Examining Heart Rate Variability and Anxiety in Children and Adolescents with Congenital Heart Disease

A Thesis

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Abstract

Congenital heart disease (CHD) is a term which includes a range of developmental cardiac diseases with severe health impacts. In the past, research has solely focused on improving medical outcomes for individuals with CHD and has successfully increased the chance of survival. To date, there has been little research on the mental health of this population. Existing research has examined cardiac physiology in adults with anxiety disorders. However, limited to no research has explored cardiac physiology in individuals with CHD, more specifically in children with CHD. The present study examined the connection between measures of heart rate variability (HRV) and anxiety-related constructs in children with CHD and typically developing children. Eighty-one children (40 diagnosed with CHD; 41 typically developing) ages 7 to 16 years (mean age = 11.7, *SD* = 2.38) completed a battery of cardiac and anxiety measures. We hypothesized that children with CHD would demonstrate significantly lower HRV and significantly higher levels of anxiety than typically developing children. Results demonstrated significantly lower primary time domain HRV measures and primary frequency domain HRV measures as well as higher LF/HF ratio than typically developing children. The current study was the first of its kind to explore time and frequency domain measures of HRV with anxiety, anxiety sensitivity, intolerance of uncertainty, and health anxiety in this population of Canadian children with CHD. Information gleaned from the current study will contribute to the understanding of psychopathology in this specialized medical population.

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1.0 Introduction

Congenital heart disease (CHD) is a term to encompass a wide range of disorders which arise from abnormal heart development (Cassidy et al., 2018), it is the most common congenital birth defect and one of the most common causes of death for infants under one year worldwide (Bernier, Stefanescu, Samoukovic, & Tchervenkov, 2010). Further, it is estimated that 25% of children who are diagnosed with CHD will require some type of surgical intervention in their first year (Cassidy et al., 2018). While this was once a lethal diagnosis, advancements in cardiac technology have significantly increased the likelihood of survival. Now more than 90% of individuals diagnosed with CHD in childhood will reach adulthood (Moons et al., 2010). Therefore, the focus of research for this population has begun to shift away from survival-focused strategies and move instead towards practical improvements to daily lifestyle and other aspects of wellness.

Available literature has recently begun to outline the connection between physiological measures of health and measures of anxiety in adults. However, individuals with cardiac-related chronic diseases differ significantly in their typical cardiac physiological measures as compared to healthy populations. While some literature discusses the prevalence of anxiety disorders in adults with CHD, there is currently no existing research that has examined the association between physiological measures of cardiac functioning and anxiety in children with CHD. Evidence suggests that measures of cardiac variability are directly related to anxiety disorders (Pittig et al., 2013), specifically, one's ability to adapt to the environment and to respond appropriately (Thayer & Lane, 2000). Heart rate variability (HRV) is one such measure which current research suggests could be used as a predictor of anxiety disorders. However, there is limited literature describing the connection between cardiac variability and anxiety in specialized

cardiac populations. Therefore, the present study seeks to explore the connection between physiological measures of cardiac functioning and measures of anxiety-related constructs in children with CHD, while adding to the current knowledge of well-being for individuals with CHD.

1.1 Congenital Heart Disease

There are a large number of defects and malformations that fit under the umbrella of CHD. As such, there are a variety of classifications used in discussions of this disease. The severity of CHD is typically classified as "simple" or "complex" where these terms refer to the severity of lesions present in each case (Warnes et al., 2001). Further diagnostic distinction is made between cyanotic CHD (i.e., in which the individual has a bluish tint to the skin due to low oxygen saturation) and non-cyanotic CHD (i.e., the individual maintains normal oxygen saturation and normal skin colouring; Cassidy et al., 2018). The classifications of the severity of CHD are diagnostic of the physical criteria only and do not take into account the many complex factors that contribute to the experience of individuals with CHD (Jackson et al., 2016). A child with a "less-severe" type of CHD may experience as much distress due to disease as a child with a "more-severe" type of CHD. Many individuals experience psychological and physiological symptoms of their CHD diagnosis that they must manage across their lifetime.

The cost of caring for a child who has been diagnosed with CHD is incredibly high. An American study on the out-of-pocket costs estimates that in the first twelve months, the family of a child with severe CHD can cost up to $11,000 USD (Elhoff et al., 2016). If a child is admitted to the emergency room, a multi-day stay can cost a total of up to $59,975 (Chan, 2018). Beyond the first year of life, the number of hospital visits and other health care utilization will vary greatly according to several factors (i.e., items on the Pediatric Cardiac Quality of Life

Inventory; Ernst et al., 2018). Of those factors, the most relevant to the present study, it has been shown that depression and anxiety are related to greater rate of health care utilization for adults with CHD (Benderly et al., 2018) this may lead to greater costs for the individual (or their family) and put stress on medical systems.

