Received: 16 June 2021 | Revised: 8 September 2021 | Accepted: 15 October 2021

DOI: 10.1002/lim2.53

Lifestyle Medicine Open Access WILEY

ORIGINAL ARTICLE

Improved mood following a single immersion in cold water

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Abstract

Background: An increasing volume of anecdotal and scientific evidence suggests that mood may be enhanced following swimming in cold water. The exact mechanisms responsible are largely unknown, but may include the effects of exercise from swimming and the effects of cold. This study examined the effect on mood following immersion in cold water, where swimming was not the primary activity.

Methods: The Profile of Mood States (POMS) questionnaire was completed by 64 undergraduate students. The following week, 42 participants completed up to 20-min immersion (18′36″ ± 1′48″) in cold sea water (13.6°C). Twenty-two participants acted as controls. The POMS was completed immediately following the cold-water immersion by both groups.

Results: The cold-water immersion group showed a significant decrease, with a large effect size, of 15 points from 51 to 36, compared to 2 points in the control group, 42 to 40. Positive sub-scales increased significantly in the cold-water immersion group (Vigour by 1.1, and Esteem-Related Affect by 2.2 points) and negative sub-scales showed significant reductions (Tension by 2.5, Anger 1.25, Depression 2.1, Fatigue 2.2, and Confusion 2.8 points). The control showed no significant change except for depression, which was significantly higher after the period by 1.6 points.

Conclusion: Cold-water immersion is a well-tolerated therapy that is capable of significantly improving mood in young, fit, and healthy individuals. A key aim of this study was to control for the effects of swimming as a mechanism responsible for the improvement in mood which has been shown in previous studies. Thus, the change in mood evidenced in this study was not due to physical activity per se. Consequently, the hypothesis that cold in and of itself can improve mood is supported.

1 | INTRODUCTION

Have we become too comfortable? This question, posed by Tipton in 2019,[1] refers to the fact that humans have become increasingly sedentary and physiologically unchallenged due to the high degree of control we have imposed over our environment. Humans are endothermic, maintaining a near constant core temperature no matter what the temperature of their surroundings. Our modern western culture has provided an unprecedented level of thermal comfort. Central heating, air conditioning, readily available hot water, insulated housing, and clothing wrap modern humans in a constant comfortable environment that is a long way from the evolutionary crucible in which our genes were selected.[2,3] An increasing body of anecdotal evidence[4–6] and academic evidence[7,8] suggests that environmental stress that challenges our body's thermal equilibrium may produce significant health benefits.

Voluntary exposure to the elements is nothing new, and many cultures throughout history have engaged in such practices. For example, the Japanese have practised the ritual of bathing in hot springs heated by geothermal energy (Onsen), or by using baths specifically built for the purpose of relaxation and spiritual renewal (Ofuro), rather than just for washing. In Finland, the ancient practise of sauna is part of the national psyche. This practice involves alternating exposures to heated rooms followed by immersion in cold water or snow.[9] In Europe, the use of cold and hot water spas as centres of healing dates back at least as far as the Roman period. In 43 AD, having conquered most of southern Britain, the Romans set about building spa resorts. The first of these, Aquae Sulis, or modern-day Bath, is still a spa town, with the local bubbling hot springs filling the Thermea bath. The Romans were also aware of the curative properties of Lake Heviz in Hungary, now the home of St. Andrew's State Hospital for Rheumatology and Rehabilitation where balneological treatments are administered to hundreds of patients every year.

An increasingly popular form of environmental exposure is cold water swimming (CWS). Defined by Kolettis and Kolettis,[7] CWS is 'swimming when air and water temperatures are below 18 degrees centigrade'. CWS has a long history of participation all over the world. 'Polar Bear' clubs have an annual New Year's Day dip, and participation has been increasing year on year. On New Year's Day in 1976, 641 swimmers in Vancouver jumped into 6°C water; by 2019, this figure had risen to nearly 2000. In the United Kingdom, the Outdoor Swimming Society was founded in 2006 with 300 members, rising to a membership of 100,000 by 2020.[10]

This increase in popularity is surprising, given that CWS is not without serious risk. Historically, hypothermia was always regarded as the primary risk to health from cold water immersion, but the water temperature would need to be very cold, and the immersion time relatively long (30 min plus) before hypothermia would become an issue.[11] It is accepted that cold-water shock is the primary hazard accounting for the majority of deaths from cold-water immersion.[12] The cold-water shock response is triggered by a rapid reduction in skin temperature and is characterised by a sudden inspiratory gasp. This is followed by significant hyperventilation, increasing the risk of inspiring water, and tachycardia that considerably increases cardiovascular strain, thus significantly increasing the risk of drowning.[13] Given the potential for adverse responses, and the real risk of death from sudden exposure to cold water, the benefits of CWS must indeed be worth the considerable risks involved.

