Predicting the life-threatening cold shock response: who is at greatest risk of drowning in cold water?

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The Lifesaving Foundation Conference, Glenroyal Hotel, Maynooth, Ireland, September 10th to 14th 2018
Drowning Statistics

United Kingdom

400-1000 accidental deaths by drowning

Worldwide

372,000+ in World Health Organisation Report (x4 to 5)

Drivers of Drowning:

- Low Water Temperature
- Lack of Basic Swimming and Survival Skills
- Poor Safety Standards

Regional Statistics

400-1000 accidental deaths by drowning

Global Statistics

372,000+ in World Health Organisation Report (x4 to 5)

Drivers of Drowning:

- Low Water Temperature
- Lack of Basic Swimming and Survival Skills
- Poor Safety Standards
Safe Refuge is Closeby…

- 67% of drownings occur in strong swimmers
- 55% occur within 3m of safe refuge (i.e. land)
- Most people who fall in are clothed

Cold Shock Summary

Respiratory

Gasp Response
Inspiratory Shift
Hyperventilation
Decreased BHTime

Seek
Peak Decline Survival

Cardiovascular

A threat to otherwise healthy individuals: 90% of cases

A threat to unhealthy individuals (underlying CV disorder): 10% of cases

Seek Survival

Magnitude

Duration
Safety Behaviour in Cold Water: Rationale

- Impaired Swimming & Self-Rescue
- Cold Shock: Respiratory & Cardiovascular Impairment
- Clothing Provides Buoyancy

Published Sources of Evidence

“Float to Live” – RNLI Respect the Water Campaign

If you fall into cold water, fight your instinct to swim hard. Instead just float until you can control your breathing #RespectTheWater

Fight your instinct and F.L.O.A.T to live. #RespectTheWater

Fight your instinct to panic or swim hard. Gently move your hands and feet to help you float. In 40-90 seconds you'll be able to control your breathing.
Safety Behaviour in Cold Water: Rationale

- Impaired Swimming & Self-Rescue
- Cold Shock: Respiratory & Cardiovascular Impairment
- Clothing Provides Buoyancy

Published Sources of Evidence

Hypothesis

Factors and interventions that *reduce* the magnitude and duration of the CSR *reduce* drowning risk

Factors and interventions that *increase* the magnitude and duration of the CSR *increase* drowning risk
Mean [SD] heart rate (HR) and respiratory frequency (fR) in the first 30 seconds of CWI across 5 habituation immersions in a habituation only group (HAB) and a habituation with psychological skills group (H-PST); n = 20, * (p<0.05). From Barwood et al., (2007), Aviat Space Environ Med 78: 1029-1034.
Influences on the CSR

**Reduce CSR**
- Prior experience (i.e. training)
- Repeated cold water exposure (i.e. habituation)
- Clothing/skin protection
- High aerobic fitness

**Increase CSR**
- Large skin temp gradient
- Threat perception
- Fast rate of water entry
- Body surface area exposed
- Emotional state (i.e. extent of Anxiety)
Conclusion: Anxiety plays a central role in Cold Shock during immersion.

Cold Shock Habituation.
Anxiety Increases CSR

Member of the public

Risk to: 65 million

Results

• Acute anxiety significantly increased the magnitude and duration of the CSR

MAGNITUDE: Heart rate only (9-12 b.p.m⁻¹ higher)

DURATION: Sustained higher heart rate; Ventilation higher by 5.4 L.min⁻¹

Applied Significance:
Increased risk of drowning to all
Research Questions

RQ1: Could anxiety level \textit{prior} to immersion predict the CSR?

RQ2: How is this relationship changed after repeated immersion (i.e. habituation)?
Experimental Set-Up

Standardised Immersion

- Ethically approved studies
- Measurement of Cold Shock Response ($f_c, f_R, V_t, V_E$ & Anxiety)
- Standardised duration (7-min), rate and depth
- CWI = 15° C; Water temperature controlled (+/- 0.5° C)
- Null Hypothesis: Acute anxiety would not predict components of the CSR
- **Statistics:** Linear regression (Pre Anxiety); Pearson’s correlation
Statistics Explained

**Interpretation**
- **r values**
  - +1 or -1
  - None: 0 to 0.3
  - Weak: 0.3 to 0.5
  - Moderate: 0.5 to 0.7
  - Strong: ≥0.7

