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ORIGINAL ARTICLE

School burnout and heart rate variability: risk of cardiovascular disease and hypertension in young adult females

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ABSTRACT

Emerging research documents the relationship between school burnout and some indicators of increased cardiovascular risk. Indicators of cardiovascular functioning assessed via ambulatory blood pressure and heart rate variability (HRV) have not been thoroughly explored in this research domain. Therefore, the current study examined relationships between school burnout and indicators of cardiac functioning via 24 h ambulatory blood pressure (BP) and electrocardiogram monitoring in a sample of young adult female undergraduates ($N = 88$). Two hypotheses were tested: (1) that independent of related negative affective symptomology (depression and anxiety), increased school burnout would be related to greater systolic and diastolic BP, higher low frequency (LF) HRV and lower very low frequency (VLF) HRV, and (2) that lower VLF would be related to greater school burnout independently of LF HRV. Hierarchical multiple regression analyzes showed that school burnout was significantly related to elevated ambulatory BP (systolic and diastolic) and HRV markers of increased cardiac sympathovagal tone. These findings support the hypotheses and suggest that school burnout might be implicated in the development of pre-hypertension or early cardiovascular disease. Study limitations and the need for future longitudinal research are discussed.

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Introduction

Recently research has documented that school burnout is linked to indicators of increased cardiovascular risk through analyzes of laboratory and ambulatory hemodynamics (May, Sanchez-Gonzalez, & Fincham, 2014a; May, Sanchez-Gonzalez, Brown, Koutnik, & Fincham, 2014b; May, Seibert, Sanchez-Gonzalez, & Fincham, 2016). For example, in two studies assessing young adult female undergraduate students, laboratory beat-to-beat blood pressure (BP) and ambulatory BP measurements indicated that increased school burnout was associated with (1) increase cardiac sympathovagal tone and sympathetic vasomotor tone, (2) inefficient myocardial oxygen consumption, (3) increased 24 h ambulatory heart rate (HR) and BP, (4) blunted diurnal variability in systolic BP (SBP), diastolic BP (DBP), and mean arterial pressure, and (5) increased arterial stiffness (May et al., 2014a). Similarly, in a study utilizing a sample of young adult male undergraduate students who underwent cardiovascular measurement during a cold pressor task, individuals with higher burnout showed greater changes in aortic and brachial SBP and DBP as well as left ventricular work and myocardial oxygen consumption (e.g. cardiac hyperactivity, May et al., 2014b).

An often-unexplored aspect of heart rate variability (HRV) is the very low frequency (VLF) power spectral components of HRV (McCraty & Shaffer, 2015). Until recently the VLF band of HRV (0.0033–0.04 Hz range) was less understood and underutilized in research as compared to high frequency (HF, 0.15–0.4 Hz range) and low frequency (LF, 0.04–0.15 Hz range) HRV. Research has unveiled many associations between the VLF band and physiological ailments. Importantly, Hadase et al. (2004) demonstrated that reduced VLF predicted cardiac events independently of LF and total HRV power. Likewise, Huikuri et al. (1995) showed reduced VLF to be the strongest independent predictor of ventricular tachycardia in patients who have suffered a prior myocardial infarction. Thus, research demonstrates a stronger association with VLF and all-cause mortality and sudden death than LF and HF HRV bands (Bigger et al., 1992; Bigger, Fleiss, Rolnitzky, & Steinman, 1993; Hadase et al., 2004; Schmidt et al., 2005; Tsuji et al., 1994, 1996). However, the physiological implications associated with VLF alterations in the context of school burnout remain unexplored.

Our group has documented that school burnout is related to suboptimal physiological functioning, and in turn, may be linked to cardiovascular risk factors. However, school burnout research has yet to report relationships with ambulatory HRV, including VLF which is considered a surrogate of systemic inflammation (Günther et al., 2012; Kop et al., 2010; Stein et al., 2008). This is particularly important given the independence of VLF from HF and LF HRV in predicting adverse cardiovascular risk and mortality. Therefore, this study examined the relationship between school burnout and 24 h ambulatory blood pressure and HRV measurements in a sample of young adults. Two hypotheses were tested: (1) independent of related affective

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symptomology (depression and anxiety), increased school burnout scores would be related to elevated BP and HRV indices, specifically greater SBP and DBP as well as higher LF and lower VLF, (2) independent of LF HRV, lower VLF would be related to greater school burnout.