One potential benefit of CWS is a reduction in depression and a corresponding elevation in mood. CWS has been shown to reduce the symptoms of depression. Van Tulleken et al.[14] reported a case study of a 24-year old female suffering from intractable anxiety and major depressive disorder who had been pharmacologically treated since the age of 17 years. After completing 1 month of supervised open-water swimming, she was able to reduce her medication, and by 4 months she was medication free. Shevchuk[15] tested the hypothesis that cold water could relieve the symptoms of low mood and depression by using a daily progressive cold shower protocol over a 2-year period. He concluded that the acute effects of cold showers led to feeling energised, to increased optimism and well-being, and to the alleviation of fever and pain. Furthermore, the chronic effects of repeated cold showers induced an increased capacity for work, increased psychomotor processes, and a positive emotional state. It would appear that cold water was a sufficient thermal stressor to affect mood and promote positive feelings. Although these findings are encouraging, the investigations by Van Tulleken et al.[14] and Shevchuk[15] had very low numbers of participants: a single depressed female in the former and three participants in the latter, none of whom were clinically depressed.

Research by Demori et al.,[16] using a cross-sectional questionnaire design with over 200 participants, concluded that winter sea bathing was associated with higher perceived psycho-physical well-being. In a study by Huttunen et al.,[17] 36 participants completed a 4-month programme of winter swimming from October to January, and 23 non-swimmers acted as controls. At the beginning and at the end of the swim period, both groups completed the Profile of Mood States (POMS), and a subjective symptoms questionnaire. Following the programme, swimmers showed significantly lower scores for tension and fatigue compared to non-swimmers, and had increased vigour, better memory, and improved mood. In addition, in those swimmers who had reported symptoms such as pain before the programme, 40% reported pain relief as a result of the swim. This was a consistent finding irrespective of the diagnosis, rheumatism, asthma, fibromyalgia, or arthrosis. Individuals with chronic health conditions have higher rates of depression[18]; therefore, CWS might provide multiple treatment pathways, treating the depressive symptoms by elevating mood, and having a secondary effect by alleviating the pain associated with the chronic health conditions.

However, not all studies have shown positive effects. Lindeman et al.[19] found no significant differences in psychopathology between 25 winter swimmers and 11 control participants following a 4-month period of swimming. In fact, the mental health of both groups was good. Moreover, there was no change in psychopathology in the swimming group after the 4-month intervention. Despite the lack of improvement in the quantitative analysis, when asked the question of why they participated in winter swimming, swimmers gave responses such as 'Because of general well-being after swimming', 'To refresh the mood', and 'To improve coping with stress'. The comments clearly demonstrated the swimmer's strong beliefs in and conviction to the benefits of winter swimming. The studies by Demori et al.,[16] Huttunen et al.,[17] and Lindeman et al.[19] recruited participants who were already experienced winter swimmers, which may account for the differences seen. In addition, the recruitment of participants who are already winter swimmers may reflect a higher affinity for outdoor exercise and connection to nature. In a recent study by Massey et al.,[20] 61 novice swimmers enrolled on a 10-week open-water swimming programme. The POMS was administered before and after the first swim, which was in a pool, before and after their first open-water swim, and before and after their final swim. The results were compared against 22 non-swimming controls. The swimmers showed significant increases in the positive sub-scales and decreases in the negative sub-scales. Total mood disturbance was therefore reduced following each swim. In addition, reductions in the negative sub-scales, and total mood disturbance, was recorded over the duration of the 10-week programme. In contrast to previous work,[16,17,19] Massey et al.[20] delivered the open-water swim programme during the summer months in the United Kingdom, and all participants wore wetsuits, thus confounding the comparisons between the effects of the interventions, as the water temperatures would be significantly different between winter in Scandinavia and summer in the United Kingdom. However, cold-shock responses are still likely given the average water temperatures in the United Kingdom are still considered 'cold', and although wetsuits do allow for an increase in immersion time, cold shock is still experienced as the suit is flooded with cold water. Furthermore, all studies have used a swimming programme, yet anecdotal evidence suggests that the benefits from cold water may be acquired by 'dipping' rather than swimming, and this is supported by the research of Shevchuk.[15]

So far, the studies by Van Tulleken et al.[14] and Shevchuk[15] were completed over several months to years, and the only studies that have quantitatively assessed changes in mood showed a significant increase following 2–4 months of regular swimming in either cold water or open water.[17,20] Although Massey et al.[20] did record significant changes in mood following open-water swimming, it is currently unknown what the acute effect of cold-water immersion is on mood when swimming is not the primary activity. Therefore, our primary hypothesis suggests an increase in positive mood following immersion in cold water without swimming as an activity. In addition, we recorded participant's connectedness to nature to assess possible bias in the sample due to the cold-water immersion participants having a higher affinity for nature.