**Correlation Vs Regression**

<table>
<thead>
<tr>
<th>Basis for Comparison</th>
<th>Correlation</th>
<th>Regression</th>
</tr>
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<tbody>
<tr>
<td><strong>Meaning</strong></td>
<td>Correlation is a statistical measure which determines co-relationship or association of two variables.</td>
<td>Regression describes how an independent variable is numerically related to the dependent variable.</td>
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<tr>
<td><strong>Usage</strong></td>
<td>To represent linear relationship between two variables.</td>
<td>To fit a best line and estimate one variable on the basis of another variable.</td>
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<tr>
<td><strong>Indicates</strong></td>
<td>Correlation coefficient indicates the extent to which two variables move together.</td>
<td>Regression indicates the impact of a unit change in the known variable (x) on the estimated variable (y).</td>
</tr>
</tbody>
</table>
RESULTS

ACUTE ANXIETY PRIOR TO IMMERSION PREDICTS CARDIAC COMPONENT OF CSR IN 1st MINUTE OF CWI IN UNHABITUATED PARTICIPANTS

CSR on 1st minute of CWI (n = 48)  
$r^2 = .190$

ACUTE ANXIETY PRIOR TO IMMERSION PREDICTS RESPIRATORY COMPONENT OF CSR IN 1st MINUTE OF CWI IN HABITUATED PARTICIPANTS WITH LOWER(ER) LEVELS OF ANXIETY

CSR on 1st minute of CWI (n = 25)  
$r^2 = .320$

ACUTE ANXIETY PRIOR TO IMMERSION PREDICTS CARDIAC COMPONENT OF CSR IN 1st MINUTE OF CWI IN HABITUATED PARTICIPANTS WITH HIGHER(ER) LEVELS OF ANXIETY

CSR on 1st minute of CWI (n = 25)  
$r^2 = .197$

Cold Shock Response Predictor S
Initial Immersion

- Weak to moderate relationship between anxiety and $f_c$
- No relationship between anxiety and $f_R$
- Large variability in extent of CSR
- Data indicative of largely thermally driven response
- After repeated immersion (habituation)?
During 1\textsuperscript{st} Minute of Immersion after Habituation

**Breathing Frequency**

**Heart Rate**

During 1\textsuperscript{st} Minute of Immersion after Habituation
Discussion

• Pre immersion state anxiety predicts different components of the CSR before and after habituation. May account for 20 to 30% of CSR; null hypothesis rejected

• Caveat: Immersion procedure (i.e. rate) may over estimate contribution to CSR made by anxiety

• After habituation respiratory component more accurately predicted when anxiety levels are low. The resultant CSR is more varied and less predictable if anxiety is high

• In situations where immersion is anticipated (e.g. helicopter ditching, boat sinking) high trait or state anxiety levels may magnify the CSR

• Safety and survival training should incorporate ways to minimise state anxiety and focus on procedural environmental cues to maximise chances of survival
Acute Anxiety Predicts Components of the Cold Shock Response on Cold Water Immersion: Toward an Integrated Psychophysiological Model of Acute Cold Water Survival

Martin J. Barwood\textsuperscript{1}, Jo Corbett\textsuperscript{2}, Heather Massey\textsuperscript{2}, Terry McMorris\textsuperscript{3}, Mike Tipton\textsuperscript{2} and Christopher R. D. Wagstaff\textsuperscript{2}

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\textsuperscript{3}Department of Psychology, Faculty of Health and Life Sciences, Northumbria University, Newcastle upon Tyne, United Kingdom
This model enables our hypotheses to be tested
“Float to Live” – RNLI Respect the Water Campaign

“FLOAT FIRST – KEEP CALM – SEEK SURVIVAL”
Who is at Greatest Risk?

**Risk Profile**

- No prior training, experience or cold water exposure
- Semi-clothed/unclothed
- Hot skin (exercise or seasonal climate)
- Low aerobic fitness
- Falling in to deep water
- Fast rate of water entry
- High threat perception
- Negative emotional state (i.e. Anxiety***, panic)

***Only factor in list shown to predict CSR components
Acknowledgements

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  • Prof. Mike Tipton
  • Dr Jo Corbett
  • Dr Heather Massey
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LSA Combinations: A Caveat

SHORT COMMUNICATION

Inherent Work Suit Buoyancy Distribution: Effects on Lifejacket Self-Righting Performance

Martin J. Barwood, Geoffrey M. Long, Heather Lunt, and Michael J. Tipton

56% failure rate; 10 of 18