EVIDENCE-BASED APPROACHES TO SPACFLIGHT PARTICIPANT TRAINING FOR COMMERCIAL SPACEFLIGHT

Tarah L. Castleberry, DO, MPH

James M. Vanderploeg, MD, MPH

ICASM 2017 Rome, Italy

utmb Health
Aerospace Medicine

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.

Evidence

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. Pattarini, David P. Reyes, Robert A. Mulcahy, Alejandro Garbino, Charles H. Mathers, Johnené L. Vardiman, Tarah L. Castleberry, and James M. Vanderploeg

- Layperson cen[illegible] studies

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

Rebecca S. Blue; Frederick Bonato; Kimberly Seaton; Andrea Bubka; Johnené L. Vardiman; Charles Mathers; Tarah L. Castleberry; James M. Vanderploeg

[illegible]eral, [illegible]trolled [illegible]borbital

  - Identified need to investigate training and psychological responses
- Total through centrifuge experiences = ~300 subjects
- Evaluated the training involved in recent study*

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

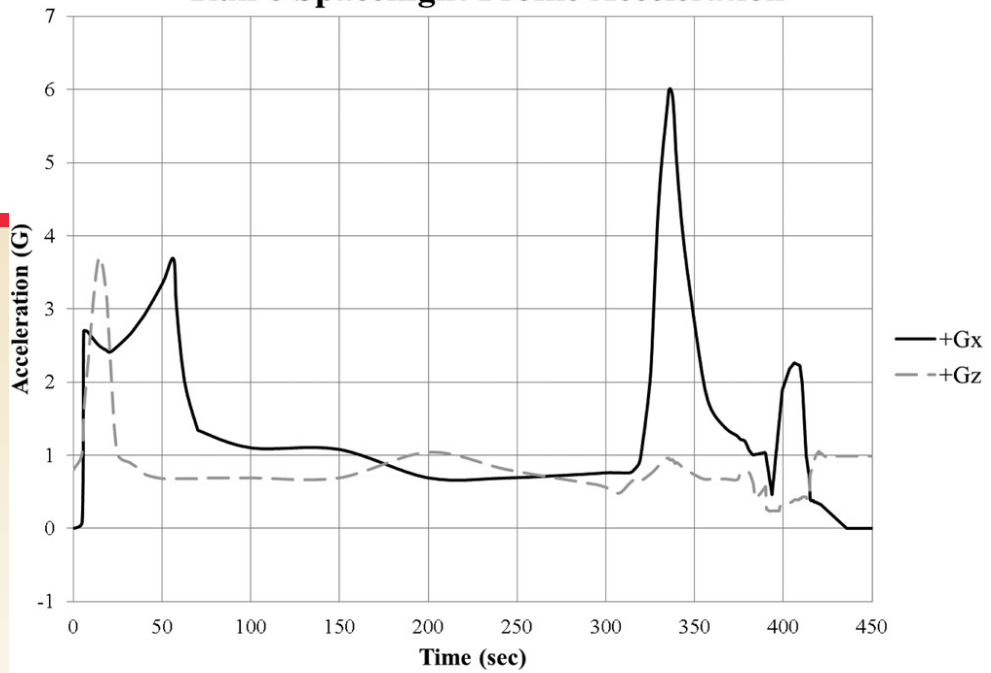
Mitigate Risk

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

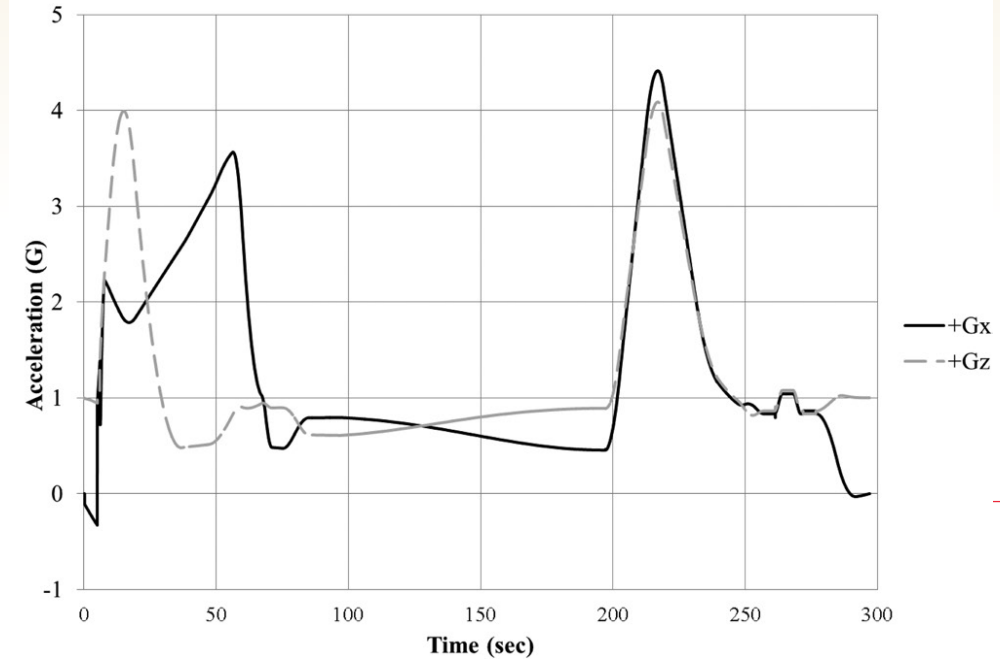
Experience – Enjoy!