2 | METHOD

2.1 | Participants

Following ethical approval and informed consent (UoC 2021_42), 64 undergraduate students were recruited from 82 students studying sport-related degrees at the University of Chichester (Figure 1). After initial screening using a health history questionnaire, the following groups were excluded from the study: a history of hypertension or hypotension, diagnosed cardiovascular disease, a diagnosis of circulatory disease such as Raynaud's disease or peripheral vascular disease, depression or anxiety disorders, or the treatment for mental health issues. Previous research has shown these groups are susceptible to changes in blood pressure and or cardiac arrhythmias,[11] non-freezing cold injuries,[21] or medications that would alter mood. A further 18 declined to participate. Subsequently, participants selected either the control group (CON $n = 22$) or the cold-water immersion group (CWI $n = 42$) based on whether they wished to complete the immersion protocol. As with all studies of this type, selection was undertaken on a voluntary basis once participants had been given sufficient information about the study. The research on winter swimmers in Scandinavia used participants who were already winter swimmers and Massey et al.[20] recruited participants who wanted to take part in open-water swimming. We recruited students that wanted to be immersed in cold water. The control groups were willing to complete the testing, but were not willing to participate in the swimming or the immersion. Therefore, a clear selection bias exists between those wanting to get cold and wet and those who do not. This will reflect many aspects of participant choice. We speculated that affinity for the outdoors and connectedness to nature might play a part in the recruitment process, and as such participants completed the Connectedness to Nature Scale. The average age was 21 ± 2 years for the CON group and 23 ± 6 years for the CWI group.

2.2 | Procedures

At baseline, a week prior to the immersion, all participants completed a questionnaire booklet recording basic demographic variables, the short version of the POMS,[22] and the Connectedness to Nature Scale[23] as detailed below. Baseline questionnaires were completed indoors in small groups of six. The CWI group completed the POMS immediately following the immersion whilst on the beach. The CON group completed the POMS within 1 day of the immersion whilst indoors on the university campus. Thus, a 7- or 8-day period separated the time points for completing the POMS.

2.3 | CWI protocol

The CWI group was driven in small groups by mini-bus to a local beach approximately 20 min from the university campus. It was not feasible to transport all participants in 1 day, so testing was completed over a 3-day period – 22 on day 1, 11 on day 2, and 11 on day 3. The weather conditions on the first day were good. The sea state was calm, with a brisk onshore breeze and ambient temperature was recorded at 14°C. The second and third day of testing, weather conditions were poor. The sea state was rough, with consistent swell and a strong onshore wind gusting to 30 mph. The ambient temperature was 11°C, and the water temperature across the 3 days averaged 13.6°C (see Figure 2). Participants were asked to wade out into chest-deep water and to maintain their position. This was easily achieved on day 1, but on day 2 and day 3 participants often had to brace themselves against the oncoming swell, and in some cases swim to maintain their position in the sea. The advice given was to maintain a 'head-out' position, but face immersion as a result of the waves, or swimming, did occur. Participants wore minimal clothing, for example shorts or swimming costumes. The immersion time was voluntary up to a maximum of 20 min and was recorded when the participant exited the water. Water temperature in the United Kingdom in early November 2020 was between 13 and 15°C. In these conditions, hypothermia was not a risk, as it takes at least 30 min for hypothermia to develop even in ice-cold water.[11] However, investigators remained vigilant for the following key symptoms: cold pale skin, blue lips, tiredness, confusion, fast breathing, and/or slurred speech. During the immersions, there was lifeguard cover, beach cover, and kayak cover. Investigators were first aid trained. Additionally, a hypothermia treatment pack was available in the vehicles which included blankets, warm drinks, and sugary snacks. Immedi-

