THE EFFECTS OF AUTOGENIC FEEDBACK TRAINING EXERCISE ON HEART RATE VARIABILITY

[1,2]Mary Grace Nimmer, [4,5]Fernando Espinosa, [1,3]Gary Ellis, [4]Patricia Cowings, [4]William Toscano, [1,3]Allison Ludwig, [1,2]Tayton Hess, [2]Mariateresa Sestito, [1]Kevin Novak

[1]Naval Medical Research Unit Dayton, [2]ORISE, [3]Leidos, [4]NASA, [5]San Jose State University

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- **Source of Support**
  - This work was funded by/supported by S&A 20-012.
- **Human Research/Institutional Review Board (IRB)**
  - The study protocol was approved by the NAMRU-D Institutional Review Board in compliance with all applicable federal regulations governing the protection of human subjects.

Autogenic Feedback Training Exercise (AFTE)

- Combines autogenic therapy and biofeedback
- Teaches subjects to self-regulate various physiological parameters in motion sickness (MS) provocative environments
- Shown to be effective for
  - Mitigating MS and space sickness[1,2,3]
  - Improving cognitive and physiological performance under stress[4]
- Non-pharmacological intervention
  - Better than promethazine for mitigating MS symptoms[5]
  - No unwanted side effects of medication
- Shows promise as a potential MS intervention for military aviators[3]

Heart Rate Variability (HRV)

- HRV: changes in the time intervals between consecutive heartbeats
- An indicator of health and autonomic nervous system function
  - Generally, a healthy heart has greater inter-beat interval variability
- Controlled by the ANS and CNS; cardiovascular, endocrine, and respiratory systems; baroreceptors and chemoreceptors[6]
- Metrics: time domain, frequency domain, nonlinear
  - Ultra short-term, short-term, 24-hour

Influences on HRV
Age
Sex
Heart Rate
Respiration
Aerobic Fitness
Health Status
Circadian Rhythm

HRV: Physiological Influence

	Physiological Influences	
Time Domain Metrics	• PNS and SNS activity	• HR control mechanisms (RSA, baroreflex, rhythmic vascular tone)

	Frequency	Respiratory Range	Physiological Influences
LF Band	0.04-0.15 Hz	3-9 BPM	• Combined PNS, SNS, and baroreflex • PNS alone • Baroreflex alone
HF Band	0.15-0.4 Hz	9-24 BPM	• PNS • RSA