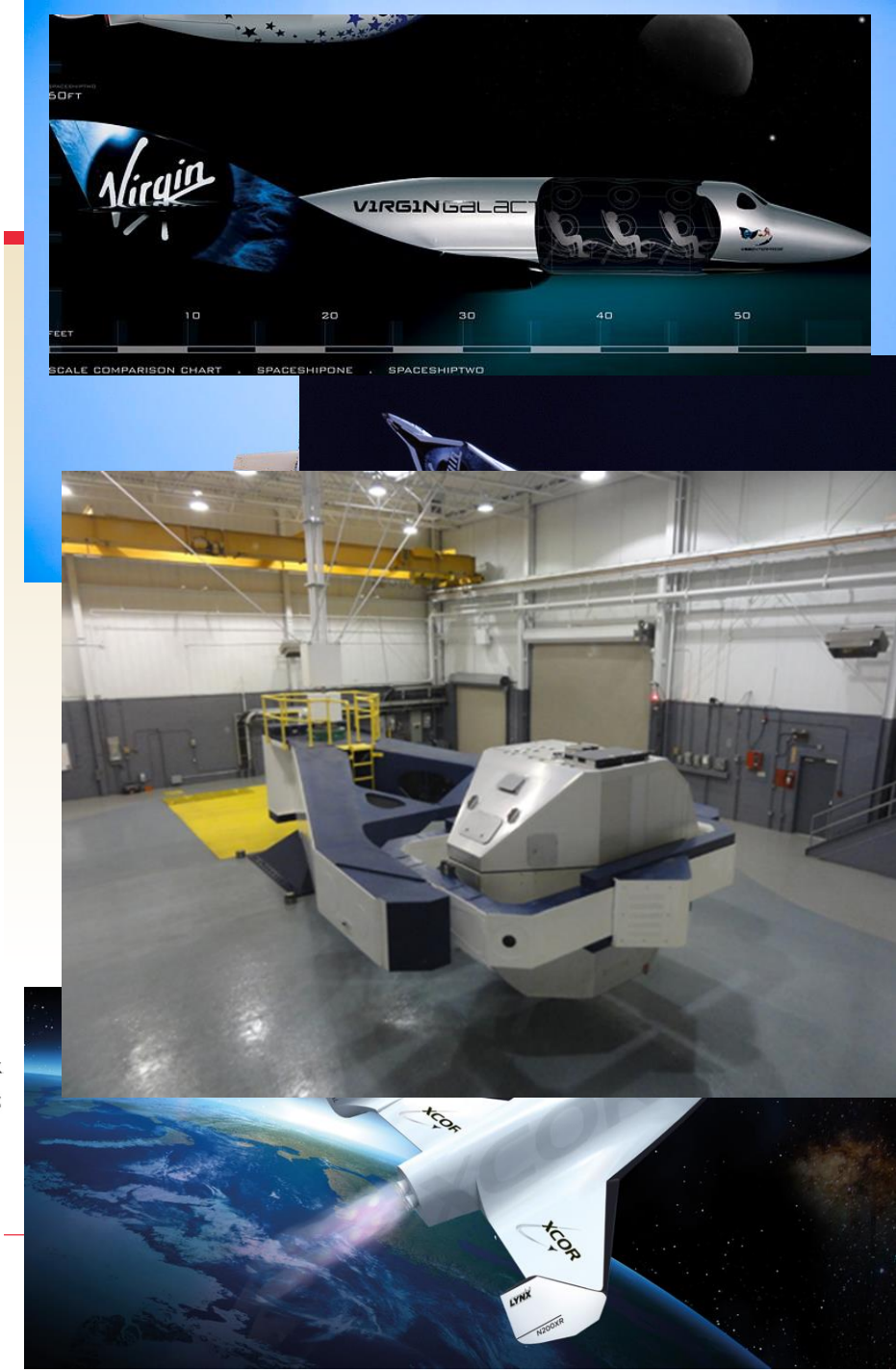
Effective & Efficient for company and SFP; proper preparation for physiological and psychological stressors of spaceflight

Run 6 Spaceflight Profile Acceleration



Run 7 Spaceflight Profile Acceleration





Typical centrifuge simulated suborbital spaceflight training & studies

	Centrifuge Run #	Duration in centrifuge	Peak G	Duration at Peak G
Single-Direction Training Runs	1	2 min	+2.15 Gz	15 sec
	2	2 min	+3.5 Gz	15 sec
	3	2 min	+3.0 Gx	15 sec
	4	2 min	+6.0 Gx	15 sec
Simulated Spaceflights	5 Upright launch, reclined entry 50% profile	7 min	+1.7 Gz +3.0 Gx	5 sec
	6 Upright launch, reclined entry 100% profile	7 min	+3.8 Gz +6.0 Gx	5 sec
	7 Upright launch & entry 100% profile	6 min	+4.0 Gz +4.5 Gx R = +6G	5 sec

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

Blue, et al. AMHP 2017; 88(7):641-650.