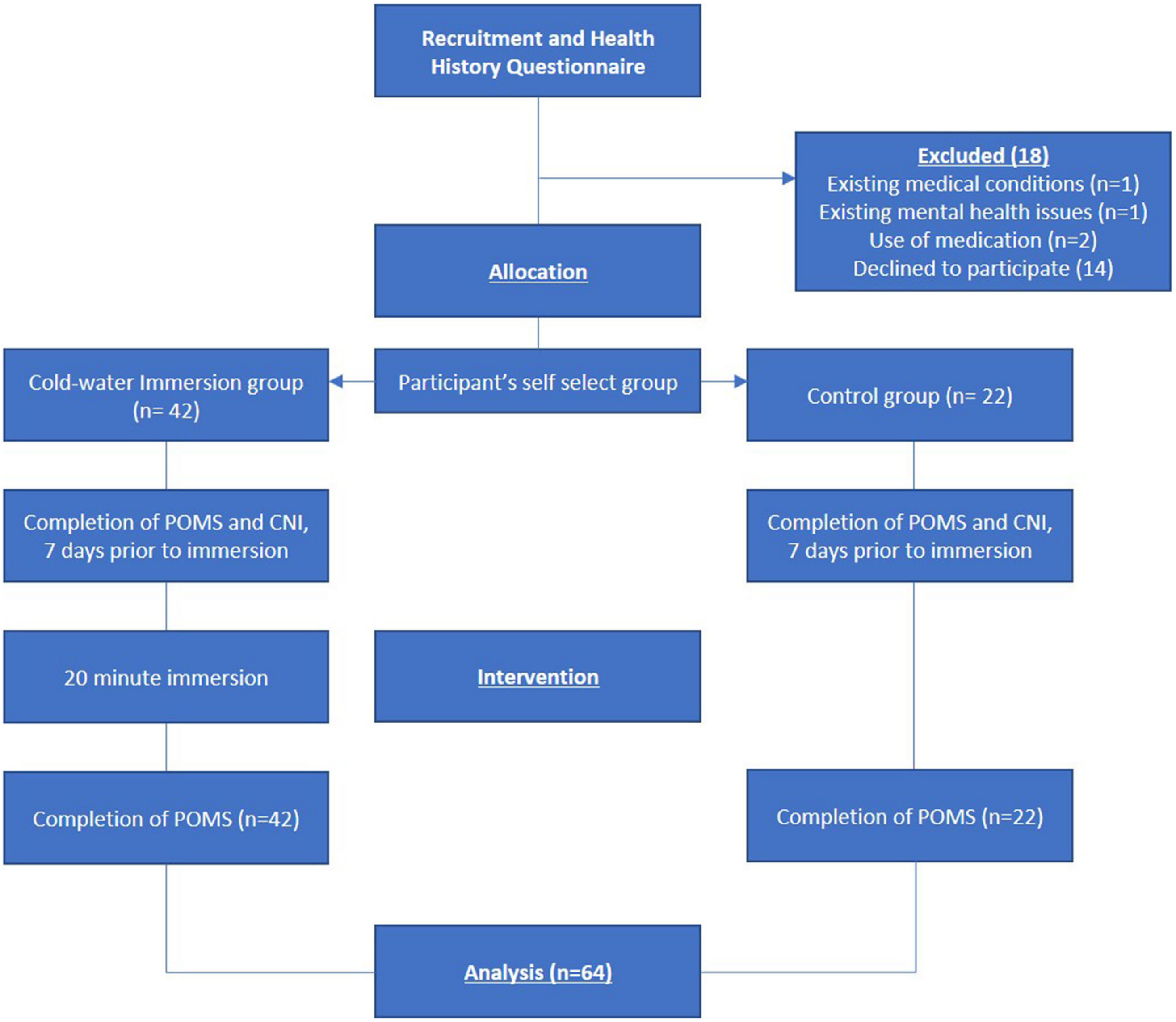

FIGURE 1 Participant selection consort diagram

FIGURE 2 Cold-water immersion

ately after the immersion, participants dried and dressed quickly, ate snacks, and consumed hot drinks. Hats and gloves were recommended, and spares were available in the vehicle. Participants then completed the short version of the POMS questionnaire. A common and well-documented consequence of cold-water immersion is 'after drop'.[24] In this investigation, the participants engaged in limited activity, thus the 'after drop' experienced was likely due to conductive processes. It is a natural feature of cold-water immersion and often elicits shivering. Participants were made aware that this might happen and were reassured when it did, as it can be quite unnerving.

