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# Clinical and non-clinical depression and anxiety in young people: A scoping review on heart rate variability

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#### ABSTRACT

*Background:* Heart rate variability (HRV), a measure of cardiac autonomic nervous system functioning, has emerged as a physiological indicator for emotional regulation and psychological well-being. HRV is understudied in the context of depression and anxiety in young people (10–24 years old). Main objectives: (1) describe the nature and breadth of reviewed studies; and (2) synthesize main findings in the context of clinical and non-clinical populations of young people with depression and/or anxiety.

*Methods*: The Arksey and O'Malley methodology was utilized for this scoping review. CINHAL, EMBASE, Medline, PsychInfo, Scopus, Web of Science, as well as grey literature, were searched. Two reviewers screened titles, abstracts and full papers for inclusion. A total of 20 citations were included in the final review (19 citations peer-reviewed journal articles, 1 journal abstract). Numerical and thematic analysis was used to summarize study findings.

*Results*: In clinical populations of either depression or anxiety, HRV was lower compared to controls. In nonclinical populations of either depression or anxiety, HRV was found to be lower in those who reported more depression or anxiety symptoms.

*Limitations:* The quality of the reviewed articles was not assessed which limits the ability to generate conclusions regarding study findings.

*Conclusion:* Changes in HRV were found across the spectrum of clinical and non-clinical populations of young people with depression or anxiety. Neurophysiological research on depression and anxiety in young people can act as a first step to understanding how physiological flexibility (i.e. HRV) is related to psychological flexibility (i.e. daptive or maladaptive responses to life events).

#### 1. Introduction

Mental health issues, specifically depression and anxiety, are a significant global burden of disease across communities of the world. According to the World Mental Health Survey conducted in 17 countries, about 1 in 20 people report having episodes of depression (World Federation for Mental Health, 2012). Depression and anxiety often start in adolescence, with an estimated prevalence of 10% to 25% (Green et al., 2004; Mental Health Commission of Canada, 2013), which is experienced more than any other age group (Sunderland & Findlay, 2013). Within a Canadian sample, approximately 2.8 million young people (10.1% of the population) reported symptoms consistent with at least one mental health issue, which included major depressive disorder

as the most common type of mood disorder (4.7% of all types of mental health issues), and generalized anxiety disorder accounting for 2.6% of this population (Sunderland & Findlay, 2013). According to the fifth edition of the Diagnostic Statistics Manual (DSM-5), depression is characterized by feelings of hopelessness, depressed mood, fatigue, and a diminished interest or pleasure in activities (American Psychiatric Association & American Psychiatric Association, 2013). Anxiety is defined as feelings of excessive worry, restlessness, tiring easily, trouble concentrating and difficulty sleeping (American Psychiatric Association & American Psychiatric Association, 2013). Depression and anxiety are examined concurrently in this review, as they are often comorbid presentations. In fact, it is estimated that more than two thirds of individuals with mental health issues display depressive and

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anxious symptoms (Kessler & Walters, 1998; Moffitt et al., 2007).

A recent review indicated that the onset of mental health problems usually occurs during the transition period between childhood and young adulthood (Kessler et al., 2007), with significant emotional turbulence occurring as young people shape their self-identities (Canadian Network for Mood and Anxiety Treatments, n.d.). During the transition from childhood to young adulthood, substantial neurodevelopment is underway. In particular, the maturation of the prefrontal cortex plays a critical role in higher order cognitive functioning as well as emotional regulation (Weir et al., 2012). Thus, the notion of developmental risk for acquiring depression and anxiety becomes apparent during this stage of life, as it is characterized by a confluence of biological (e.g. onset of puberty), psychological (e.g. abstract thinking) and social challenges (e.g. school, friend relationships; Sisk & Foster, 2004; Somerville et al., 2010). These maturational changes occur along different temporal trajectories from neurodevelopment, increasing young people's vulnerability to mental health issues (Somerville et al., 2010). Consequently, this increased vulnerability may also lead to persistent issues in adulthood. For example, young people with a diagnosis of an anxiety or mood disorder face an approximate 45% chance of carrying it into adulthood (Pine, 1999). Similarly, in prospective studies, most adults who meet criteria for an anxiety as well as a depressive disorder suffered from one of these issues in childhood (Newman et al., 1996; Pine et al., 1998). These developmental trends underscore the importance of identifying factors that enhance our understanding of young people with depression and anxiety (Kessler & Walters, 1998; Weir et al., 2012). It is important to note here that substantial literature exists for "children" (Chalmers et al., 2014) and "adult" populations (Kemp et al., 2010) on the relationship between HRV and clinical/nonclinical mental health issues. However, based on the complexity of this transitional period between childhood and adolescence, the term "young people" has been used to capture this understudied population. As such, this review is anchored in the definition of young people defined by the World Health Organization (1986), as 10 to 24 years of age.

