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Martin Barwood Ph.D.
Leeds Trinity University (UK)

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Predicting the Magnitude and Duration of the Life-Threatening Cold Shock
Response on Accidental Immersion: Estimating the Risk of Drowning
Martin J Barwood[1]*

Corresponding Author* [1]Leeds Trinity University,
Department of Sport, Health and Nutrition, Horsforth, Leeds, U.K.
M.Barwood@leedstrinity.ac.uk

Introduction

Drowning is a leading cause of accidental death. In cold-water, sudden skin cooling triggers the life-threatening cold shock response (CSR). The respiratory component of the CSR includes an inspiratory gasp and uncontrollable hyperventilation both of which increase the risk of water entering the airway and lungs leading to death by drowning. We estimate that this component of the response accounts for 90% of unintentional drowning. The cardiovascular component is also hazardous and includes an increase in heart rate, blood pressure and reduction in peripheral blood vessel diameter (i.e. vasoconstriction) thereby increasing cardiovascular strain. Abnormal heart rhythms (i.e. arrhythmias) are also likely to occur. We estimate approximately 10% of drowning cases can be attributed to a cardiovascular mechanism of impairment. Collectively, any intervention that reduces or increases the CSR may, in part, alter the risk of death by drowning on accidental immersion. Clearly it would be advantageous to know *before* accidental immersion occurs which variables are likely to influence the extent of the CSR and who is at greatest risk. For example, to date it is known that some CSR components can be reduced by habituation (i.e. reduced response to stimulus of same magnitude) induced by 3 to 5 short cold-water immersions (CWI). Other factors known to alter the CSR include but are not limited to aerobic fitness, prior training and rate of water entry.

Purpose

In the present research we have been exploring if we can predict the magnitude of the CSR with key variables collected *prior to immersion* with a focus on psychological components. In previous experiments we have shown that high levels of anxiety, a plausible emotion during the life-threatening situation of CWI: magnifies the CSR in participants who are not accustomed to CWI (i.e. unhabituated participants), reverses habituated components of the CSR and prevents/delays habituation when high levels of anxiety are experienced concurrent to immersions suggesting anxiety is integral to the CSR. Accordingly we examined whether *prior* ratings of acute anxiety are predictive of components of the CSR *during* immersion. Secondly, we sought to examine whether anxiety ratings correlated with components of the CSR *during* immersion. We were also interested if these relationships were changed by undergoing habituation (i.e. repeated immersions in to cold water). These possibilities were assessed with a view to developing a list of plausible predictors of the CSR in order to protect those at greatest risk of drowning if accidentally immersed.

Method

Forty-eight unhabituated participants completed one initial seven-minute immersion in to cold water (15°C). Due to novelty they were naturally highly anxious prior to this immersion (IMM1). Of that cohort, twenty-five participants completed four further CWIs that would ordinarily induce CSR habituation. They then completed a control immersion (CON2) or an immersion where anxiety level was increased *prior to* immersion by undertaking a cognitively stressful task (i.e. mental arithmetic; CWI-ANX). Multiple regression analysis was used to identify components of the CSR (i.e. extent of respiratory and cardiovascular response) from the most life-threatening period of immersion (1st minute) predicted by the anxiety rating *prior to* immersion. Relationships between anxiety rating and CSR components *during* immersion were assessed by correlation.

Results

Anxiety rating predicted the heart rate component of the CSR in unhabituated participants (IMM1; $p<0.05$, $r=0.536$, $r^2=0.334$). After habituation immersions anxiety rating predicted the respiratory frequency component of the CSR when anxiety levels were lowered in the control immersion (CON2; $p<0.05$, $r=0.566$, $r^2=0.320$) but predicted the heart rate component of the CSR ($p<0.05$, $r=0.518$, $r^2=0.268$) when anxiety was increased (CWI-ANX) suggesting different drivers of the CSR when anxiety levels were high compared to low after habituation. Correlation data supported these predictive relationships.

Discussion

Acute anxiety was integral to the CSR before and after habituation and partly predicts the magnitude of the response. Interventions that reduce the anxiety associated with immersion may, in part, reduce the magnitude of the CSR and therefore drowning risk. Our data suggested that anxiety level should be considered as a risk factor in drowning. These findings were discussed along with other key factors known to influence the extent of drowning risk.

Keywords: Drowning prevention, "float first," cold-water survival, open water safety.

Dr. Martin Barwood PhD has 10 years of research experience in the area of Environmental Physiology, Sports Performance and Health, with over a hundred published journal articles, abstracts and industry reports. His work has included examining the efficacy of ergogenic aids, the health consequence of over-exposure to extreme environments, human performance in cold water and human adaptation to heat and cold. He has presented at national and international conferences and makes frequent research contributions to the fields of Health and Sports Performance.