2.4 | Profile of Mood States (Short Form)

The original POMS was developed by McNair, Lorr, and Doppleman in 1971.[25] It is a psychological rating scale used to assess transient changes in mood. This 65-item inventory assesses Total Mood Disturbance, which is composed of the following negative mood sub-scales: Tension, Anger, Depression, Fatigue, Confusion, and the positive mood sub-scale, Vigour. It has been used extensively and has good psychometric properties, but it can take some time to complete. This has resulted in a shortened version, the POMS short form, developed and tested by Shacham.[22] Further research by Curran et al.[26] concluded the POMS short form had excellent correlations with the original version ($r > 0.95$) whilst substantially reducing the response burden. In addition, this questionnaire has been used in previous research on CWS and has been shown to be sensitive to change.[17,20] Six further questions assessed 'Esteem-Related Effects'. High values on the negative mood sub-scales indicated significant mood disturbance, as did low values on the positive sub-scales. Total Mood Disturbance was calculated by summing the negative sub-scales and subtracting Vigour and the Esteem-Related Effects. A constant of 50 was then added to the score to avoid negative values. High scores indicated greater Total Mood Disturbance (TMD).

2.5 | Connectedness to nature scale

The Connectedness to Nature Scale was developed by Mayer and Frantz[23] as an empirical tool for assessing the relationships between humans and the natural world. In the original paper, the researchers completed a series of five studies, concluding the scale had strong construct validity and good reliability (Alpha score of 0.82). The scale has been used extensively. The 14-item inventory is simply scored by either summing the response, to give a range from 14 to 70 (as in this study), or by averaging the responses giving a range from 1 to 5.

2.6 | Data analysis

Data were checked for normal distribution using skewness and kurtosis ratios. Normal distribution was accepted if the values fell within plus and minus 2. Total mood disturbance was normally distributed for both groups and was analysed using a two-way mixed model ANOVA (Control vs. CWI, and pre- vs. post-swim). Effect size (ES) for the ANOVA was calculated using partial Eta squared. Post hoc analysis for the ANOVA was completed using *t*-tests, with effect size calculated using Cohen's *d*. Connectedness to Nature and the sub-scales of the POMS were not normally distributed and therefore non-parametric tests were used to assess differences between groups (Mann–Whitney *U*) and differences over time (Wilcoxon). Effect sizes for non-parametric comparisons were calculated using matched rank biserial correlation. Data are presented as means ± standard deviations. Statistical significance was accepted if *p*-value was less than 0.05.

3 | RESULTS

This investigation successfully immersed 42 participants in cold water of 13.6°C. All participants were naive to the practice of cold-water immersion; however, the majority managed to complete the maximum duration of 20 min. The average immersion time for the group was 18′36″ ± 1′48″. There were no significant adverse events during or following the immersion. One female participant withdrew after 16 min reporting that she felt light-headed, but this quickly passed, and she reported that she felt well by the time the others in her group had left the sea. One male withdrew after 13 min reporting that he felt very cold. In addition, a minor incident leaving the sea resulted in a cut to the lower leg of one female participant; this was treated on the beach. Following the immersion, many participants said that they had enjoyed the experience. One female said that she 'really didn't enjoy it at all' and would never do it again.

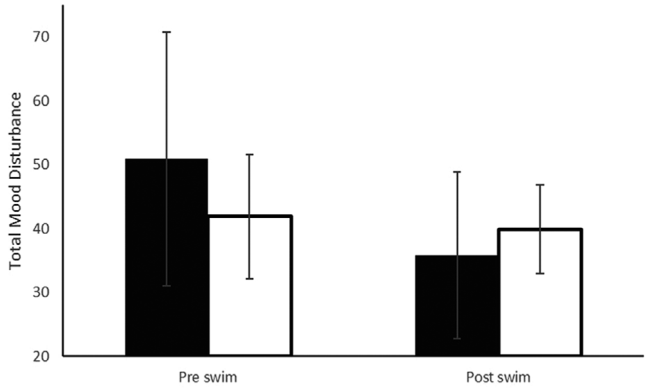

FIGURE 3 Total Mood Disturbance (TMD). Solid bars – cold-water immersion group; open bars – control group

There was no significant difference between the groups for connectedness to nature (total score, CON 46.6 ± 5.6, CWI 48.8 ± 6.3), nor were there significant differences between genders, or across the three days of testing. Therefore, the results are presented for the Control and CWI groups in Figure 3 (TMD) and Table 1 (POMS sub-scales).