Methods

Participants

Eighty-eight young adult female undergraduate students (M_{age} = 20.42 years, SD = 1.49, M_{height} = 165.73 cm, SD = 8.10, M_{weight} = 65.34 kg, SD = 12.65) qualified for study inclusion (an additional 17 participants volunteered for the study but were unable to participate due to exclusion criteria). Study inclusion criteria specified participants be full time undergraduate students (enrolled in 12 credit hours of study) and be over the age of 18 years. In an attempt to avoid potential cardiovascular functioning confounds, participants were excluded from study participation through an online health screening assessment if they smoked, exercised regularly, defined as >120 min per week in the previous 6 months, were hypertensive (BP ≥140/90 mmHg), had chronic diseases, or were taking beta blockers, antidepressants, or stimulants [as previously specified in May et al. (2014a, 2014b)]. Participants were asked to abstain from caffeine, alcohol, and strenuous physical activity for at least 24 h prior to testing. Female participants were tested in the early follicular phase of the menstrual cycle to avoid potential variations in pressure wave morphology and cardiac reactivity. The sample was 88% Caucasian, 6% African American, 2% Asian, and 4% endorsed either biracial or non-disclosed ethnicity. Participants were recruited from undergraduate classrooms as an option for voluntary class credit and all data was collected in the middle (weeks 3–9) of the fall semester. All participants gave their written consent prior to study participation as approved by The Florida State University Institutional Review Board. It should be noted that two male students participated in the study and were eliminated from demographics and statistical analyzes due to differential male and female cardiovascular outcomes in HRV (Saleem, Hussain, Majeed, & Khan, 2012).

Instruments and measures

Anthropometrics

Height was measured using a stadiometer and body weight was measured using a Seca scale (Sunbeam Products Inc., Boca Raton, FL).

Ambulatory blood pressure (BP) and electrocardiograph (ECG) monitoring

Ambulatory BP measurements were collected using validated oscillometric 90217 A SpaceLabs (Spacelabs; Wokingham, Berkshire, UK) recorders and calibrated to take four measurements per hour for 24 h. Ambulatory ECG measurements were taken with First Beat Body Guard ECG monitors (Turku Finland) over a period of 24 h to acquire R-R intervals. The main spectral components of the HRV that were calculated using the procedures previously reported by our group (May et al., 2016). Briefly, spectral components calculated were the low frequency (LF; 0.04–0.15 Hz) and the high frequency (HF; 0.15–0.4 Hz) and the VLF (0.0033–0.04 Hz range). HF of HRV is considered a marker of vagal tone, high LF HRV denotes cardiac sympathovagal tone while low VLF HRV denotes autonomic dysfunction and inflammation (Kop et al., 2010; Stein et al., 2008; Task Force, 1996). Since the Shapiro–Wilk test was significant for the spectral HRV components, a logarithmic transformation (ln) was used to correct for non-Gaussian distributions of data.

School burnout

School burnout was measured using the School Burnout Inventory (SBI; Salmela-Aro, Kiuru, Leskinen, & Nurmi, 2009). The SBI consists of nine items measuring three first-order factors of school burnout: (a) exhaustion at school (four items), (b) cynicism toward the meaning of school (three items), and (c) sense of inadequacy at school (two items). Summed scores from the first-order factors comprise a second-order overall school burnout score. All the items are rated on a 6-point Likert-type scale ranging from 1 (*completely disagree*) to 6 (*strongly agree*). Higher composite scores indicate higher burnout with a potential range of 45 (9–54). Reliability for the present sample was $\alpha = 0.94$.

Depression

Depression was measured using the 10-item Center for Epidemiologic Studies Depression Scale (CES-D; Radloff, 1977; Santor & Coyne, 1997). The CES-D has been widely used as a measure of depressive symptoms in non-clinical samples. It asks participants to respond to a list of ways they may have felt or behaved during the previous week. Sample items include, "I was bothered by things that usually don't bother me," and "I felt hopeful about the future," (reverse coded). Responses ranged from 0 = *rarely or none of the time (less than one day)* to 3 = *most or all of the time (5–7 days)*. Responses were summed into one overall score, with a possible range of 0–30. Reliability for the sample was $\alpha = 0.84$.

