Associations among Measures of Physical Health, Mental Health, and Neural Efficiency

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Introduction

- Research evidence clearly supports the relevance of resting heart rate variability (HRV) to various physiological functions, including decision-making, motor execution, and emotional regulation.[1-3]
- Resting HRV may be a useful index for assessment of overall performance capabilities and wellness.[4]
- Higher resting state HRV has been related to cognitive flexibility[5-6]
- Perceptual-motor efficiency can be represented by a combination of reaction time and response accuracy.
- The pupil light reflex (PLR) appears to be an indicator of neural processing efficiency of the optical system.[7]
- Mood disorders and sleep-related problems have been associated with alteration of autonomic function.[5]

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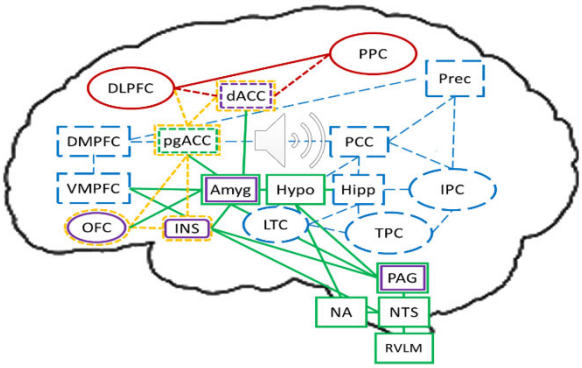
Purpose

The purpose of this study was to assess possible inter-relationships among resting HRV, reaction time, response accuracy, PLR, and survey responses relating to physical and mental health, which could serve to identify individuals likely to derive benefit from interventions to improve health and functional status.



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Participants

- 28 (23.1 +/- 1.1 yrs old) Master's level college students volunteered for participation in study
- 34 students originally volunteered with data unable to be collected for 3/34 and 3/34 unable to complete full study, leaving 28 final participants
- Final participants composed of 14 Males (23.4 +/- 1.0 yrs; 71 +/- 2.5 in, 207.9 +/- 36.8 lbs) and 14 Females (22.8 +/- 1.1 yrs, 65.8 +/- 3.0 in, 168.4 +/- 41.3 lbs)
- 26/28 participants completed all 4 days of data collection, while one participant completed 2 days and another completed 3 days
- 93% (26/28) played high school or collegiate sports
- 39% (11/28) reported history of concussion

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Methods

- Measurements of resting HRV (Corsense monitor and Elite HRV smartphone app), perceptual-motor efficiency (smartphone flanker test; 3 trials), and PLR (Reflex smartphone app) obtained on 4 consecutive days (6-10 AM)
- Surveys included the Depression, Anxiety, and Stress Survey (DASS), and Pittsburgh Sleep Quality Index (PSQI)

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HRV

- HRV measures variability in time between successive heartbeats
  - Reflects balance of parasympathetic vs sympathetic systems
- Resting HRV measured while sitting for 120 seconds; natural log of root mean square of successive differences

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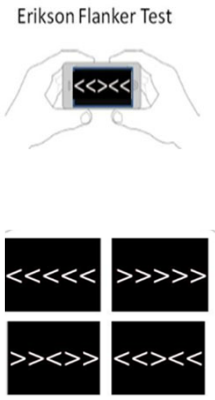
Flanker Test

- Indicates Perceptual-Motor Efficiency
  - Recognition of Stimulus (perception)
  - Rapid Cognitive Processing (interpretation)
  - Muscle Response (Decision/motor activation)

- Perceptual-motor efficiency represented by reaction time (RT), response accuracy (RA), inverse efficiency (IE = RT / RA), and intra-individual variability (SDRT); each metric derived from 3 sets of 20 stimulus responses that followed 1 familiarization trial



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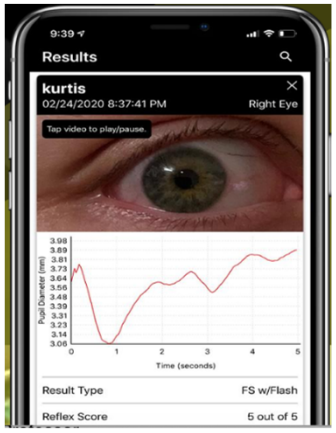
Pupil Light Reflex

- PLR recorded by 5-second video of eye response to smartphone camera light; left eye and right eye measured separately
  - constriction time (Constrict)
  - constriction latency (Latency)
  - minimum diameter (Min Dia)
  - maximum diameter (Max Dia)
  - average diameter (Avg Dia)