Overall, Total Mood Disturbance was not significantly different at baseline between the Con group and the CWI group (Figure 3). The ANOVA showed a main effect for time (decreased TMD) with a large effect size ($F_{(1,62)} = 15.8$, $p < 0.001$, ES = 0.071). The interaction was also significant ($F_{(1,62)} = 9.3$, $p = 0.003$, ES = 0.041). Post hoc *t*-tests indicated a significant reduction with a large effect size in TMD for the CWI group from 51 to 36 points ($t_{(41)} = 5.0$, $p < 0.001$, ES = 0.773), with no change in the CON group, 42–40.

At baseline, the CWI group differed significantly from the CON group in having higher levels of negative mood disturbance for Depression, Fatigue, and Confusion, but significantly higher positive mood for Vigour (Table 1). CWI significantly reduced all negative mood sub-scales with effect sizes ranging from medium to large (Tension by 2.5, Anger 1.25, Depression 2.1, Fatigue 2.2, and Confusion 2.8 points). The controls showed no significant change except for depression, which was significantly lower by 1.6 points. CWI significantly increased both positive sub-scales with large effect sizes (Vigour by 1.1 and ERA by 2.2 points) (see Table 1).

Comparisons between the groups following the cold-water immersion indicated that for the CWI group negative subscales were lower

TABLE 1 Changes in Profile of Mood State sub-scales in CWI and Control group before and after cold-water immersion

	Before cold-water immersion		After cold-water immersion		
	CWI	Controls	CWI	Controls	Effect size
Tension	4.6 ± 4.5	2.5 ± 2.4	**2.1 ± 2.3**	3.0 ± 2.1	0.514
Anger	2.1 ± 2.7	1.2 ± 1.9	**0.85 ± 1.6**	1.2 ± 2.5	0.559
Depression	2.9 ± 4.7	0.3 ± 0.4*	**0.77 ± 2.1**	**1.3 ± 1.7**	0.616
Fatigue	6.4 ± 4.5	3.4 ± 2.3*	**4.2 ± 3.6**	3.2 ± 2.6*	0.429
Confusion	5.8 ± 4.3	3.6 ± 3.3*	**3.0 ± 3.0**	3.0 ± 2.7	0.848
Vigour	7.1 ± 3.5	5.1 ± 3.7*	**8.2 ± 4.1**	7.2 ± 3.7*	−0.588
Esteem-related effects	14.1 ± 3.6	14.1 ± 3.3	**16.3 ± 3.6**	15.4 ± 4.0	−0.780

Note: Results are means ± SD. Asterisk indicates significant difference between CWI and Control groups (Mann–Whitney). Bold text indicates significant change from before to after the cold-water immersion (Wilcoxon). Effect size represents the change from before to after immersion in the CWI group.

and no longer significantly different from the CON group, except for Fatigue, which, although significantly lower than baseline, remained statistically higher than the CON group. Vigour and Esteem-Related Effects were now significantly higher than the control group (Table 1).

4 | DISCUSSION

This study recorded the acute change in mood following a 20-min immersion in cold water for a group of participants naive to cold-water immersion. The scores were compared to an age-matched control group, who also did not differ in their connectedness to nature score. We have shown that mood can be significantly improved following a single bout of cold-water immersion lasting approximately 18 min, even without participating in swimming as the primary activity. Instead, participants were immersed in chest-deep water and required to hold their position. Following the immersion, the CWI group felt less negative mood disturbance on all sub-scales of the POMS, and showed significantly increased vigour and esteem-related effects. The control group showed no such change with the exception of a significant increase in the depression sub-scale. The findings are consistent with previous research, in particular, those of Huttunen et al.,[17] who also demonstrated reduced negative mood and increased positive mood on the POMS following 4 months of regular winter swimming, and Massey et al.,[20] who demonstrated acute changes in mood following a pool swim and open-water swimming. Furthermore, our findings provide quantitative support for the work of both Van Tulleken et al.[14] and Shevchuk[15] and reinforce the conclusions of Demori et al.[16] that winter swimmers have higher perceptual well-being.

