EVIDENCE-BASED APPROACHES TO SPACFLIGHT PARTICIPANT TRAINING FOR COMMERCIAL SPACEFLIGHT

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Introduction

• Potential commercial spaceflight participants may have little experience with air or space flight or in high performance environments.

• No guidelines or standards exist to help commercial spaceflight companies develop effective training programs.

• Recent centrifuge studies with layperson subjects could give some guidance on development of training programs.
• Layperson centrifuge studies
  - Initially investigated health effects in general, individuals with a wide age range and controlled medical conditions are likely to tolerate suborbital spaceflight well
  - Identified need to investigate training and psychological responses
  - Total through centrifuge experiences = ~300 subjects
  - Evaluated the training involved in recent study*

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* Commercial Spaceflight Participant G-Force Tolerance During Centrifuge-Simulated Suborbital Flight

Tolerance of Centrifuge-Simulated Suborbital Spaceflight by Medical Condition

Rebecca S. Blue, James M. Pattrarini, David P. Reyes, Robert A. Mulcahy, Alejandro Garbino, Charles H. Mathers, Johnene L. Vardiman, Tarah L. Castleberry, and James M. Vanderploeg

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The Effects of Training on Anxiety and Task Performance in Simulated Suborbital Spaceflight

Rebecca S. Blue; Frederick Bonato; Kimberly Seaton; Andrea Bubka; Johnene L. Vardiman; Charles Mathers; Tarah L. Castleberry; James M. Vanderploeg
Goals of a Training Program

Knowledge & Skills

- Gear and worn items
- Spacecraft – seats, restraints, ingress, egress
- Experience – acceleration, flight environment
- Nominal, off nominal & emergency situations

Mitigate Risk

- Physiological and/or psychological risk, anxiety, motion sickness, disruption to mission

Experience – Enjoy!

Effective & Efficient for company and SFP; proper preparation for physiological and psychological stressors of spaceflight
Review of commercial spaceflight profiles.
## Typical centrifuge simulated suborbital spaceflight training & studies

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<thead>
<tr>
<th>Centrifuge Run #</th>
<th>Duration in centrifuge</th>
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Study - Effects of Training on Anxiety & Task Performance in Simulated Suborbital Spaceflight

• 148 subjects (105 men, 43 women)
  • 19-72 yrs, mean age 39.4 +/- 13.2
  • BMI 17.3-38.1, mean 25.1 +/- 3.7
• Varied training length and exposures
  • 2-7 centrifuge runs over 0.5 to 2 days
  • Culminating in 2 simulated suborbital spaceflights
• 4 cohorts
  • 2 received dedicated anxiety-mitigation training
• Screening questionnaires (MSSQ, psych screening), medical monitor observations for anxiety and performance – Stroop test, emergency sim task completion, & post flight questionnaires
• Pre & Post BP and HR;
• EKG and video monitoring continuous in centrifuge

Women were significantly more likely to request participation in shorter training programs ($0.5 - 1 \text{d} = 65\%, \ 2 \text{d} = 35\% \chi^2 = 5.53, \ df = 1, \ P = 0.02$)

No significant age differences betw M & W or betw the cohorts

No significant difference in BMI by sex or by cohort

No significant difference in self-reported exercise tolerance overall by sex, age or between cohorts
Results

29 subjects identified with anxious signs/symptoms
  Questionnaire and medical monitor observations
10 subjects opted out of one or more runs (3 men, 7 women), dispersed across cohorts
  No significant correlation between:
  - Cohort groups & opting out
  - Medical/psych history & opting out or enjoyment
  - Baseline BP and those who opted out
  - Exceptions
    - More women than men opted out
    - The men who opted out were significantly older than those who completed all runs (opted out: 53.3+/-13.5 yr, completed: 39.2+/-12.8 yr, P=0.03)
    - Those with a history of motion sickness more likely to opt out (2 emesis after run 6)
    - Baseline HR was lower in those who chose to opt out or reduce experience compared to those who completed all (opted out: 63.1+/-10.1bpm, completed: 70.0+/-10.3, P=0.04)

Baseline hemodynamics demonstrated no significant difference in HR or BP among cohorts; although Men had significantly higher systolic BP at baseline than Women (M 123+/-13.1 mmHg, W 117+/-10.8 mmHg, p=0.01). No sex-specific difference in baseline diastolic BP or HR.

No GLOC
Nausea was a common complaint, generally following runs; 5% reported nausea to the point of adversely affecting the experience
1 reported panic attack during run 3
Most only report issues in private or in writing
Results, cont.

MT & CAT – higher pre-spin HR compared to baseline (MT 70.8+/−13.8bpm vs 78.6+/−13.8bpm P<0.01; CAT 68.4+/−9.6bpm, 73.9+/−12.9bpm p,0.01)

MT – post-spin HR was significantly increased compared to CAT & CPAT cohorts (MT: 78.8+/−14.7bpm, CAT: 71.4+/−11.4bpm, P=0.02; CPAT:68.9+/−12.1bpm, p<0.01)

MT & CPT groups showed significantly increased HR during entry +6Gx exposure compared to the CAT & CPAT cohorts (MT: 103.5+/−25.6bpm, CPT: 100.9+/−17.9bpm, CAT: 89.2+/−19.2bpm, CPAT:86.8+/−19.2bpm; p=0.05). This was only noted during run 6, and MT results normalized during run 7 for all hemodynamics compared to the other cohorts.

CAT & CPAT groups (2d training) reported fewer anxiety symptoms after run 6 (first simulated spaceflight) (number of symptoms reported after Run 6, 0.5-1d: 1.6+/−2.0, 2d: 0.4+/−0.9, P<0.001)

MT & CPT groups (1/2 and 1 day training) reported significant improvement in symptoms between runs 6 and 7, but no such improvement was noted in the longer training cohorts.

Single-directional G training did not significantly improve tolerance

Performance

No significant difference in errors or time to completion of stroop test in individuals of any group

Non-psychological training subjects had fewer errors during emergency scenario, but took longer to complete the task

Discussion: What do results suggest for development of training protocols

- Best when high fidelity exposures
  - High fidelity exposures, which closely match spaceflight profiles, are more effective than single-directional exposures
  - Sequential exposures improve physical & psychological tolerance
- Close observation with trust building is important for trainers/investigators
- Difficult to predict anxiety-related responses (no current accurate screening tool)
- Training programs can help identify and mitigate physiological and psychological risk

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Acknowledgements & THANK YOU!

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