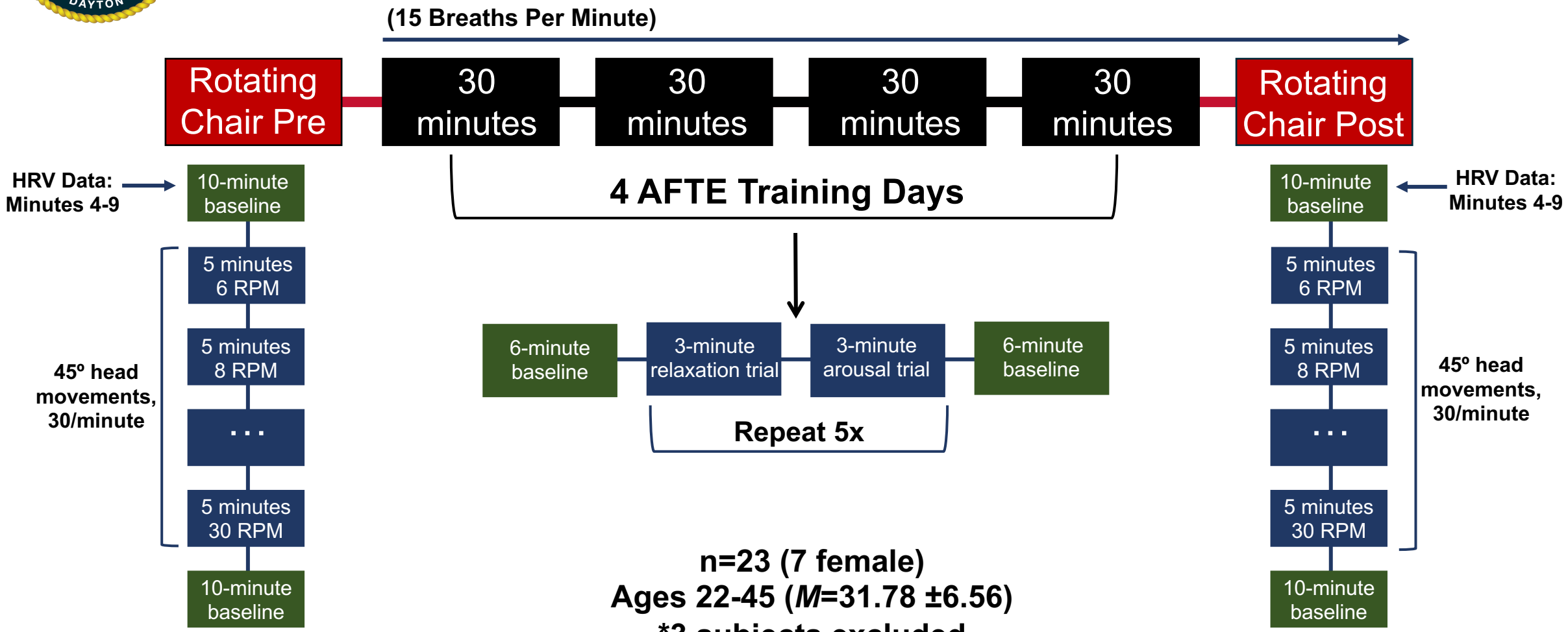
AFTE, HRV, and Motion Sickness

- MS symptoms are correlated with increased SNS influence (e.g., increased heart rate, peripheral vasoconstriction) and irregular patterns of vagal activity.
- Indices of HRV can reflect dynamic ANS processes and neurocardiac function.
- MS is associated with a decrease in HRV.[7]
  - HRV biofeedback increases HRV.[8]
  - Other nonpharmacological interventions for mitigating MS symptoms through manipulation of ANS activity may therefore also produce an effect on HRV.
- Understanding HRV changes following AFTE may help to elucidate AFTE's specific effects and inform its implementation for MS mitigation.

How does 2 hours of AFTE affect indices of HRV?

We expect to see that AFTE training will indirectly improve HRV under stress.
E.g., increases in mean NN, RMSSD, pNN50, HF; decrease in LF

Methods: AFTE



n=23 (7 female)
Ages 22-45 (*M*=31.78 ±6.56)
***3 subjects excluded**

Diagnostic Symptom Scoring

Malaise Level	Pts	VMT	TMP	DIZ	HAC	DRZ	SWT	PAL	SAL	NSA	ED	EA
Pathognomic	16	I										
Major (severe)	8					III	III	III	III	II/III		
Minor (moderate)	4					II	II	II	II	I		
Minimal (mild)	2					I	I	I	I		I	
AQS	1		I / II	I / II	I							I

Malaise Levels Identified by Total Points Scored

Frank Sickness	Severe Malaise	Moderate - A	Moderate - B	Slight Malaise
S	MIII	MIIA	MIIB	MI
16 pts	8 – 15 pts	5 -7 pts	3 – 4 pts	1 -2 pts

Pensacola Diagnostic Rating Scale[9]

Symptoms assessed at the end of each 5-minute rotation epoch.
Rotating chair test stopped at ≥8 points (severe malaise).

Methods: HRV Analysis

Parameter	Unit	Description[10]
Mean NN	ms	Average interval duration before normal R peaks
RMSSD	ms	Root mean square of successive NN interval differences
pNN50	%	Percentage of NN intervals that differ by >50 ms
HF power	ms^2	Absolute power of the high-frequency band (0.15–0.4 Hz)
LF power	ms^2	Absolute power of the low-frequency band (0.04–0.15 Hz)
LF/HF	%	Ratio of LF-to-HF power

HRV data recorded by SOMNOtouch™ NIBP.

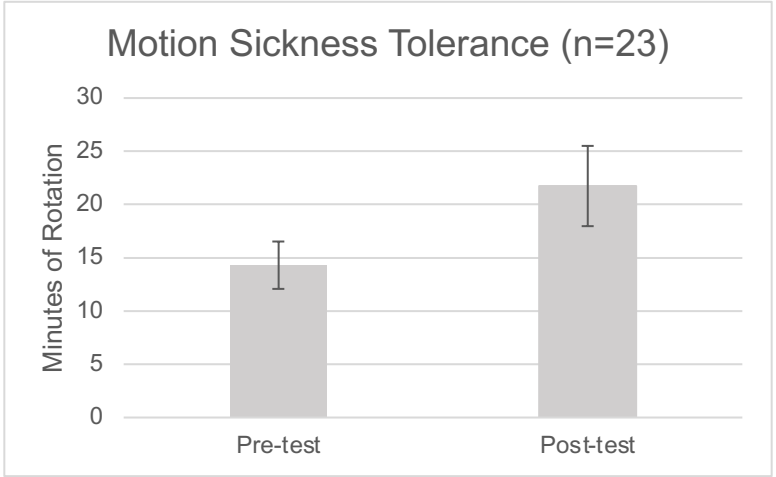
Photo adapted from Majumder, 2020.[11]