A key aim of this study was to record the acute changes in mood following immersion in cold water. With the exception of Massey et al.,[20] all other studies have assessed the change in mood over a much longer time period, generally months to years.[14,15,17,19] Our study confirms that the therapeutic benefits of cold water may be gained from a single exposure. Furthermore, the immersion was remarkably well-tolerated in the CWI group, albeit they were young, fit, and healthy individuals. Our study also sought to remove swimming as the primary activity, and thus exclude the potential for the effect to have come from the exercise rather than the immersion. It is well documented that exercise in and of itself can improve mood.[27] Moreover, structured and supervised pool swimming has been shown to improve mood[28] and reduce anxiety and depression.[29] The participants in the CWI group did move around to maintain the position in the sea, particularly on the second and third days when the conditions were more difficult, but they refrained from swimming for more than a couple of strokes. Thus, the improvement in mood cannot be attributed to swimming per se. Although the effects of movement and low-level exercise remain as confounding elements, the participants were sport students accustomed to much longer bouts of physical activity, and such a short-duration and low-intensity activity would be unlikely to have a significant effect.

In contrast, another significant difference between this study and the work of Massey et al.[20] was the nature of the immersion. Massey et al. introduced their swimmers to sea-swims through pool-based swims, using wetsuits for thermal protection and buoyancy. Clearly, although the use of wet suits does not prevent cold shock, the thermal protection is increased, reducing the environmental challenge of cold-water immersion and prolonging swim time. Our participants wore minimal clothing, usually shorts or a swimsuit, thus maximising the contact with the sea, likely provoking a strong vasoconstrictive effect.[30] Previous research, such as Huttunen et al.[17] and Lindeman et al.,[19] exposed their participants to water temperatures which were likely to be well below those experienced by the participants in the study by Massey et al's.[20] or the participant in Van Tulleken et al's.[14] study. We reported water temperatures of 13.6°C which likely fall somewhere between the water temperature in Massey et al's[20] study and the research carried out in Scandinavia. It is still difficult to isolate whether the effect on mood arises from the swimming, the cold shock response, or the temperature of the water. Our study would suggest that water temperature does have a role to play. An important point to consider is the discrepancy in the 'dose' of cold-water immersion that participants received in this study and across other studies. In this context, the dose refers to the combination of several factors including the water temperature, the duration of the immersion, and the exposed surface of skin in contact with the water. Clearly, these factors are worthy of further investigation in order to better describe the underlying mechanisms and to provide a more targeted approach to the therapy.

If we accept the evidence, such as it is, that CWS and or CWI can improve mood and reduce depression, the putative relationship between the variables must demonstrate plausible biological mechanisms. Currently, there are several key theoretical concepts which help to build a plausible biological case for the association between cold water and mood. These include exercise,[27,31] group and social interactions,[32] blue space,[33,34] contact with nature,[35] the hydrostatic pressure of water, the cold shock response,[36] and the adaptive responses which accompany habitual cold exposure[37] or, more likely, a combination of them all.

Although this study did not investigate the physiological mechanisms responsible for triggering the change in mood, it is likely that the cold shock response is pivotal in bringing about the effect. There is a considerable body of material which has investigated cold shock from the perspective of risk. Early work from the 1960s onwards, such as that of Keatinge,[38] investigated the detrimental effects of cold shock on survival following sudden cold-water immersion, and the work of Tipton[12] has confirmed cold shock as the primary hazard associated with death from drowning. It is somewhat ironic that the physiological responses deemed detrimental to human survival might also hold the key to the positive effects we see in mood. Although the precise mechanisms are still to be clarified, previous research has shown a single immersion in cold water triggers a stress reaction, increasing the activity of the nervous system, activating both the sympathetic–adrenal–medullary and the hypothalamic–pituitary–adrenal (HPA) axes.[30] This generalised response to CWI includes the release of cortisol[39] and increased secretion of the catecholamines.[36] However, not all studies have shown this to be the case.[40] The interaction between the nervous system and the endocrine system is complicated and shows much inter- and intra-variability. That aside, both increased cortisol and increased beta-endorphin have been associated with better psychological health. Zorrilla, DeRubeis, and Redei[41] showed that individuals who had higher levels of circulating cortisol and beta endorphin were more emotionally stable, hardier, and had higher self-esteem, suggesting a strong relationship between psychological health and the HPA axis. Furthermore, Harte, Eifert, and Smith[42] showed that increased mood following running or meditation was associated with increased plasma corticotropin-releasing hormone (CRH). CRH is released in response to stress, but Harte et al.'s paper was the first to demonstrate elevations in CRH following an activity that was not overtly physically stressful. The increase in mood following running was also associated with elevated beta endorphin, but this was not the case following meditation. CRH is a key hormone that is responsible for production of cortisol and other biologically active substances including beta endorphin. Stress is still an important component linking the release of CRH, with the subsequent release of beta endorphin. Irrespective of which mechanisms are responsible for the change in mood following CWI, the likelihood is that they all share common pathways that involve the HPA axis. It is currently unknown as to which component (or combination of components) of CWI is responsible for the positive changes in mood, but our research does suggest that cold shock is an important feature, but continued cooling of the body might also represent a mechanism. The participants in this study were immersed for approximately 18 min. Currently it is unknown what length of time immersed in cold water is required before changes in mood could be expected. The cold shock phase typically lasts 0–3 min,[43] after which sympathetic activity declines, although never reaching resting values,[12] and perhaps a greater duration in the cold is required. Further research should aim to determine the minimum time requirement that elicits a quantifiable change in mood and to establish whether a dose–response relationship exists.

