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Physiology of school burnout in medical students: Hemodynamic and autonomic functioning

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ABSTRACT

This study investigated the relationship between burnout and hemodynamic and autonomic functioning in both medical students (N = 55) and premedical undergraduate students (N = 77). Questionnaires screened for health related issues and assessed school burnout and negative affect symptomatology (anxiety and depression). Continuous beat-to-beat blood pressure (BP) through finger plethysmography and electrocardiogram (ECG) monitoring was conducted during conditions of baseline and cardiac stress induced via the cold pressor task to produce hemodynamic, heart rate variability, and blood pressure variability indices. Independent sample *t*-tests demonstrated that medical students had significantly higher school burnout scores compared to their undergraduate counterparts. Controlling for age, BMI, anxiety and depressive symptoms, multiple regression analyses indicated that school burnout was a stronger predictor of elevated hemodynamics (blood pressure), decreased heart rate variability, decreased markers of vagal activity and increased markers of sympathetic tone at baseline for medical students than for undergraduates. Analyses of physiological values collected during the cold pressor task indicated greater cardiac hyperactivity for medical students than for undergraduates. The present study supports previous research linking medical school burnout to hemodynamic and autonomic functioning, suggests biomarkers for medical school burnout, and provides evidence that burnout may be implicated as a physiological risk factor in medical students. Study limitations and potential intervention avenues are discussed.

1. Introduction

Data from the American College Health Association-National College Health Assessment II (ACHA-NCHA II), pooling from 108 universities and including over 93,000 college students indicates that maladaptive affective functioning is the most prevalent psychological impediment to successful academic performance among US college students (ACHA-NCHA II, 2015). In fact, students overwhelmingly ranked the negative impact of stress as the leading factor affecting their individual academic performance during the last 12 months. Accordingly, considerable resources (both research and public policy based) have been allocated toward identifying, understanding, and decreasing affective symptomatology that diminishes the mental and physical health of collegiate populations (Regeher, Glancy, & Pitts, 2013).

A growing concern regarding affective symptomatology in academic populations is school burnout. School burnout is school-related stress conceptualized as chronic exhaustion from school-related work, cynicism toward the meaning of school and a belief of inadequacy in school related accomplishment (Salmela-Aro, Kiuru, Leskinen, & Nurmi, 2009). Prior research shows that school burnout is associated with an imbalance of hemodynamic functioning. *Hemodynamics* is the study of blood movement or blood flow and how physical forces affect circulation (Guyton & Hall, 1996). Specifically, school burnout (a) is associated with cardiac hyperactivity during conditions of cardiac stress and recovery via a cold pressor task (CPT; submersion of one's hand in water of <4 °C for a specified amount of time) and (b) predicts arterial stiffness and blunted diurnal blood pressure variability as assessed through ambulatory blood pressure monitoring (see May, Sanchez-Gonzalez, Brown, Koutnik, & Fincham, 2014; May, Sanchez-Gonzalez, & Fincham, 2014). All the above findings relating school burnout to physiological functioning were independent of affective symptomatology (i.e., anxiety and depression). Moreover, the cardiovascular responses of individuals suffering from

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higher levels of burnout have been identified as risk factors for the future development of cardiovascular disease (Bajko et al., 2012; FitzGerald, Ottaviani, Goldstein, & Shapiro, 2012; Matthews et al., 2004). Arguably these findings make school burnout a potential public health issue of particular concern to educators and health care policy makers.

School burnout is pervasive at multiple educational levels: it has been found in high school students (Salmela-Aro et al., 2009; Walburg, 2014), undergraduate students (May, Sanchez-Gonzalez, Brown et al., 2014; May, Sanchez-Gonzalez, & Fincham, 2014), and graduate students (Dahlin & Runeson, 2007; Dyrbye, Thomas, & Massie et al., 2008; Dyrbye et al., 2011). Current research suggests that burnout may be particularly deleterious in medical students as various forms of burnout in this population have been associated with numerous negative professional and physical health issues, including depressive symptoms and suicidal ideation (Dahlin & Runeson, 2007; Dyrbye et al., 2008, 2011), unprofessional behavior (Brazeau, Schroeder, Rovi, & Boyd, 2010; Dyrbye, Massie et al., 2010), medical school dropout contemplation, (Dyrbye et al., 2011; Dyrbye, Thomas et al., 2010) lower empathy (Brazeau et al., 2010; Thomas et al., 2007), sleep disorders (Pagnin et al., 2014) and lower performance-based self-esteem (Dahlin, Joneborg, & Runeson, 2007).

The prevalence of medical school burnout is high. IsHak et al. (2009) showed that across 51 studies the prevalence of burnout ranged from 28 to 45% in medical students (Dyrbye, Thomas, & Huntington, 2006; Willcock, Daly, Tennant, & Allard, 2004) and 27% to 75% (averaged 50%) in residents (Martini, Arfken, Churchill, & Balon, 2004). In a more recent literature review of 9 studies, medical student burnout ranged from 45% to 71% (IsHak et al., 2013). Thus nearly half of all medical students experience burnout during their medical education making this an at-risk population.