Anxiety

Anxiety was measured using the 20-item State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970). Participants were asked to respond to anxiety items such as "upset," "calm," "secure," "at ease," and "nervous." Responses were scored on a 4-point Likert scale (1 = *not at all* to 4 = *very much so*). Half of the items were reverse coded so that higher scores indicated greater anxiety. Items were then summed to create a composite anxiety score with a possible range of 20–80. Reliability for the sample was $\alpha = 0.88$.

Procedure

After completing an online health history form, eligible participants were scheduled for a laboratory appointment to complete a 24 h ambulatory BP and ECG assessment. Upon arrival, participants completed a questionnaire containing the school burnout, depression, and anxiety scales. Anthropometrics were then measured and participants were fitted with ambulatory BP and ECG monitoring devices. Ambulatory setup and monitoring began between 0800 and 1100 h and concluded when the recorders were returned to the laboratory the following day after 24 h of measurement.

Statistical analysis

Investigators suggest the need to control for depressive and anxiety symptoms in designs focusing on burnout measurements as affective disorders may have overlapping symptomatology (Melamed, Shirom, Toker, Berliner, & Shapira, 2006; Schaufeli & Buunk, 2003; Shirom, 2009). Therefore, to evaluate hypothesis 1 (independent of related affective symptomology, increased school burnout scores will relate to greater LF and lower VLF) hierarchical multiple regression (HMR) analyzes were conducted to test the association between school burnout scores and physiological parameters and to demonstrate any incremental contribution of school burnout scores above anxiety and depressive symptomatology in accounting of variance in physiological variables. Model 1 of the HMR contained the anxiety and depression predictors and Model 2 introduced school burnout as a predictor. To evaluate hypothesis 2 (independent of LF HRV, reduced VLF will relate to greater school burnout), a HMR was conducted on school burnout scores with LF HRV serving as the predictor in Model 1 and in Model 2 VLF HRV was added as a predictor. All statistical analyzes were performed using IBM SPSS version 20.

Results

Controlling for depression and anxiety scores, HMR analyzes demonstrated significant associations between higher school burnout and elevated SBP, DBP and LF HRV as well as decreased VLF HRV (Table 1). School burnout scores were not significantly related to values of HF HRV. This supports hypothesis 1 that independent of related affective symptomology (depression and anxiety), increased school burnout scores are related to BP and HRV indices (increased LF and reduced VLF). Furthermore, HMR analyzes indicated reduced VLF scores, independently of LF HRV, were significantly related to increased school burnout scores, supporting hypothesis 2 (lower VLF will relate to school burnout independently of LF HRV). As shown in Table 2, independent of LF, VLF accounts for 5% of the unique variance in school burnout scores. In fact, when introducing VLF into the regression model, LF becomes statistically non-significant in predicting school burnout (see Model 2).

Discussion

Extending the construct of occupational burnout to students in academic populations, school burnout is conceptualized as a three-dimensional affective response to school-related stress characterized by chronic exhaustion, cynicism toward

Table 1. Hierarchal multiple regressions of depression, anxiety, and school burnout scores accounting for variance in 24 h Ambulatory SBP, DBP, LF, and VLF.

Outcome	Predictors (M, SD)	β	*sr*	*p*	Model R^2	Model ΔR^2	Model *F*
SBP (mmHg)							
Model 1	STAI (29.14, 11.85)	0.01	0.01	.097	0		$F(2, 85) = 0.15$, $p = .860$
	CES-D (8.84, 4.82)	0.05	0.04	.112			
Model 2	STAI	0.16	0.11	.506	0.07	0.06	$\Delta F(1, 84) = 5.65$, $p = .020$
	CES-D	0.16	0.12	.273			
	SBI (19.84, 9.63)	0.34	0.25	.002			
DBP (mmHg)							
Model 1	STAI	0.04	0.03	.798	0		$F(2, 85) = 0.17$, $p = .845$
	CES-D	0.04	0.03	.791			
Model 2	STAI	0.17	0.13	.22	0.14	0.13	$\Delta F(1, 84) = 12.92$, $p < .001$
	CES-D	0.13	0.1	.347			
	SBI	0.49	0.36	<.001			
HF ln (ms^2)							
Model 1	STAI	−0.09	−0.07	.500	0.01		$F(2, 85) = 0.30$, $p = .740$
	CES-D	−0.1	−0.08	.482			
Model 2	STAI	−0.05	−0.03	.759	0.01	0	$\Delta F(1, 81) = 0.33$, $p = .567$
	CES-D	−0.13	−0.10	.372			
	SBI	−0.1	−0.07	.533			
LF ln (ms^2)							
Model 1	STAI	0	0.00	.978	0.01		$F(2, 85) = 0.62$, $p = .541$
	CES-D	0.12	0.10	.362			
Model 2	STAI	0.15	0.10	.335	0.06	0.05	$\Delta F(1, 84) = 4.18$, $p = .044$
	CES-D	0	0.00	.98			
	SBI	0.32	0.22	.044			
VLF ln (ms^2)							
Model 1	STAI	0.01	0.01	.955	0		$F(2, 85) = 0.07$, $p = .926$
	CES-D	−0.05	−0.04	.728			
Model 2	STAI	−0.17	−0.12	.272	0.06	0.06	$\Delta F(1, 84) = 5.22$, $p = .025$
	CES-D	−0.09	−0.07	.55			
	SBI	−0.36	−0.3	.025			

