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EDITED BY
Hamdi Chtourou,
University of Sfax, Tunisia

REVIEWED BY
Jessica Anne Mee,
University of Worcester,
United Kingdom

*CORRESPONDENCE
Metodija Kjertakov,
metodija.kjertakov@live.vu.edu.au

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# Hot water immersion could be an effective alternative to physical exercise in improving cardiovascular fitness during the COVID-19 pandemic

Metodija Kjertakov* and Aaron Petersen

Institute for Health and Sport, Victoria University, Melbourne, VIC, Australia

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Recent reports of a significant association between increased cardiorespiratory fitness (CRF) and reduced risk of developing severe coronavirus disease-2019 (COVID-19) symptoms (Brawner et al., 2021; Ekblom-Bak et al., 2021) point out the need for interventions to improve CRF in the general population. Papers published in this (Wang et al., 2020) and other journals (Dixit et al., 2020; Ranasinghe et al., 2020; Rodríguez et al., 2020; Sá Filho et al., 2020; Khoramipour et al., 2021) have already provided exercise recommendations for increasing and maintaining CRF during the COVID-19 pandemic. However, none of those papers have recognised that there are individuals who, due to temporary or permanent disabilities, are unable to exercise. Consequently, no alternative strategies to physical exercise have been provided. This paper intends to fill that gap in the COVID-19 literature.

Currently, several lines of evidence (Miyamoto et al., 2005; Ohori et al., 2012; Bailey et al., 2016; Hesketh et al., 2019) indicate that passive heat exposure may serve as an effective alternative to aerobic exercise training in improving CRF. Two of the four available studies in this research area have directly compared the effects of passive heat exposure with those of traditional exercise on CRF assessed by measuring peak oxygen uptake ($\dot{V}O_{2peak}$) during an incremental test to exhaustion administered before and after the interventions (Bailey et al., 2016; Hesketh et al., 2019). In the study by Bailey et al. (2016), 18 healthy, recreationally active, females ($\dot{V}O_{2peak}$ = ~36 ml·kg$^{-1}$·min$^{-1}$) performed 8 weeks of moderate-intensity cycling training ($n$ = 9) or hot (42 °C) water immersion to the sternum ($n$ = 9) for 30 min three times per week. Interestingly, the magnitude of increase in the $\dot{V}O_{2peak}$ value post-interventions was almost identical between the groups (~5.5%). Hesketh et al. (2019) allocated 20 sedentary males ($\dot{V}O_{2peak}$ = 46 ml·kg$^{-1}$·min$^{-1}$) to 6 weeks of either resting in a heat chamber at 40°C for 40–50 min, three times per week ($n$ = 10) or time-matched moderate-intensity cycling training ($n$ = 10). Following the interventions, the passive heat exposure group experienced an increase in $\dot{V}O_{2peak}$ comparable (5%) to that of the exercise training group (7%). Although the other two studies (Miyamoto et al., 2005; Ohori et al., 2012) did not include an exercise group, their findings confirm the cardiovascular benefits of passive heating in a clinical

population. Indeed, Miyamoto et al. (2005) reported improved exercise tolerance by 15% in 15 hospitalised patients with chronic systolic congestive failure following a heating treatment consisting of 5 weekly 15–20 min sauna (60°C) bathing sessions performed over 4 weeks. In 5 of those patients, the researchers also administered a $\dot{V}O_{2peak}$ test and observed an increase in their post-intervention $\dot{V}O_{2peak}$ by 22%. The study by Ohori et al. (2012) recruited 41 patients with chronic heart failure to examine the effects of sitting in a 60 °C sauna room for 15 min, five times a week, for 3 weeks on exercise tolerance (in all patients) and $\dot{V}O_{2peak}$ (in 20 patients). The heating therapy improved exercise tolerance by 12% and increased $\dot{V}O_{2peak}$ by 8%.

In addition to the beneficial effects on CRF, there is also evidence that passive heating may improve skeletal muscle contractile function. In a study conducted on 14 healthy males, Racinais et al. (2017) found increased peak twitch amplitude and maximal voluntary torque of the soleus muscle following 11 consecutive days of whole-body heat exposure (1 h per day) in a heat chamber at 48–50°C. Given that weak muscle strength may predispose a person to severe COVID-19 (Cheval et al., 2021), the findings of Racinais et al. (2017) are highly relevant in the context of strengthening the resilience to severe forms of the disease in individuals unable to exercise. Other documented exercise mimetic properties of passive heat treatment in the form of sauna bathing and hot water immersion include reduced body weight, improved glycemic control in people with type 2 diabetes mellitus, reduced depression, and improved appetite, sleep quality, and wellbeing (Dorsey et al., 1996; Hooper et al., 1999; Naumann et al., 2017; Hayashi et al., 2022).

Obviously, of the heating methods mentioned in the two preceding paragraphs, hot water immersion has the highest practical value because many households possess the necessary equipment (i.e., a bathtub and hot water) for its implementation. Furthermore, hot water immersion is, in general, deemed safe (Thompson et al., 2017). Although heat illness has been pointed out by some as a potential consequence of taking a hot bath (Hoekstra et al., 2020), no ill health effects were observed in studies that had participants with impaired thermoregulatory capacity (i.e., spinal cord injury and diabetic patients, and elderly people) submerged up to the nipple line/neck in 39°C–42°C water for 20–60 min (Hooper et al., 1999; Gass et al., 2001; Rivas et al., 2016; Akerman et al., 2019; Yamashiro et al., 2020; James et al., 2021). Theoretically, the risk for heat stroke associated with the hot water immersion treatment described by Bailey et al. (2016) previously in the text is low because this treatment induces an increase in body core temperature no higher than 38°C. The onset of heat stroke is associated with core temperatures above 40°C (Costrini et al., 1979; Aarseth et al., 1986; Epstein et al., 1995; Kjertakov and Epstein, 2013). Available evidence indicates that hot water immersion is generally only contraindicated in people with epilepsy, as in some of this population hot bathing can provoke seizures (Stensman and Ursing, 1971; Satishchandra et al., 1988; Bebek 2001; Yalçın et al., 2006). It also needs to be noted that hot water immersion may cause transient symptomatic hypotension in some individuals (Turner et al., 1980).

Based on the findings of Bailey et al. (2016), sitting three times a week for 30 min in a bath filled with 42°C water up to the sternum (arms outside the water) for 2 months is expected to improve CRF in individuals with low fitness levels (i.e., $\dot{V}O_{2peak}$ $<50\ ml{\cdot}kg^{-1}{\cdot}min^{-1}$). Other possible beneficial effects of this treatment may include enhanced muscle contractility and improved mental health. However, it is unknown whether maintaining the same frequency and duration of the hot water immersion sessions beyond the 2 months treatment period will keep improving CRF. Based on the principles of adaptation theory (Adolph, 1955), one may assume that longer or more frequent hot water immersion sessions would be required to achieve further improvement in CRF. Nevertheless, long-term hot water immersion studies are needed to confirm that assumption. Currently, there is sufficient evidence to suggest that passive heating could be an effective alternative to physical exercise in improving CRF in people who cannot exercise, with hot water immersion being the most practical existing heating method.

## Author contributions

MK conceived the idea, performed the literature search, and wrote the manuscript. AP reviewed the manuscript. Both authors contribute to the article and approved the final version.

## Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

## Publisher's note

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