Swimming and Splashing

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General

Al Haddad, H., Laursen, P. B., Ahmaidi, S., & Buchheit, M. (2010). Influence of cold water face immersion on post-exercise parasympathetic reactivation. *European Journal of Applied Physiology*, *108*(3), 599-606.

The aim of the present study was to investigate the effect of cold water face immersion on post-exercise parasympathetic reactivation, inferred from heart rate (HR) recovery (HRR) and HR variability (HRV) indices. Thirteen men performed, on two different occasions, an intermittent exercise (i.e., an all-out 30-s Wingate test followed by a 5-min run at 45% of the speed reached at the end of the 30-15 Intermittent Fitness test, interspersed with 5 min of seated recovery), randomly followed by 5 min of passive (seated) recovery with either cold water face immersion (CWFI) or control (CON). HR was recorded beat-to-beat and vagal-related HRV indices (i.e., natural logarithm of the high-frequency band, LnHF, and natural logarithm of the square root of the mean sum of squared differences between adjacent normal R-R intervals, Ln rMSSD) and HRR (e.g., heart beats recovered in the first minute after exercise cessation) were calculated for both recovery conditions. Parasympathetic reactivation was faster for the CWFI condition, as indicated by higher LnHF (P = 0.004), Ln rMSSD (P = 0.026) and HRR (P = 0.002) values for the CWFI compared with the CON condition. Cold water face immersion appears to be a simple and efficient means of immediately accelerating post-exercise parasympathetic reactivation.

Al Haddad, H., Laursen, P. B., Chollet, D., Lemaitre, F., Ahmaidi, S., & Buchheit, M. (2010). Effect of cold or thermoneutral water immersion on post-exercise heart rate recovery and heart rate variability indices. *Autonomic Neuroscience*, *156*(1-2), 111-116.

This study aimed to investigate the effect of cold and thermoneutral water immersion on post-exercise parasympathetic reactivation, inferred from heart rate (HR) recovery (HRR) and HR variability (HRV) indices. Twelve men performed, on three separate occasions, an intermittent exercise bout (all-out 30-s Wingate test, 5 min seated recovery, followed by 5 min of submaximal running exercise), randomly followed by 5 min of passive (seated) recovery under either cold (CWI), thermoneutral water immersion (TWI) or control (CON) conditions. HRR indices (e.g., heart beats recovered in the first minute after exercise cessation, HRR(60)(s)) and vagal-related HRV indices (i.e., natural logarithm of the square root of the mean of the sum of the squares of differences between adjacent normal R-R intervals (Ln rMSSD)) were calculated for the three recovery conditions. HRR(60)(s) was faster in water immersion compared with CON conditions [30+/-9 beats min(-)(1) for CON vs. 43+/- 10 beats min(-)(1) for TWI (P=0.003) and 40+/-13 beats min(-)(1) for CWI (P=0.017)], while no difference was found between CWI and TWI (P=0.763). Ln rMSSD was higher in CWI (2.32+/-0.67 ms) compared with CON (1.98+/-0.74 ms, P=0.05) and TWI (2.01+/-0.61 ms, P=0.08; aES=1.07) conditions, with no difference between CON and TWI (P=0.964). Water immersion is a simple and efficient means of immediately triggering post-exercise parasympathetic activity, with colder immersion temperatures likely to be more effective at increasing parasympathetic activity.

Al Haddad, H., Parouty, J., & Buchheit, M. (2012). Effect of daily cold water immersion on heart rate variability and subjective ratings of well-being in highly trained swimmers. *International Journal of Sports Physiology and Performance*, *7*(1), 33-38.