$N = 88$; SBP ($M = 112.75$, $SD = 8.96$); DBP ($M = 69.74$, $SD = 6.46$); HF ln ($M = 6.94$, $SD = 2.24$); LF ln ($M = 7.32$, $SD = 2.68$); VLF ln ($M = 9.40$, $SD = 1.32$) as criterion, respectively. ln: natural logarithmic transformation; *sr*: semi-partial correlation; CES-D: Center for Epidemiologic Studies Depression Scale; STAI: State-Trait Anxiety Inventory; SBI: School Burnout Inventory; SBP: systolic blood pressure; DBP: diastolic blood pressure; HF: high frequency; LF: low frequency; VLF: very low frequency.

Table 2. Hierarchical multiple regression of 24 h ambulatory LF and VLF HRV values accounting for variance in school burnout scores.

Outcome	Predictors (M, SD)	β	*sr*	*p*	Model R^2	Model ΔR^2	Model *F*
SBI							
Model 1	LF ln (ms^2)	0.21	0.21	.047	0.04		$F(1, 86) = 4.06$, $p = .047$
Model 2	LF ln (ms2)	0.08	0.07	.497	0.09	0.05	$\Delta F(1, 85) = 4.36$, $p = .040$
	VLF ln (ms2)	−0.25	−0.2	.040			

$N = 88$; ln: natural logarithmic transformation; *sr*: semi-partial correlation; SBI: School Burnout Inventory; LF: low frequency; VLF: very low frequency.

the meaning of school and a belief of inadequacy in school-related accomplishment (Salmela-Aro et al., 2009). This study examined relationships between school burnout and indicators of physiological functioning via 24-h ambulatory blood pressure (BP) and electrocardiogram (ECG) monitoring in a young adult female undergraduate sample. All proposed study hypotheses were confirmed. In regards to hemodynamics, findings indicated that increased school burnout was significantly related to elevated ambulatory BP (systolic and diastolic). Additionally, analyzes of frequency domain markers of heart rate variability (HRV) demonstrated that independent of related affective symptomology increased school burnout scores was related to greater LF HRV and lower VLF. Finally, lower VLF was shown to be related to greater school burnout independent of LF HRV.

As a novel contribution to the literature, this research provides the only analyzes of data regarding school burnout scores and ambulatory ECG readings. Furthermore, prior to this research, laboratory or ambulatory based assessments have not reported on the relationships between school burnout and VLF HRV. Investigations into relationships between occupational burnout and HRV are also similarly sparse. Data regarding occupational burnout and laboratory HRV parameters is very limited as only a handful of studies have been published, largely assessing European samples and producing largely mixed findings (de Vente, van Amsterdam, Olff, Kamphuis, & Emmelkamp, 2015, Kanthak, Stalder, Hill, Thayer, Penz, & Kirschbaum, 2017; Lennartsson, Jonsdottir, & Sjörs, 2016; Zanstra, Schellekens, Schaap, & Kooistra, 2006). Even more rare are occupational burnout studies examining ambulatory HRV (Teisala et al., 2014). It would be of interest in future research to evaluate the differences and similarities of the context of burnout ("school" versus "occupational" burnout) and their relation not only to HRV indices but also to any indicator of physiology as this comparative research has yet to appear.