This study has clear limitations in terms of the selection of participants. Other than the selection issues highlighted in the method, it may be the case that individuals with low mood may be more motivated to take part in the study than those individuals who consider their mood to be good. This may reflect an individual's hope that a particular treatment would help alleviate low mood. This was born out to some extent in our data. Although there was no significant difference in total mood disturbance at baseline, the CWI group, in comparison to the control group, had significantly higher scores for the negative sub-scales of depression, fatigue, and confusion. Although somewhat counterintuitively, the positive sub-scale for vigour was higher in the CWI group than in the controls. Having unmatched groups at baseline is an issue, but it would be unlikely that groups could be matched across all six subscales. The higher negative mood in the CWI may reflect their decision to participate in the study. CWI has received a relatively high degree of media attention recently, and perhaps those individuals with worse mental health are more likely to volunteer as participants and 'give it a go'. Furthermore, participants were not randomly allocated to the CWI or the control group, due to their preferences for participation. Rather than relying on control groups composed of 'non-willing' volunteers, future studies should consider randomising participants willing to undergo CWI to a treatment group and a control group. One final point may reflect that the pre-measure for the POMS was completed indoors, and the post measure, for the CWI group, outdoors.

In conclusion, cold-water immersion is a well-tolerated intervention that is capable of acutely increasing mood in young, fit, and healthy individuals. The CWI group saw a significant improvement in total mood disturbance, which occurred through a reduction in all negative mood sub-scales and an increase in all positive mood sub-scales. The control group scores did fluctuate between the baseline measure and 7–8 days afterwards, but only the sub-scale for depression showed a significant change. There was no significant difference between the groups for connectedness to nature, and we reject the hypothesis that participants who engage in the practice of CWI are more connected to nature than those who are not. Furthermore, the participants in this study did not swim and wore only minimal clothing. Thus, we can rule out the effects of physical activity per se and speculate on the mechanisms which may be responsible for the improvement in mood, that is cold shock and/or prolonged body cooling. Consequently, the hypothesis that cold water can improve mood is supported. Although this study has focused on the effects of cold-water immersion in a natural environment, there may well be other factors that are responsible for the changes in mood. These include the social aspects of the group, or the general effect of nature, and the dose of CWI received.

Therefore, further research is required to continue to untangle this complicated and enigmatic therapy.

4.1 A cautionary note

Cold-water immersion is not without significant risk. Cold shock can cause death from cardiac arrhythmias and via inhalation of water through the involuntary gasp response.[12] This was tragically highlighted by the death of a 14-year-old boy, who in the summer of 2015 jumped into the River Wear and suffered a fatal heart attack due to cold shock.[44] Over a summer weekend in the summer of 2021, six deaths were recorded in rivers and lakes of England.[45] We recommend that individuals wishing to engage in cold water immersion should take some simple precautions to mitigate the risk from cold shock. Above all, a slow and controlled entry into the water reduces the effect of cold shock. This can be done by splashing water onto the body and face before full immersion and by moving slowly into deeper water. Cold shock causes hyperventilation which significantly reduces breath hold time. Again, this can be reduced by a slow and controlled entry and not to proceed further into the water until breathing is under control. Consider starting in the summer months when the water temperature is warmer and gradually adapt to the colder months. It is prudent to go with a friend or be accompanied by someone who has experience of cold-water immersion. There are now many groups which offer 'newbie' sessions, and there is good advice on the Outdoor Swimming Society website. If there are underlying health conditions such as high blood pressure or heart disease, a discussion with a general practitioner is recommended.

ACKNOWLEDGEMENTS

The authors wish to thank the participants, the lifeguards, and West Wittering estates for granting access to the beach.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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How to cite this article: Kelly JS, Bird E. Improved mood following a single immersion in cold water. *Lifestyle Med*. 2022;3:e53. https://doi.org/10.1002/lim2.53