PURPOSE: We investigated the effect of daily cold water immersion (CWI), during a typical training week, on parasympathetic activity and subjective ratings of well-being. METHODS: Over two different weeks, eight highly trained swimmers (4 men; 19.6 ± 3.2 y) performed their usual training load (5 d/wk, approx. 21 h/wk). Last training session of each training day was immediately followed by 5 min of seated recovery, in randomized order, with CWI (15°C) or without (CON). Each morning before the first training session (6:30 AM) during the two experimental weeks, subjective ratings of well-being (eg, quality of sleep) were assessed and the R-R intervals were recorded for 5 min in supine position. A vagal-related index (ie, natural logarithm of the square root of the mean of the sum of the squares of differences between adjacent normal R-R intervals; Ln rMSSD) was calculated from the last 3-min segment. RESULTS: Compared with CON, CWI effect on Ln rMSSD was rated as possibly beneficial on day 2 [7.0% (-3; 19)], likely beneficial on day 3 [20.0% (1.5; 43.5)], very likely beneficial on day 4 [30.4% (12.2; 51.6)] and likely beneficial on day 5 [24.1% (-0.4; 54.8)]. Cold water immersion was associated with a likely greater quality of sleep on day 2 [30.0% (2.7; 64.6)], very likely on day 3 [31.0% (5.0; 63.1)] and likely on day 4 [38.6% (11.4; 72.4)] when compared with CON. CONCLUSION: Five minutes of CWI following training can reduce the usual exercise-induced decrease in parasympathetic activity and is associated with improved rating of perceived sleep quality.

Buchheit, M., Peiffer, J. J., Abbiss, C. R., & Laursen, P. B. (2009). Effect of cold water immersion on postexercise parasympathetic reactivation. *American Journal of Physiology*, *296*(2), H421-H427.

The aim of the present study was to assess the effect of cold water immersion (CWI) on postexercise parasympathetic reactivation. Ten male cyclists (age, 29 +/- 6 yr) performed two repeated supramaximal cycling exercises (SE(1) and SE(2)) interspersed with a 20-min passive recovery period, during which they were randomly assigned to either 5 min of CWI in 14 degrees C or a control (N) condition where they sat in an environmental chamber (35.0 +/- 0.3 degrees C and 40.0 +/- 3.0% relative humidity). Rectal temperature (T(re)) and beat-to-beat heart rate (HR) were recorded continuously. The time constant of HR recovery (HRRtau) and a time (30-s) varying vagal-related HR variability (HRV) index (rMSSD(30s)) were assessed during the 6-min period immediately following exercise. Resting vagal-related HRV indexes were calculated during 3-min periods 2 min before and 3 min after SE(1) and SE(2). Results showed no effect of CWI on T(re) ($P = 0.29$), SE performance ($P = 0.76$), and HRRtau ($P = 0.61$). In contrast, all vagal-related HRV indexes were decreased after SE(1) ($P < 0.001$) and tended to decrease even further after SE(2) under N condition but not with CWI. When compared with the N condition, CWI increased HRV indexes before ($P < 0.05$) and rMSSD(30s) after ($P < 0.05$) SE(2). Our study shows that

CWI can significantly restore the impaired vagal-related HRV indexes observed after supramaximal exercise. CWI may serve as a simple and effective means to accelerate parasympathetic reactivation during the immediate period following supramaximal exercise.

Darou, S. (2015, November 29). *How to Control Inflammation with Your Brain*. Retrieved from http://upliftconnect.com/control-inflammation/

de Oliveira Ottone, V., de Castro Magalhaes, F., de Paula, F., Avelar, N. C. P., Aguiar, P. F., de Matta Sampaio, P. F., … Rocha-Vieira, E. (2014). The Effect of Different Water Immersion Temperatures on Post-Exercise Parasympathetic Reactivation. *PLoS One, 9*(12), e113730.

Purpose: We evaluated the effect of different water immersion (WI) temperatures on post-exercise cardiac parasympathetic reactivation. Methods: Eight young, physically active men participated in four experimental conditions composed of resting (REST), exercise session (resistance and endurance exercises), post-exercise recovery strategies, including 15 min of WI at 15°C (CWI), 28°C (TWI), 38°C (HWI) or control (CTRL, seated at room temperature), followed by passive resting. The following indices were assessed before and during WI, 30 min post-WI and 4 hours post-exercise: mean R-R (mR-R), the natural logarithm (ln) of the square root of the mean of the sum of the squares of differences between adjacent normal R–R (ln rMSSD) and the ln of instantaneous beat-to-beat variability (ln SD1). Results: The results showed that during WI mRR was reduced for CTRL, TWI and HWI versus REST, and ln rMSSD and ln SD1 were reduced for TWI and HWI versus REST. During post-WI, mRR, ln rMSSD and ln SD1 were reduced for HWI versus REST, and mRR values for CWI were higher versus CTRL. Four hours post exercise, mRR was reduced for HWI versus REST, although no difference was observed among conditions. Conclusions: We conclude that CWI accelerates, while HWI blunts post-exercise parasympathetic reactivation, but these recovery strategies are short-lasting and not evident 4 hours after the exercise session.