Results: AFTE and MS Tolerance

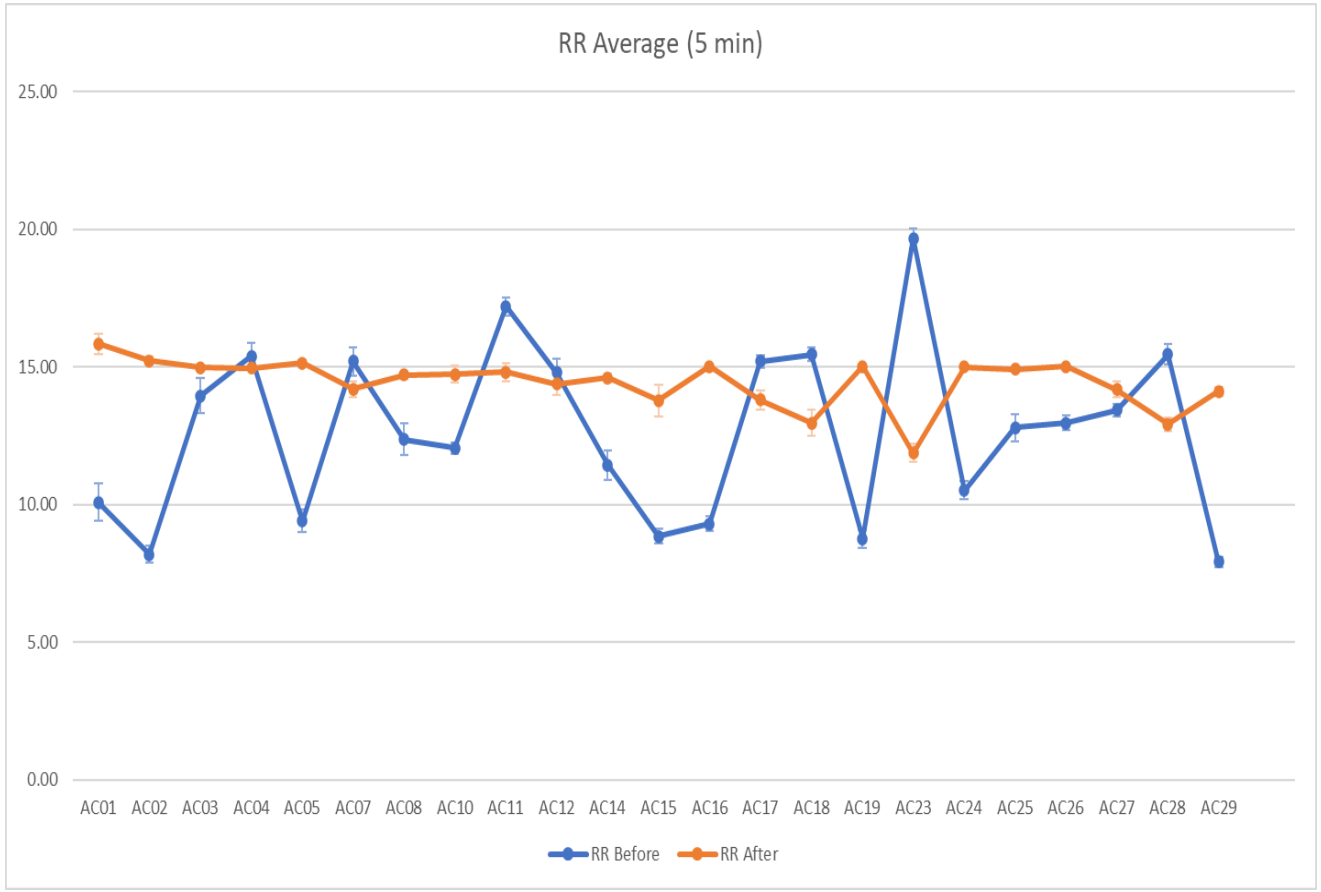
There were significant improvements in both minutes and cumulative rotations following AFTE.

	Pre-AFTE	Post-AFTE
Average Minutes	14.30 ±2.22	21.74 ±3.77
Average Rotations	134.43 ±30.12	265.83 ±72.02

	Mean Difference	df	t	p	Hedge's g
Minutes	7.43 ±2.01	22	3.70	.001	0.50
Rotations	133.39 ±45.76	22	2.87	.009	0.50