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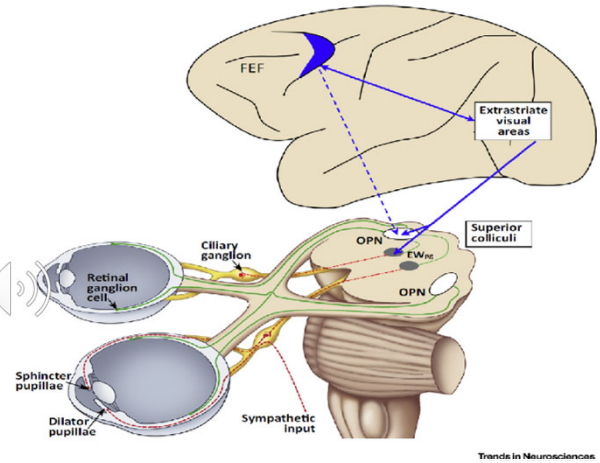
Pupillary Light Reflex

Figure 1. Cortical and Subcortical Structures That Might Be Involved in the Attentional Modulation of the Pupillary Light Response. Green lines show the retinal input and red lines the pupillomotor output. Blue lines show hypothetical cortical projections. Luminance-encoding elements are represented as white boxes. For simplicity, connections and projections are represented for one side only. Abbreviations: EWpg, Edinger–Westphal preganglionic subdivision; FEF, frontal eye fields; OPN, olivary pretectal nucleus.



Binda P, Gamlin PD. Renewed attention on the pupil light reflex. *Trends Neurosci*. 2017;40(8):455-7.

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Data Analysis

- Bivariate correlations among pairs of variables calculated (Pearson r)
- Resting HRV converted to binary variable (Hi HRV vs Lo HRV) on the basis of median value for cohort, as well as sex-specific median values for determination of any relevant sex differences in associations
- Receiver operating characteristic (ROC) analyses performed to quantify discriminatory power of continuous variables for identification of Hi HRV vs Lo HRV on the basis of area under curve (AUC)
- Cross-tabulation analyses of binary variables created by ROC cut points performed to quantify sensitivity, specificity, and odds ratio (OR), along with 95% confidence interval (CI) for OR
- Logistic regression used to identify 2-factor combination of continuous variables that provided strongest discriminatory power for identification of Hi HRV vs Lo HRV

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Correlation

Correlations

		HRV	Lat R	Lat L	PSQI	DASS Dep	SDRT	IE
HRV	Pearson Correlation	1	-0.048	-0.052	-0.292	0.007	-.534**	-.669**
	Sig. (2-tailed)		0.807	0.792	0.132	0.970	0.003	0.000
Lat R	Pearson Correlation	-0.048	1	0.136	.475*	0.197	0.187	0.340
	Sig. (2-tailed)	0.807		0.491	0.011	0.314	0.340	0.077
Lat L	Pearson Correlation	-0.052	0.136	1	0.291	.529**	-0.183	-0.009
	Sig. (2-tailed)	0.792	0.491		0.133	0.004	0.352	0.963
PSQI	Pearson Correlation	-0.292	.475*	0.291	1	.571**	0.257	0.317
	Sig. (2-tailed)	0.132	0.011	0.133		0.002	0.187	0.100
DASS Dep	Pearson Correlation	0.007	0.197	.529**	.571**	1	-0.200	-0.084
	Sig. (2-tailed)	0.970	0.314	0.004	0.002		0.308	0.670
SDRT	Pearson Correlation	-.534**	0.187	-0.183	0.257	-0.200	1	.854**
	Sig. (2-tailed)	0.003	0.340	0.352	0.187	0.308		0.000
IE	Pearson Correlation	-.669**	0.340	-0.009	0.317	-0.084	.854**	1
	Sig. (2-tailed)	0.000	0.077	0.963	0.100	0.670	0.000	

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Lo HRV

Median HRV values (lnRMSSD)
Male median = 4.27
Female median = 4.13

Test Variable	AUC	Cut point	P	SN	SP	OR	95% CI
IE	0.684	≥ 544 ms	0.064	71	64	4.5	.91, 22.15
SD_Rt_all	0.612	≥ 52 ms	0.104	86	43	4.5	.72, 29.15
L Lat	0.628	≥ 219 ms	0.118	50	79	3.67	.70, 19.12
PSQI	0.630	≥ 8	0.104	43	86	4.5	.72, 28.15
R constriction	0.653	≥ 1.56 s	0.027	64	79	6.6	1.23, 35.44

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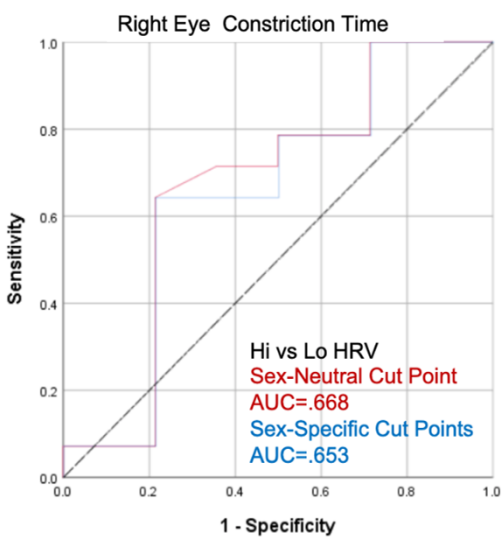