Datta, A., & Tipton, M. (2006). Respiratory responses to cold water immersion: neural pathways, interactions, clinical consequences awake and asleep. *Journal of Applied Physiology*, *100*, 2057-2064.

The ventilatory responses to immersion and changes in temperature are reviewed. A fall in skin temperature elicits a powerful cardiorespiratory response, termed "cold shock," comprising an initial gasp, hypertension, and hyperventilation despite a profound hypocapnia. The physiology and neural pathways of this are examined with data from original studies. The respiratory responses to skin cooling override both conscious and other autonomic respiratory controls and may act as a precursor to drowning. There is emerging evidence that the combination of the reestablishment of respiratory rhythm following apnea, hypoxemia, and coincident sympathetic nervous and cyclic vagal stimulation appears to be an arrhythmogenic trigger. The potential clinical implications of this during wakefulness and sleep are discussed in relation to sudden death during immersion, underwater birth, and sleep apnea. A drop in

deep body temperature leads to a slowing of respiration, which is more profound than the reduced metabolic demand seen with hypothermia, leading to hypercapnia and hypoxia. The control of respiration is abnormal during hypothermia, and correction of the hypoxia by inhalation of oxygen may lead to a further depression of ventilation and even respiratory arrest. The immediate care of patients with hypothermia needs to take these factors into account to maximize the chances of a favorable outcome for the rescued casualty.

Hayashi, N., Ishihara, M., Tanaka, A., Osumi, T., & Yoshida, T. (1997). Face immersion increases vagal activity as assessed by heart rate variability. *European Journal of Applied Physiology and Occupational Physiology*, *76*(5), 394-399.

We examined whether the diving reflex without breath-holding (face immersion alone) increases vagal activity, as determined by heart rate variability. A group of 15 men [mean age 20 (SD 3) years, height 172 (SD 5) cm, body mass 68 (SD 9) kg] performed 12 trials at various breathing frequencies (5, 10, 15, 20, 30 breaths x min(-1) and uncontrolled breath) with or without face immersion. The R-R intervals of the ECG and gas exchange variables were recorded during the 2 min of each trial. The subjects immersed their faces in 8 10 degrees C water while breathing through a short snorkel. The subject sat in the same position either with or without face immersion. The mean R-R interval (RRmean), standard deviations (SD[RR]) and coefficient of variance (CV[RR]) of the R-R interval were calculated from the R-R intervals during 30-120 s. The face immersion significantly increased SD(RR) and CV(RR) ($P < 0.05$), and increased RRmean ($P < 0.05$) at 20 breaths x min(-1). Face immersion itself had no effect on oxygen uptake, tidal volume, end-tidal O_2 and CO_2 partial pressures. The diving reflex without breath-holding increased the heart rate variability, indicating that face immersion alone increases vagal activity.

Kinoshita, T., Nagata, S., Baba, R., Kohmoto, T., & Iwagaki, S. (2006). Cold-water face immersion per se elicits cardiac parasympathetic activity. *Circulation Journal*, *70*(6), 773-776.

