Behavioural analysis of human survival characteristics following sudden water immersion

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Overview

Background

Methods (Study 1)
Preliminary findings

Methods (Study 2)
Preliminary findings

Conclusions and Implications

Future options
Drowning in New Zealand

• NZ has one of the worst records for drowning in the developed world.

Cold Shock and Habituation

- Cold Shock response
  - Inspiratory gasp
  - Hyperventilation
  - Increased heart rate
  - Hypertension
  - Peripheral vasoconstriction
    (Tipton, 1989)

- Coordination of breathing and swimming difficult

- Flow on effects not known (i.e. behaviour)

- With repeated immersion in cold water (<15°C) initial shock response supressed

- Habituation (5 x 2 min ‘dunkings’) combined with mental skills training most effective

- The effect can persist for at least 14 months!

  (Barwood et al, 2007)
Research Questions

1. To contrast initial responses to sudden water immersion in temperate (27°C) versus cold (10°C) water

2. Are behavioural responses to sudden water immersion explained by underlying physiological responses (i.e., disrupted breathing and brain blood flow)?

3. Does swimming skill influence the physiological or behavioural responses following sudden water immersion?

4. Can inexperienced swimmers be trained to suppress hyperventilation following sudden cold water immersion?
Study 1: Experimental Design

Competitive (N = 11)

Recreational (N = 16)
  Swim > 200m

Non-swimmers (N = 12)
  Swim < 200m

Neutral (27°C)
  Cold (10°C)

Day 1: Physiology
Day 2: Behavioural
Physiology Test

Task:
- Sudden immersion, head out (1-2 sec approx)
- Tread water (150 sec)

Respiratory
- Breathing frequency
- Volume of expired Oxygen
- Pressure of expired Carbon Dioxide

Cardiovascular
- Heart Rate
- Brain blood flow
- Brain oxygenation

Other
- Ratings of perceived effort
- Anxiety, etc...
Behavioural Test

Task:

Sudden immersion
Tread water (150 sec) and also...
  Memory recall
  Respond to river/rapids scenario
  ‘Survival’ swim
  (60% then 90% max. speed)

Measures:

  Movement patterns
  Self-reported anxiety
  Short-term memory recall
  Decision congruency (expert)
  Duration of survival swim
Example data of breathing frequency
Effect of water temperature on breathing frequency

- Cold (10°C)
- Neutral (27°C)
Effect of water temperature on duration spent swimming

(60% maximal swimming speed)
Effect of water temperature on swimming distance
(60% maximal swimming speed)
Effect of water temperature on anxiety
(State Trait Anxiety Inventory cumulative score)
Effect of water temperature on ratings of perceived exertion
(Borg’s RPE Scale: 6-20)
Preliminary Results

≈ Similar physiological responses across 3 groups

≈ Swimming performance better in neutral temp.

≈ Non-swimmers particularly anxious in cold water

≈ Cold water perceived as substantially more effortful/demanding
Study 2: Experimental Design

Can immersion training attenuate cold shock response? (Barwood et al., 2006/07)

Novice / inexperienced swimmers (< 200m)

Pre and post training immersions
  - Physiology
  - Behavioural
Habituation Intervention

- 8 cold immersions (3 min)
- Tuition by SESNZ accredited mental skills trainer
  - Relaxation
  - Imagery
  - Self-talk
  - Goal-setting
- Feedback on treading water technique
- Group and individual sessions (8 days)
Preliminary Results: Phase 2

Respiration:

- **96 ± 33%** decrease in average breathing frequency after intervention
- **69 ± 40%** decrease in ventilation following intervention
Breathing frequency before and after habituation

Before habituation
After habituation

Breathing Frequency [breaths/min]

Control
Intervention

Before habituation
After habituation
Duration of swimming before and after habituation
Summary of early observations

Very encouraging results from habituation training

- Less hyperventilation
- Lower heart rates
- Reduced anxiety
- Improved treading water technique
Conclusions

1. Contrast initial responses to sudden water immersion in temperate (27°C) versus cold (10°C) water
   - Cold shock response; individual variations in extent
   - Increased anxiety, discomfort, impaired movement efficiency / coordination

2. Are behavioural responses to sudden water immersion explained by underlying physiological responses (i.e., disrupted breathing and brain blood flow)?
   - Relationships between variables being explored
   - Treading water competency a key factor
   - No change in short-term recall, more complex decision-making?
Conclusions

3. Does swimming skill influence the physiological or behavioural responses following sudden water immersion?
   • Similar physiological responses regardless of skill level
   • Water confidence linked to reduction in severity of cold shock?

4. Can inexperienced swimmers be trained to suppress hyperventilation following sudden cold water immersion?
   • Yes, a relatively short and simple habituation procedure coupled with mental skills training is effective
     (Also marked improvements in treading water competency, duration of effect to be assessed over next 18 months)
Implications

• Following sudden cold water immersion:
  – Initial breath hold (no gasp)
  – 1-2 minutes hyperventilation (assess situation, get breathing back under control)
  – Reduced swimming capacity (swim or float)
  – Discomfort peaks (5-7 mins), rapid loss of function (+8 mins)

• Specific training and education regarding:
  – cold water immersion
  – mental skills
  – treading water / floating
Future research?

• Do these effects persist out of the laboratory?

• How much habituation is required?

• How long does the habituation effect last?

• How best to practically deliver habituation / training

• Target populations?
  – Children
  – Maori, Pacific Islanders, Asian
  – Young NZ males

• Influence of clothing (e.g., waders, boots)

• Effect of alcohol ingestion upon sudden water immersion
Thank you for your support
Questions?

References


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