Changes in Respiratory Rate

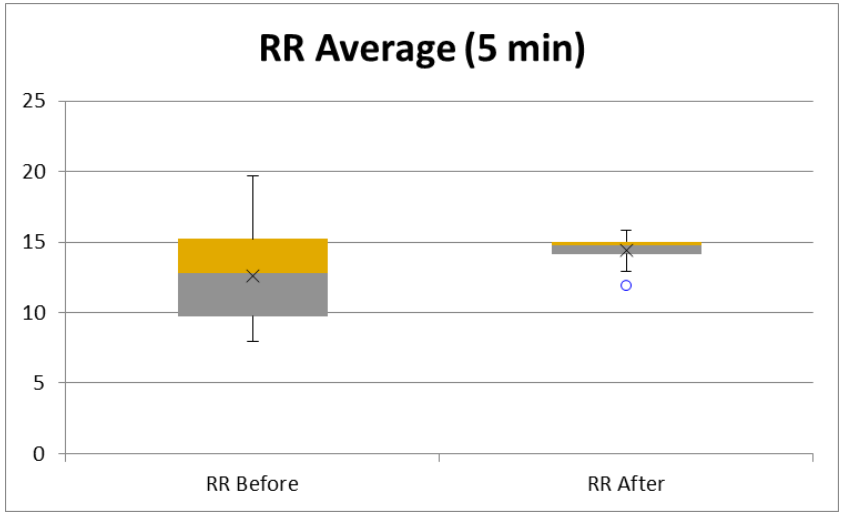


Average RR (n=23):

- Pre-AFTE: M= 12.62 (SEM=0.66)
- Post-AFTE: M = 14.44 (SEM=0.19)

Subjects increasing average RR (n=15):

- Pre-AFTE: M= 10.80 (SEM=0.52)
- Post-AFTE: M = 14.82 (SEM=0.13)



Respiratory Rate and HRV Correlation

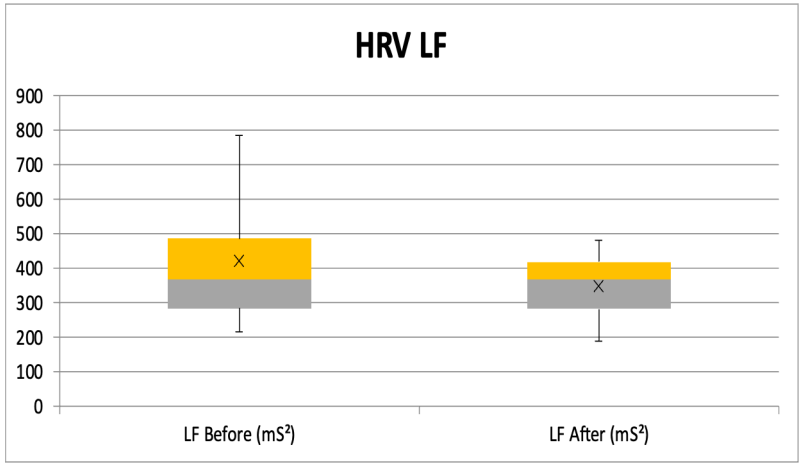
Pre-AFTE

- Time domain metrics **not** correlated to RR
- LF power **correlated** to RR
  - r(22) = -.51, p < .05
- HF power **correlated** to RR
  - r(22) = -.23, p < .05

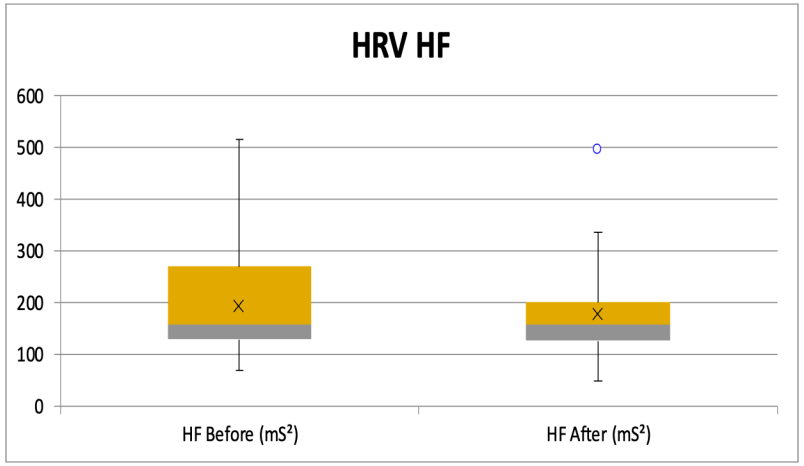
Post-AFTE

- Time domain metrics **not** correlated to RR
- LF power **correlated** to RR
  - r(22) = .14, p = .003
- HF power **not** correlated to RR