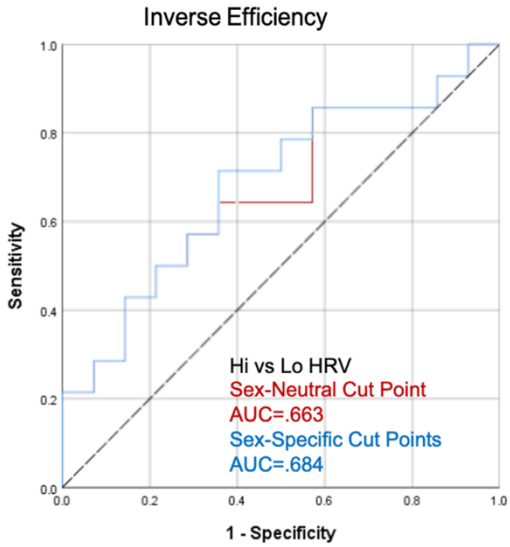

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Discussion and Clinical Relevance

- The use of HRV, Flanker test, and PLR testing via smartphone apps, along with wellness surveys such as DASS or PSQI can create an overall picture of neural processing efficiency.
- Having more reaction time variability (SDRT) from trial to trial is associated with how fast and accurate you are in decision making and reaction time.
- We demonstrated a strong correlation between HRV and inverse efficiency which could be due to overlapping neural circuitry within the anterior cingulate cortex and the insula[8].
- Research evidence supports the potential for improvement of emotional and physical health through various interventions by being able to determine those with less efficient neural processing and thus at higher risk for injuries.
- By using various indicators of neural processing and efficiency through the use of smartphone apps we may be able to identify those with higher risk for injuries and be able to improve their overall health, recovery process, and mental wellbeing.
- Our findings suggest the use of a biopsychosocial approach to health and performance optimization

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References

1. Thayer JF, Hansen AL, Saus-Rose E, Johnsen BH. Heart rate variability, prefrontal neural function, and cognitive performance: the neurovisceral integration perspective on self-regulation, adaptation, and health. Ann Behav Med. 2009;37(2):141-53.
2. Williams PG, Cribbet MR, Tinajero R, Rau HK, Thayer JF, Suchy Y. The association between individual differences in executive functioning and resting high-frequency heart rate variability. Biol Psychol. 2019;148
3. McCraty R, Shaffer F. Heart rate variability: new perspectives on physiological mechanisms, assessment of self-regulatory capacity, and health risk. Glob Adv Health Med. 2015;4(1):46-61.
4. Wilkerson GB, Acocello SN, Davis MB, Ramos JM, Rucker AJ, JA H. Wellness survey responses and smartphone app response efficiency: associations with remote history of sport-related concussion. Percept Mot Skills.128(2):714-30.
5. Colzato LS, Jongkees BJ, de Wit M, van der Molen MJW, Steenbergen L. Variable heart rate and a flexible mind: Higher resting-state heart rate variability predicts better task-switching. Cogn Affect Behav Neurosci. 2018;18:730-738.
6. Williams DP, Thayer JF, Koenig J. Resting cardiac vagal tone predicts intraindividual reaction time variability during an attention task in a sample of young and healthy adults: Vagal tone and reaction time variability. Psychophysiology. 2016;53:1843-1851.
7. Dinalankara DM, Miles JH, Yao G. Rplr: An imaging system for measuring pupillary light reflex at a distance. Applied Optics. 2014;53(32):7787. doi:10.1364/ao.53.007787
8. Marsland AL, Kuan DC-H, Sheu LK, Krajina K, Kraynak TE, Manuck SB, et al. Systemic inflammation and resting state connectivity of the default mode network. Brain Behav Immun. 2017;62:162-70.
9. Williams DP, Koenig J, Carnevali L, Sgoifo A, Jarczok MN, Sternberg EM, et al. Heart rate variability and inflammation: a meta-analysis of human studies. Brain Behav Immun. 2019;80:219-26.

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References

6. Williams DP, Thayer JF, Koenig J. Resting cardiac vagal tone predicts intraindividual reaction time variability during an attention task in a sample of young and healthy adults: Vagal tone and reaction time variability. Psychophysiology. 2016;53:1843-1851.
7. Dinalankara DM, Miles JH, Yao G. Rplr: An imaging system for measuring pupillary light reflex at a distance. Applied Optics. 2014;53(32):7787. doi:10.1364/ao.53.007787
8. Marsland AL, Kuan DC-H, Sheu LK, Krajina K, Kraynak TE, Manuck SB, et al. Systemic inflammation and resting state connectivity of the default mode network. Brain Behav Immun. 2017;62:162-70.
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