BACKGROUND: Cold-water face immersion (FI) is known to produce physiological changes, including bradycardia, by stimulating the parasympathetic system. However, other factors such as sympathetic activity, intrapleural pressures, and changes in chemical mediators may also contribute to these changes. METHODS AND RESULTS: Eight healthy volunteers underwent a series of experiments designed to observe the effects of FI on heart rate and its variability, as detected using wavelet transformation. Each subject was instructed to bend over and put the entire face into an empty basin with and without breathing (protocols 1 and 2, respectively), and then perform FI in warm-water (protocols 3 and 4, respectively) and cold-water (protocols 5 and 6, respectively) while breathing and breath holding. Change in the R-R interval with FI was only significantly greater for protocol 6 than for the control procedure (protocol 1). Also, changes in the natural logarithm of high-frequency power with FI were significantly greater for protocols 5 and 6 than the protocol 1. CONCLUSIONS: Bradycardia associated with cold-water FI is mainly attributed to cardiac vagal

activity, which is independent of both the change in body position caused by bending over a basin and breath holding.

Mooventhan, A., & Nivethitha, L. (2014). Scientific evidence-based effects of hydrotherapy on various systems of the body. *North American Journal of Medical Sciences*, *6*(5), 199-209.

The use of water for various treatments (hydrotherapy) is probably as old as mankind. Hydrotherapy is one of the basic methods of treatment widely used in the system of natural medicine, which is also called as water therapy, aquatic therapy, pool therapy, and balneotherapy. Use of water in various forms and in various temperatures can produce different effects on different system of the body. Many studies/reviews reported the effects of hydrotherapy only on very few systems and there is lack of studies/reviews in reporting the evidence-based effects of hydrotherapy on various systems. We performed PubMed and PubMed central search to review relevant articles in English literature based on "effects of hydrotherapy/balneotherapy" on various systems of the body. Based on the available literature this review suggests that the hydrotherapy has a scientific evidence-based effect on various systems of the body.

Nestor, J. (2014, June 25). *Your body's amazing reaction to water.* Retrieved from https://ideas.ted.com/science_of_freediving/

Nestor, J. (2014). *Deep: Freediving, Renegade Science, and What the Ocean Tells Us about Ourselves*. New York, NY: Houghton Mifflin Harcourt.

Panneton, M. (2013). The Mammalian Diving Response: An Enigmatic Reflex to Preserve Life? *Physiology, 28*(5), 284-297.

The mammalian diving response is a remarkable behavior that overrides basic homeostatic reflexes. It is most studied in large aquatic mammals but is seen in all vertebrates. Pelagic mammals have developed several physiological adaptations to conserve intrinsic oxygen stores, but the apnea, bradycardia, and vasoconstriction is shared with those terrestrial and is neurally mediated. The adaptations of aquatic mammals are reviewed here as well as the neural control of cardiorespiratory physiology during diving in rodents.

Skolnick, A. (2016). *One Breath: Freediving, Death, and the Quest to Shatter Human Limits*. New York, NY: Crown Archetype.

Sramek, P., Simeckova, M., Jansky, L., Savlikova, J., & Vybiral, S. (2000). Human physiological responses to immersion into water of different temperatures. *European Journal of Applied Physiology, 81*(5), 436-442.

To differentiate between the effect of cold and hydrostatic pressure on hormone and cardiovascular functions of man, a group of young men was examined during 1-h head-out immersions in water of different temperatures (32 degrees C, 20 degrees C and 14 degrees C). Immersion in water at 32 degrees C did not change rectal temperature and metabolic rate, but lowered heart rate (by 15%)

and systolic and diastolic blood pressures (by 11 %, or 12%, respectively), compared to controls at ambient air temperature. Plasma renin activity, plasma cortisol and aldosterone concentrations were also lowered (by 46%, 34%, and 17%, respectively), while diuresis was increased by 107%. Immersion at 20 degrees C induced a similar decrease in plasma renin activity, heart rate and systolic and diastolic blood pressures as immersion at thermoneutrality, in spite of lowered rectal temperature and an increased metabolic rate by 93%. Plasma cortisol concentrations tended to decrease, while plasma aldosterone concentration was unchanged. Diuresis was increased by 89%. No significant differences in changes in diuresis, plasma renin activity and aldosterone concentration compared to subjects immersed to 32 degrees C were observed. Cold water immersion (14 degrees C) lowered rectal temperature and increased metabolic rate (by 350%), heart rate and systolic and diastolic blood pressure (by 5%, 7%, and 8%, respectively). Plasma noradrenaline and dopamine concentrations were increased by 530% and by 250% respectively, while diuresis increased by 163% (more than at 32 degrees C). Plasma aldosterone concentrations increased by 23%. Plasma renin activity was reduced as during immersion in water at the highest temperature. Cortisol concentrations tended to decrease. Plasma adrenaline concentrations remained unchanged. Changes in plasma renin activity were not related to changes in aldosterone concentrations. Immersion in water of different temperatures did not increase blood concentrations of cortisol. There was no correlation between changes in rectal temperature and changes in hormone production. Our data supported the hypothesis that physiological changes induced by water immersion are mediated by humoral control mechanisms, while responses induced by cold are mainly due to increased activity of the sympathetic nervous system.