Although the physiological determinants of VLF are still controversial [for discussion see Task Force (1996) and Reyes del Paso, Langewitz, Mulder, Van Roon, & Duschek (2013)], some research suggests that VLF is linked to increased inflammation and autonomic dysfunction (Lampert et al., 2008; Theorell, Liljeholm-Johansson, Björk, & Ericson, 2007) which are known to be implicated in the development of coronary artery disease and cardiac mortality (Kop et al., 2010). In fact, there are data to show an association between VLF and C-reactive protein, which is a well-known factor associated with all-cause mortality (Carney et al., 2007; Lampert et al., 2008). Whether school burnout can trigger low-grade inflammation in otherwise healthy young adults and predispose individuals suffering from burnout to an early development of cardiovascular disease warrants further investigation.

These study findings also provide the first replication of previously demonstrated ambulatory BP relationships with school burnout in young adult females. In May et al. (2014b) school burnout scores accounted for 4% (6% in the current study) of the unique variance in SBP values and 7% (13% in the current data) of the unique variance in DBP values. Thus, research implicating school burnout as an indicator of sub-optimal physiological functioning continues to grow, even in seemingly healthy young adult samples.

Notwithstanding the strengths of this study, it is important to consider several limitations as well as potential future research directions. First, as the data pertain only to females, an important limitation is that our findings are limited to one gender. To date, no reported data exist demonstrating school burnout relationships with male ambulatory cardiovascular functioning. It behooves prospective research to include both genders given inconsistent findings regarding gender differences in burnout studies [see Purvanova & Muros (2010) for a recent meta-analysis]. Second, the sample consisted of younger adults ($M_{age} = 20.42$ years) that are in arguably better health given the inclusion criteria used (e.g. non-smokers, lack of medications, etc.). Thus, our findings do not speak to potential age-related effects or populations that are less normotensive. Prospective research may benefit from sampling older, less healthy students, as there may potentially be an adverse synergistic effect of school burnout and aging on the cardiovascular system. Also, the reported data are cross-sectional thereby precluding inferences about direction of effects and do not speak to the interplay between school burnout and cardiovascular functioning over time. As a remedy, future studies should investigate longitudinal and temporal effects that might shed light on the development of school burnout and impaired cardiovascular functioning [see Salmela-Aro & Upadyaya (2014) as an example of evaluating differing developmental trajectories of school burnout].

Finally, this research reports on undergraduate students but some studies indicate that school burnout may vary across different academic subpopulations. For example, May and Casazza (2012) show hard science majors (curriculum with at least 6 STEM courses) experience greater perceived life stress than soft science majors (<6 STEM courses). And, speaking more specifically to school burnout, May et al. (2016) demonstrated that in comparison to a sample of pre-medical undergraduate students, graduate medical students suffered from significanlty greater school burnout and showed stronger cardiac hyperactivity during a cold-pressor task. Thus, prospective school burnout research may also benefit from examining additional academic subpopulations.

Speaking towards prospective interventions to decrease the impact of school burnout on cardiovascular functioning, research is beginning to implicate self-control as a potential point of intervention. Self-control, defined as the capacity to alter immediate impulsive thoughts, behaviors and emotions for a more delayed but desirable outcome (de Ridder, Lensvelt-Mulders, Finkenauer, Stok, & Baumeister, 2012), has been linked in separate research lines to school burnout and cardiovascular functioning. For instance, Seibert, May, Fitzgerald, and Fincham, (2016) reported a negative relationship between dispositional self-control and school burnout after controlling for affective symptomology in multiple undergraduate samples. Regarding cardiovascular functioning, May, Seibert, Sanchez-Gonzalez, Fitzgerald, and Fincham (2017) showed that greater self-control relates to increased aerobic capacity and decreased morning blood pressure surge, thus suggesting self-control is, advantageously, related to healthier cardiovascular functioning. Importantly research shows self-control can be improved inexpensively and fairly efficiently through practicing inhibition, such as squeezing a handgrip and holding it as long as possible (Muraven, 2010). Thus, interventions aimed at improving self-control may be practically adapted to both decrease school burnout and improve cardiovascular functioning. This appears as a potentially fruitful line of future research.

Conclusions

The relationships between school burnout and indicators of cardiovascular functioning were evaluated via 24-h ambulatory blood pressure (BP) and electrocardiogram (ECG) monitoring. Findings are consistent with previous research in that increased school burnout was related to elevated ambulatory BP (systolic and diastolic). As a novel contribution, findings also indicate increased school burnout was related to markers of increased cardiac sympathovagal tone. Thus, research continues to grow implicating school burnout as an indicator of suboptimal physiological functioning and might potentially be implicated with the development of pre-hypertension or early cardiovascular disease.

Disclosure statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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