Blue, et al. AMHP 2017; 88(7):641-650.

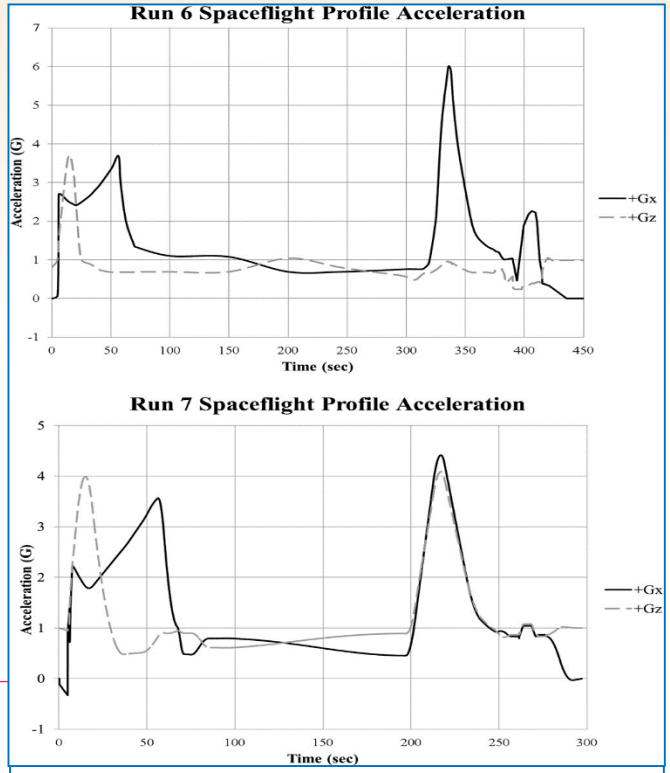
Table I. Training Lectures, Exercises, and Centrifuge Exposures Included in the Four Training Cohorts.

	AGSM	DIDACTICS	PSYCHOLOGICAL TRAINING AND EXERCISE	SINGLE-DIRECTION EXPOSURES	50% SPACEFLIGHT SIMULATION	100% SPACEFLIGHT SIMULATION	NUMBER OF CENTRIFUGE RUNS
MT	X					X	2
CAT	X	X		X	X	X	7
CPT	X	X	X		X	X	3
CPAT	X	X	X	X	X	X	7

AGSM: Anti-G straining maneuver, MT: minimal training, CAT: cognitive and acceleration, CPT: cognitive/psychological, CPAT: cognitive/psychological/acceleration.

MT: 39 (24 M, 15 W)
CAT: 36 (27 M, 9 W)
CPT: 35 (22 M, 13 W)
CPAT: 38 (32 M, 6 W)

Women were significantly more likely to request participation in shorter training programs (0.5-1d = 65%, 2 d = 35% $x^2 = 5.53$, df = 1, P = p.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



utmb Health
Aerospace Medicine

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

Blue, et al. AMHP 2017; 88(7):641-650.

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

Blue, et al. AMHP 2017; 88(7):641-650.

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

Blue, et al. AMHP 2017; 88(7):641-650.

Typical centrifuge simulated suborbital spaceflight training & studies

	Centrifuge Run #	Duration in centrifuge	Peak G	Duration at Peak G
Single-Direction Training Runs	1	2 min	+2.15 Gz	15 sec
	2	2 min	+3.5 Gz	15 sec
	3	2 min	+3.0 Gx	15 sec
	4	2 min	+6.0 Gx	15 sec
Simulated Spaceflights	5 Upright launch, reclined entry 50% profile	7 min	+3.0 Gx +1.7 Gz	5 sec
	6 Upright launch, reclined entry 100% profile	7 min	+6.0 Gx +3.8 Gz	5 sec
	7 Upright launch & entry 100% profile	6 min	+4.5 Gx +4.0 Gz R = +6G	5 sec

Acknowledgements & THANK YOU!

FAA Center of Excellence for Commercial Space Transportation

National Space Biomedical Research Institute

NASTAR Centrifuge (Environmental Tectonics Corp)

Co-Investigators:

James Vanderploeg, MD

Rebecca Blue, MD

Richard Jennings, MD

Charles Mathers, MD

Frederick Bonato, PhD

Kimberly Seaton, PhD

Andrea Bubka, PhD

Robert Mulcahy, MD

Johnene Vardiman-Ditmanson, MS