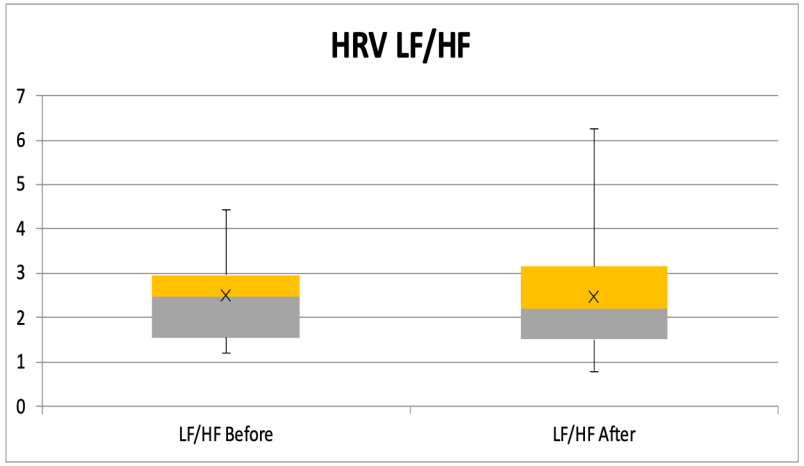
Changes in Frequency Domain Metrics



Pre-AFTE: M = 418.57 ms², SD = 165.86
Post-AFTE: 346.85 ms², SD = 123.69
t(22) = 2.60, p = .016
Hedge's g = .54

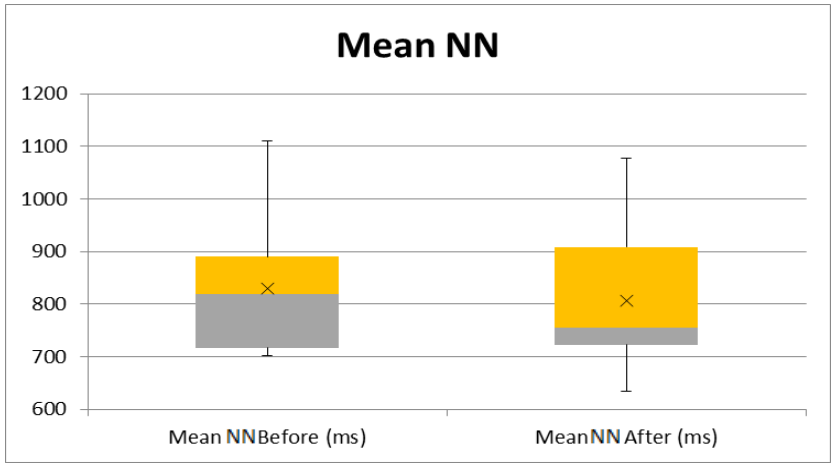


Pre-AFTE: M = 193.42 ms², SD = 105.09
Post-AFTE: 177.41 ms², SD = 100.99
Hedge's g = .16

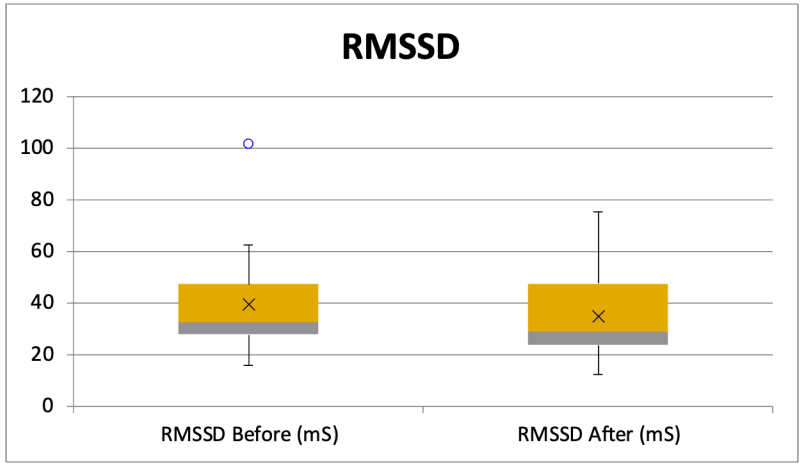


Pre-AFTE: M = 2.48, SD = 1.00
Post-AFTE: 2.46, SD = 1.29
Hedge's g = .02

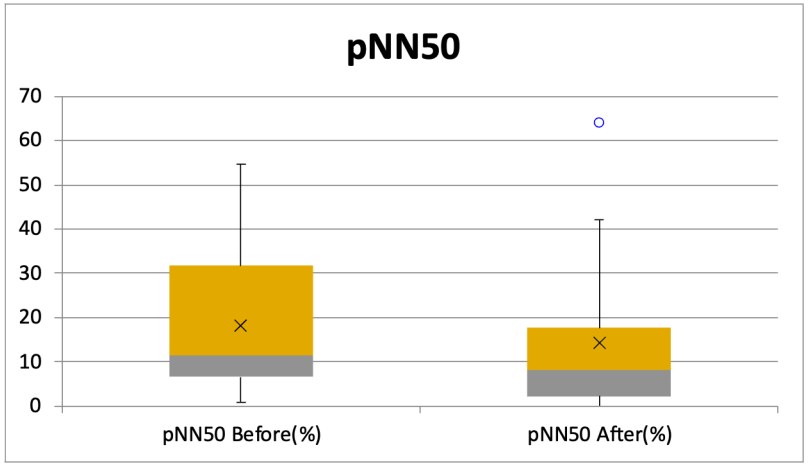
Changes in Time Domain Metrics



Pre-AFTE: M = 830.62 ms, SD = 117.41
Post-AFTE: 805.71 ms, SD = 123.69
Hedge's g = .21