Given the many negative professional and wellness issues associated with school burnout, it is surprising that the physiological effects of burnout in medical school populations remains relatively underexplored. Accordingly, we examined the relationship between medical school burnout and physiology through analysis of cardiovascular reactivity (CVR) induced by the cold pressor task (CPT). CVR is defined as the magnitude or pattern of hemodynamic responses to stressors (Manuck, 1994; Treiber et al., 2003). Research indicates that only through inducing states of CVR may some individuals be identified as at risk of deteriorated cardiovascular functioning (Manuck, 1994; May, Sanchez-Gonzalez, Brown et al., 2014; Treiber et al., 2003). Thus through CVR, cardiac anomalies undetectable at resting states may be better identified. For example, CVR has been shown to be both a marker and a mechanism in the pathogenesis of cardiovascular disease (Manuck, 1994; Treiber et al., 2003). A research review investigating CVR and the development of subclinical and clinical CVD states, found that blood pressure responses to the CPT were predictive of future hypertension in longitudinal epidemiological studies in initially normotensive samples (Treiber et al., 2003).

Physiological parameters of interest in this study include typical hemodynamic (e.g. blood pressure and heart rate) and autonomic nervous system indices (vagal modulation) as well as more progressive cardiac indicators of autonomic functioning: cardiac sympathovagal tone (through heart rate variability analysis) and sympathetic vasomotor tone (through blood pressure variability analysis). Cardiac sympathovagal tone produces an index denoting the contribution of sympathetic influence on the balance of the autonomic state resulting from sympathetic and parasympathetic influences (Goldberger, 1999; Goldstein, 1983). Elevated cardiac sympathovagal tone has been identified as an important marker of cardiovascular morbidity and mortality (Goldberger, 1999; Goldstein, 1983). Unlike cardiac sympathovagal tone which is predominately a vagal driven (parasympathetic) autonomic nervous system indicator, sympathetic vasomotor tone provides a more robust index of the sympathetic autonomic nervous system influence on the vasculature (Malliani, Pagani, Lombardi, & Cerutti, 1991). In more general terms, sympathetic vasomotor tone describes the level of nervous system stimulation on smooth muscles in the blood vessel walls which contributes to their level of contraction (i.e. *vasoconstriction*). Elevated sympathetic vasomotor tone has been associated with a variety of negative wellness indicators (e.g. affective disorders, hypertension, autonomic nervous system disorders, Izdebska, Cybulska, Izdebskir, Makowiecka-Ciesla, & Trzebski, 2004; Okamoto et al., 2012; Sanchez-Gonzalez, May, Koutnik, Kabbaj, & Fincham, 2013). Collectively, cardiac sympathovagal tone and sympathetic vasomotor tone are referred to as indicators of cardiac autonomic modulation.

Therefore, we examined the relationship between medical school burnout and CVR using indices of hemodynamics and cardiac autonomic modulation. We also explored this relationship at both the graduate and undergraduate levels of medical education. We expected medical school burnout to be associated with suboptimal cardiovascular functioning as indicated by elevated hemodynamics and imbalanced cardiac autonomic modulation (i.e. higher cardiac sympathovagal tone and sympathetic vasomotor tone). We also expected burnout to be implicated as a cardiovascular risk factor in students at both the graduate and undergraduate medical educational level. Furthermore, given the greater professional and educational burden placed on medical students in graduate programs compared to undergraduate programs (IsHak et al., 2013), we expected graduate student burnout to have stronger relationships with impaired cardiac functioning than undergraduate student burnout.

2. Methods

2.1. Participants

Fifty-five first year medical students (41 females) and 77 undergraduate university students majoring in premedical studies (61 females; 72% Seniors) qualified for study inclusion. 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 (blood pressure ≥140/90 mmHg), had chronic diseases, or were taking beta blockers, antidepressants, or stimulants (as previously specified in May, Sanchez-Gonzalez, Brown et al., 2014, May, Sanchez-Gonzalez, & Fincham, 2014). Participants were asked to abstain from caffeine, alcohol, and strenuous physical activity for at least 24 h prior to testing and were asked not to eat any food 4 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 (Adkisson et al., 2010). The graduate medical student sample was 76% Caucasian, 7% African American, 9% Hispanic, 5% Asian, and 3% endorsed either biracial or non-disclosed ethnicity. The premedical undergraduate sample was 73% Caucasian, 10% African American, 8% Hispanic, 7% Asian, and 2% endorsed either biracial or non-disclosed ethnicity. Participants were recruited through campus advertisements and from classrooms as an option for voluntary class credit with all data 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.