Anxiety

Benfield, R. D., Hortobagyi, T., Tanner, C. J., Swanson, M., Heitkemper, M. M., & Newton, E. R. (2010). The effects of hydrotherapy on anxiety, pain, neuroendocrine responses, and contraction dynamics during labor. *Biological Research for Nursing, 12*(1), 28-36.

BACKGROUND: Hydrotherapy (immersion or bathing) is used worldwide to promote relaxation and decrease parturient anxiety and pain in labor, but the psychophysiological effects of this intervention remain obscure. DESIGN: A pretest-posttest design with repeated measures was used to examine the effects of hydrotherapy on maternal anxiety and pain, neuroendocrine responses, plasma volume shift (PVS), and uterine contractions (CXs) during labor. Correlations among variables were examined at three time points (preimmersion and twice during hydrotherapy). METHODS: Eleven term women (mean age 24.5 years) in spontaneous labor were immersed to the xiphoid in 37 degrees C water for 1 hr. Blood samples and measures of anxiety and pain were obtained under dry baseline conditions and repeated at 15 and 45 min of hydrotherapy. Uterine contractions were monitored telemetrically. RESULTS: Hydrotherapy was associated with decreases in anxiety, vasopressin (V), and oxytocin (O) levels at 15 and 45 min (all $ps < .05$). There were no significant differences between preimmersion and immersion pain or cortisol (C) levels. Pain decreased more for

women with high baseline pain than for women with low baseline levels at 15 and 45 min. Cortisol levels decreased twice as much at 15 min of hydrotherapy for women with high baseline pain as for those with low baseline pain. beta-endorphin (betaE) levels increased at 15 min but did not differ between baseline and 45 min. During immersion, CX frequency decreased. A positive PVS at 15 min was correlated with contraction duration. CONCLUSIONS: Hydrotherapy during labor affects neuroendocrine responses that modify psychophysiological processes.

Autism Spectrum Disorder

Health & You: Autism and Swimming. (2015, January 8). Retrieved from http://blog.intheswim.com/health-you-autism-and-swimming/

Lawson, L. M., & Little, L. (2017). Feasibility of a swimming intervention to improve sleep behaviors of children with autism spectrum disorder. *Therapeutic Recreation Journal, 51*(2), 97-108.

Children with ASD experience high rates of sleep disturbance, but there are limited interventions addressing sleep in this population. We investigated the feasibility and acceptability of a specialized swim program, Sensory Enhanced Aquatics, for children with ASD. Additionally, we examined the extent to which the physical activity intervention impacted children's sleep behavior as well as specific child characteristics in those most responsive to intervention. We used a pre-post intervention design to test the effects of an 8-week swim intervention on sleep of ten children aged 5-12 years. Caregivers completed measures of sleep disturbance, autism severity, and sensory processing. Findings showed that children differentially responded to the swim intervention based on autism severity and sensory processing. Children with increased sensory sensitivity and decreased autism severity showed decreased sleep disturbance following the intervention. Results showed that the intervention was feasible and highly acceptable. Sensory Enhanced Aquatics differentially improved the sleep behaviors of children with ASD based on specific child characteristics. This is relevant to recreational therapist who may need to match intervention to child characteristics for best response.

Depression

Shevchuk, N. A. (2008). Adapted cold shower as a potential treatment for depression. *Medical Hypotheses, 70*(5), 995-1001.

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 C, 2-3 min, preceded by a 5-min 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.