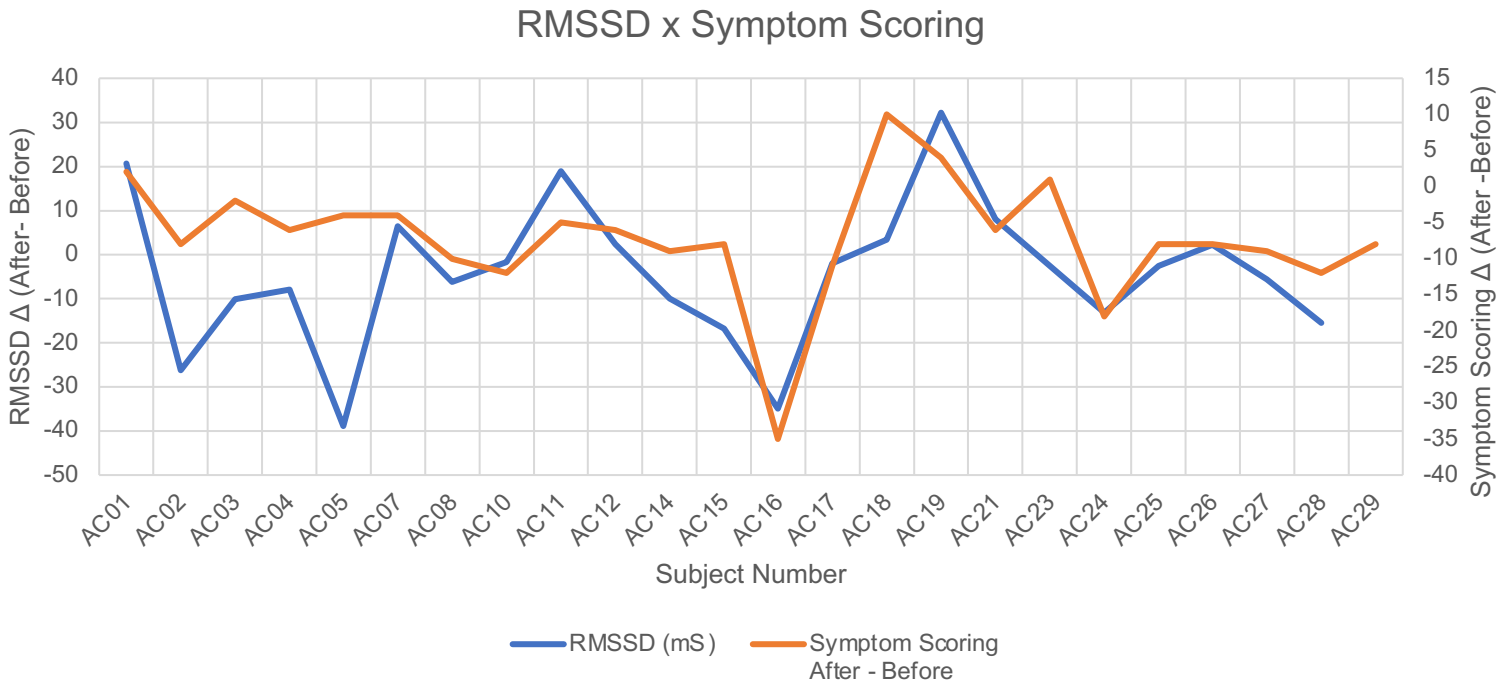
Pre-AFTE: M = 39.27 ms, SD = 19.4
Post-AFTE: 34.94 ms, SD = 18.31
Hedge's g = .30



Pre-AFTE: M = 18.24 ms, SD = 15.93
Post-AFTE: 14.31 ms, SD = 17.31
Hedge's g = .24

HRV Metrics and Symptoms

RMSSD: r(22) = 2.13, p = .04

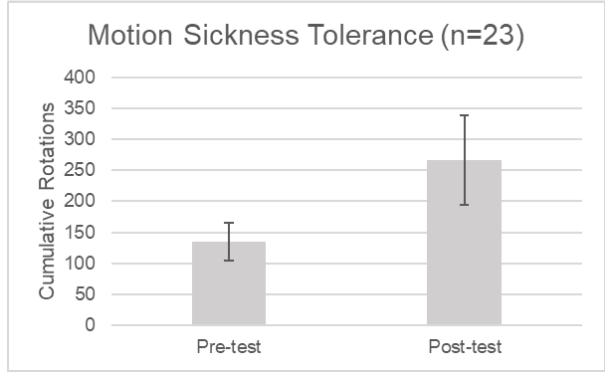


Other metrics were not correlated with changes in symptom scores.

