapy for health and mental well-being among adults in the UK.** 2024 repository.uwl.ac.uk

Lukáš Olejníček: **Benefits of hardening and cold.** B.Sci. Thesis, Supervisor: Mgr. Pavel Grepl, Univerzita Palackého v Olomouci, 2023. https://theses.cz/id/m3m0v6/Benefity_otuzovani_a_chladu_-_Olejnicek_Lukas.pdf

Lehtonen M, Airo RM: **Can winter swimming improve mental wellbeing?** *PsyArXiv Preprints*, 16 October 2023.

**Cooling improves depressed mood:**

Rymaszewska J, Ramsey D, Chladzinska-Kiejna S: **Whole-body cryotherapy as adjunct treatment of depressive and anxiety disorders**. *Arch Immunol Ther Exp (Warsz)* 2008, **56**(1):63-68.

Wehr TA, Sack DA, Rosenthal NE: **Seasonal affective disorder with summer depression and winter hypomania**. *Am J Psychiatry* 1987, **144**(12):1602-1603. (This study describes one female patient who tested cold showers for 5 days).

Yavari A: **The Effect of Swimming in Reduction of Depression in University Male Students.** *Research Journal of Biological Sciences* 2008, **3**: 543-545.

van Tulleken C, Tipton M, Massey H, Harper CM: **Open water swimming as a treatment for major depressive disorder.** *BMJ Case Rep* 2018 doi: 10.1136/bcr-2018-225007.

Siemieniec S: **Keep it Cool - Adapted Cold Showers for Anxiety.** B.Sci. Thesis in Advanced Applied Psychology, Advisor: Lucie Clements, University of Chichester, May 2020. https://www.researchgate.net/publication/344894051_Keep_it_Cool_-_Adapted_Cold_Showers_for_Anxiety

Rymaszewska J, Lion KM, Pawlik-Sobecka L, Pawłowski T, Szcześniak D, Trypka E, Rymaszewska JE, Zabłocka A, Stanczykiewicz B: **Efficacy of the whole-body cryotherapy as add-on therapy to pharmacological treatment of depression-a randomized controlled trial.** *Front Psychiatry* 2020, **11**:522.

Doets JJR, Topper M, Nugter AM: **A systematic review and meta-analysis of the effect of whole body cryotherapy on mental health problems.** *Complement Ther Med* 2021, **63**: 102783.

Pasek M, Szark-Eckardt M: **Mental effects of aquatic occupational therapy among women engaged in indoor and outdoor physical activity forms.** *Journal of Physical Education and Sport* 2021, **21**(Suppl. 5):3017–3023.

Park T: **Psychophysiological responses to acute cold water immersion.** B.Sci. Thesis in Biology, Advisor: Christopher T. Minson, University of Orgeon, December 2021. https://scholarsbank.uoregon.edu/xmlui/handle/1794/26553

Hjorth P, Sikjær MG, Løkke A, Jørgensen AM, Jørgensen N, Kaasgaard DM, Rasmussen MRV: **Cold water swimming as an add-on treatment for depression: a feasibility study**. *Nord J Psychiatry* 2023, **2023**:1-6.

Reed EL, Chapman CL, Whittman EK, Park TE, Larson EA, Kaiser BW, Comrada LN, Wiedenfeld Needham K, Halliwill JR, Minson CT: **Cardiovascular and mood responses to an acute bout of cold water immersion.** *J Therm Biol* 2023, **118**:103727.

Kurniasari MD, Monsen KA, Weng SF, Yang CY, Tsai HT: **Cold water immersion directly and mediated by alleviated pain to promote quality of life in Indonesian with gout arthritis: a community-based randomized controlled trial.** *Biol Res Nurs* 2022, **24**(2):245-258.

**Heating of the body improves depressed mood:**

Koltyn KF, Robins HI, Schmitt CL, Cohen JD, Morgan WP: **Changes in mood state following whole-body hyperthermia**. *Int J Hyperthermia* 1992, **8**(3):305-307.