In addition to the emotional characteristics of depression and anxiety, these internalizing issues also have somatic manifestations that suggest alterations in autonomic nervous system (ANS) activity such as rapid heart rate, shortness of breath, and sweating (Friedman & Thayer, 1998). The role of the ANS in contributing to internalizing mental health issues has been highlighted as the least understood and examined in young people (Graziano & Derefinko, 2013). Specifically, heart rate variability (HRV) has emerged as a physiological marker for emotional regulation, yet it remains understudied in the context of depression and anxiety in young people (Kemp & Quintana, 2013). HRV is a non-invasive, physiological indicator of ANS functioning that examines fluctuation of heart rate over time. HRV is quantified by capturing the time between beat-to-beat intervals; time domain and frequency domain measures are often computed to reflect overall variability and contribution of ANS branches, respectively (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Specific to frequency domain measures, high frequency (HF) also known as respiratory sinus arrhythmia (RSA), has been used as an index of parasympathetic-mediated control of the heart (Scott & Weems, 2014; Julian F. Thayer & Lane, 2009). Low frequency (LF) is more controversial in the literature and, is considered to be driven by both sympathetic and parasympathetic inputs (Goldstein et al., 2011; Task Force, 1996).

In psychophysiology literature, HRV is regarded as an important marker of psychological well-being and general cardiovascular health (Chalmers et al., 2014). The neurovisceral integration model (Thayer & Lane, 2000) conceptualizes this psychophysiological measure (HRV) by providing a link between HRV and mental health status (Chalmers et al., 2014). A core feature of this model is the central autonomic network, which is comprised of brain regions (e.g. prefrontal cortex, cingulate cortex, amygdala) that coordinate autonomic and

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behavioural responses to environmental adaptation challenges. As such, efferent nerve fibers from the prefrontal cortex moderate parasympathetic activity and vagal nerve inhibition of cardiac activity (i.e. creating a state of mental restoration). In young people without depression and anxiety, the balanced interplay between the parasympathetic and sympathetic nervous systems within the ANS enables optimal adaptation to environmental, cognitive and emotional influences (Thayer & Lane, 2000). This is illustrated through increased HRV, in which complexity and variability in the fluctuations of heart rate are indicative of flexibility in mind and body responses. For example, Thaver and Lane (2009) reviewed the evidence on the role of vagally mediated HRV in the regulation of both physiological and affective processes, and found that low HRV may be a risk factor for pathophysiology and psychopathology. A meta-analysis also provided evidence that HRV may serve as a proxy for integration of brain mechanisms that guide flexible control over behaviour, with important implications for stress and health (Thayer et al., 2012). It is important to note here that in cases of psychological and physical stressors (i.e. over training in the case of athletes), transient increases in HRV may also be seen (Le Meur et al., 2013), but it is unclear if this reflects appropriate autonomic responses to mobilize energy to react adaptively. However, when the parasympathetic system is chronically inhibited, the vagal brake is released causing hyperarousal of the sympathetic nervous system, which lead to both anxiety and depressive mav symptoms (Graziano & Derefinko, 2013; Porges et al., 1996). Conversely, the opposite in directional influence may also occur, in which external daily influences (i.e. stressors that lead to anxiety and depression) impact ANS functioning. Compared to young people without depression and anxiety issues, those who display sub-clinical and clinical anxiety and depression demonstrate decreased HRV; it may be possible that a reduction in HRV and behavioural inflexibility relate to common neurological changes (Chalmers et al., 2014; Thayer & Lane, 2000). It is unclear whether sympathetic hyperarousal is caused by parasympathetic inhibition, hyperactivity of the sympathetic system or a combination of both of these mechanisms. Further, it is also worth noting that sympathetic hyperarousal may not be directly linked to parasympathetic inhibition; it is possible for both branches of the ANS to be hyperaroused simultaneously (Berntson et al., 1991).

Neurophysiological research on depression and anxiety in young people can act as a first step to understanding how physiological flexibility (i.e. HRV) may be used as a proxy for psychological flexibility (i.e. adaptive or maladaptive responses to life events). A recent and rigorous systematic review and meta-analysis examined the relationship between clinical depression and HRV in children and adolescents, which found lower HRV with those individuals with clinical depression compared to controls, an effect associated with a moderate effect size (Koenig et al., 2016). This review further adds to the field of psychophysiology for the following reasons: (1) it considers a broader examination of both depression and anxiety, conditions that are highly linked with one another; (2) it aims to contextualize the nature, breadth and depth of studies being conducted across both clinical and nonclinical populations; (3) the review's purpose is to map the current state of the literature and the methodologies utilized in HRV and mental health issues in young people. More broadly speaking, the all-encompassing nature of scoping methodology acts a prompt to the scientific community (researchers and clinicians) to consider potential physiological underpinnings of mental health issues and generate future research questions. The goal of this review was not to address a narrow research question or assess the quality of included studies. Rather, scoping reviews address broad research questions and thus, the aim is to summarize results across multiple studies (Arksey & O'Malley, 2005). The research question informing this scoping review was: what is the current state of knowledge regarding the link between heart rate variability and depression and anxiety in young people?

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