Time and frequency domain metrics were not correlated with symptom profiles.

Summary of Results

- Minutes and rotations in the chair significantly increased following AFTE



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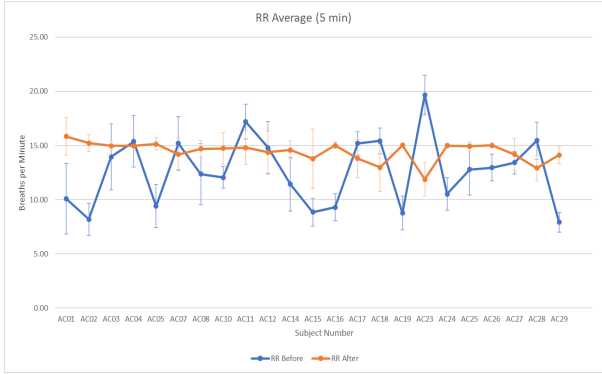
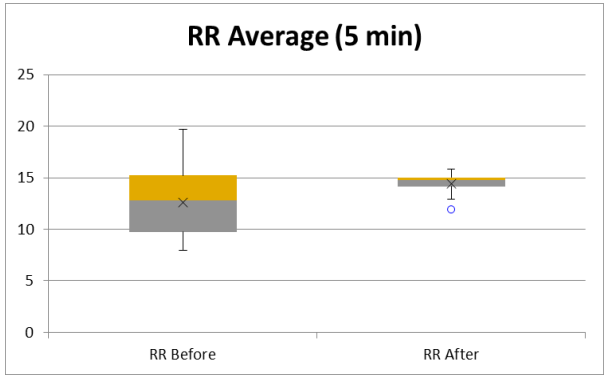
- Mean pre-AFTE respiratory rate <15BPM





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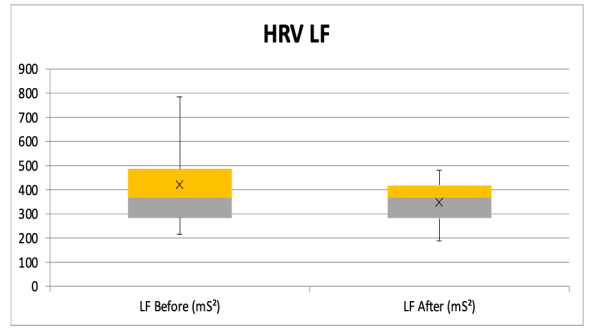
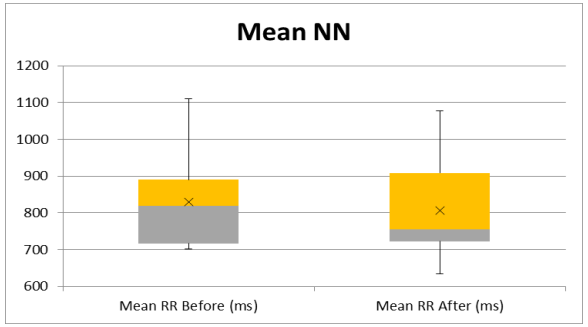
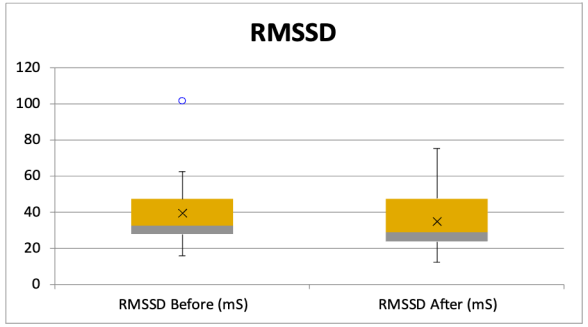
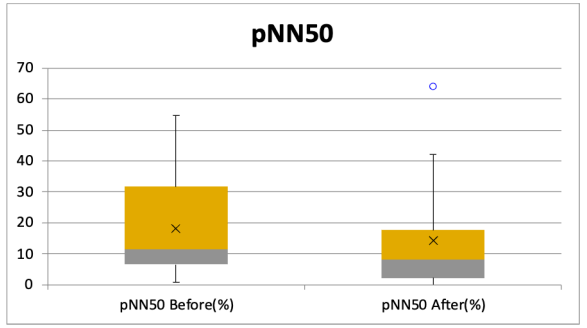
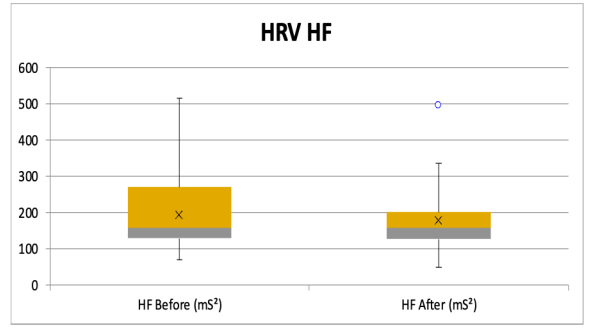
  - Decrease in LF was significant











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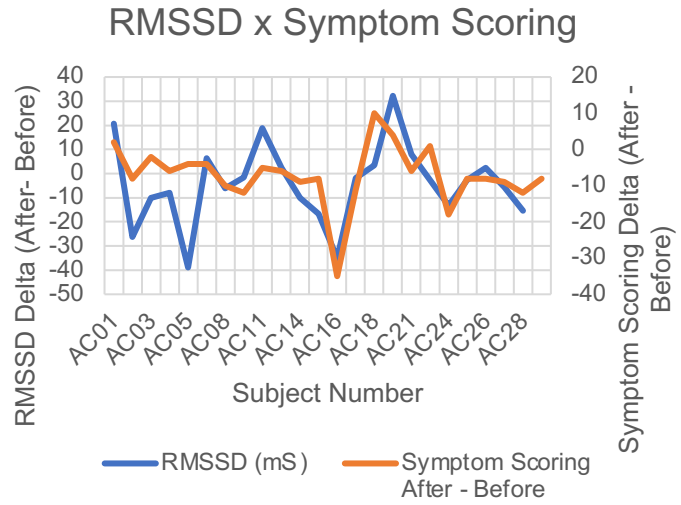
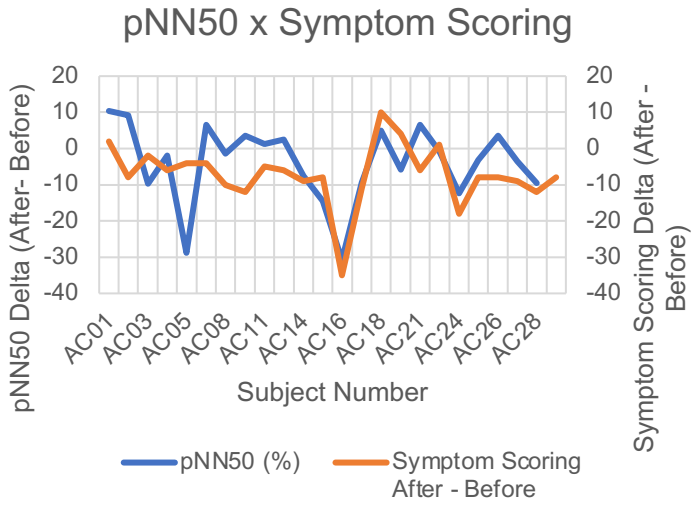
  - Decrease in LF was significant

- Changes in RMSSD correlated to changes in symptom scores at matched RPMs
  - Changes in LF, HF, LF/HF, and mean RR not correlated to changes in symptoms scores at matched RPMs
  - Further analyses needed to corroborate findings





Discussion: How AFTE Affects HRV

- LF power is influenced by dynamic relationships of the SNS, PNS, and baroreflex.
  - Increasing or decreasing RR from one's resonance frequency may lower short-term time-domain metrics and LF band power.[10]
  - The correlations change from negative to positive when transitioning from slower breathing (pre-test) to faster breathing (post-test) with higher LF power, not HF power.
  - For subjects who's pre-AFTE RR was frequently <9 BPM (n=9), increasing RR may decrease LF power.[10]
  - A decrease in LF power may reflect a decrease in SNS activity.
- The interactions of RR, PNS, and HF power are complex.
  - Increasing RR decreases RSA, and therefore HF power.
  - Rapid, shallow breathing and a stress response can decrease vagal tone and decrease PNS activity, decreasing HF.

Discussion: Future Directions

- HRV optimization, in addition to AFTE training, may further lessen MS symptoms and increase MS resiliency.
- Further research designed to evaluate AFTE and HRV specifically may help to:
  - Elucidate the effects of AFTE on HRV
  - Understand how AFTE affects HRV (i.e., changes in respiratory rate)
  - Inform individualized adjustments to the AFTE protocol
  - Allow optimization of AFTE training effects

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