A recent study of adults with CHD found that quality of life (QoL; one's own assessment of their physical and emotional well-being; Jackson et al., 2016) is correlated with morbidity and mortality, where declines in QoL will have a significantly negative impact on patient health outcomes. Children diagnosed with CHD face a set of challenges which their typically developing peers do not. Factors which are the result of managing one's CHD diagnosis are shown to have a negative impact on QoL in children (Jackson et al., 2016). This can include neurological, psychosocial, and cognitive challenges unique to children with CHD (Cassidy et al., 2018; Ernst et al, 201). For example, Cassidy et al. (2018) outline some of the means by which children with CHD can acquire or develop brain abnormalities as a result of their disease including during prenatal development, injury related to cardiac surgery, and chronic lack of oxygen in the blood (i.e., hypoxemia). Considering the potential severity of the side effects of CHD and the resulting impact on QoL, advancement of our understanding of the psychological functioning or distress experienced by those with CHD is warranted.

1.2 Anxiety

Anxiety is characteristic of the human condition. However, while the experience of anxiety is normal and healthy, anxiety disorders include fears, worries, negative beliefs, somatic symptoms during times of stress, and avoidance of situations or activities (Rapee, 2015). While academia has long acknowledged the importance of understanding how anxiety impacts an individual's day-to-day life, it has taken society as a whole longer to catch up and to learn the

vocabulary of anxiety. In literature, anxiety is thought of as a spectrum, ranging from non-pathological (e.g., so-called normal experiences of life) to extreme anxiety which interferes with one's life and mental health (Nunn, 2015). Understanding the factors which contribute to anxiety is important to the ability to treat anxiety as well as the ability of health care providers to identify and intervene for before symptoms of anxiety cause significant dysfunction and distress for the individual (Nunn, 2015). Two known constructs that are associated with anxiety and have been established as contributing factors for development and maintenance of anxiety are anxiety sensitivity and intolerance of uncertainty.

1.2.1 Associated Constructs

1.2.1.1 Anxiety Sensitivity

Anxiety sensitivity (AS) refers to the fear of fear, or the fear of anxiety-related sensations (Reiss, 1991). This is defined as the belief that the bodily sensations which are associated with anxiety may have harmful somatic, social, or psychological consequences (Taylor, 1999). Research suggests that AS may be a risk factor for panic attacks and also may maintain psychopathology such as depression and anxiety disorders (Cox et al., 2001; Norr et al., 2013; Reiss, 1991). AS has been shown in non-clinical populations to be predictive of anxiety related to one's health (Wheaton et al., 2002). Anxiety sensitivity is commonly measured in adults with the Anxiety Sensitivity Index (ASI; Reiss et al., 1986) or its later edition (i.e., the ASI-3; Taylor et al., 2007). The ASI is a self-report measure with 16 statements of negative consequences of experiencing anxiety to which the subject rates their agreement (Reiss et al., 1986). Previous research has found that children with CHD demonstrate significantly higher levels of AS (i.e., CASI; Silverman et al.,1993) compared to typically developing children (Oliver et al., 2018).

1.2.1.1 Intolerance of Uncertainty

Intolerance of uncertainty (IU) refers to a tendency of the individual to believe that the possibility of a negative event occurring, regardless of actual probability, is unacceptable (Carleton et al., 2007). Worry about the possibility of a negative event maintains a higher level of anxiety (Dugas et al., 2001). Thus, IU has a significant impact on anxiety and anxiety disorders (Greco & Roger, 2001). IU is often measured with the 12-item version of the Intolerance of Uncertainty Scale (Carleton et al., 2007). This self-report measure is composed of 12 items. Answers are on a scale, range from "not at all like me" to "entirely like me". Research has found that children with CHD demonstrate significantly higher levels of IU (i.e., the IUS revised; Walker et al., 2010) as compared to typically developing children (Oliver et al., 2018).

1.2.2 Childhood Anxiety

International data from 2009 suggests that, at any given time, approximately 5% of young in the world people meet the criteria for clinical diagnosis of an anxiety disorder (Rapee et al., 2009). In American adolescents, anxiety disorders are the most prevalent mental disorder (i.e., approximately 31% of adolescents met the criteria) with the earliest median age of onset, 6 years (Merikangas et al., 2010). In comparison, behaviour disorders were shown to be the second most common (i.e., approximately 19% of adolescents met the criteria) and the second youngest median age of onset, 11 years (Merikangas et al., 2010). The degree to which anxiety or anxiety disorders impacts one's life varies greatly. It has been shown that anxiety can impair the child to a similar degree as ADHD or depression (Ezpeleta et al., 2000). About 8% of American adolescents demonstrate severe distress or impairment related to their anxiety disorder (Merikangas et al., 2010). Furthermore, previous studies have found that childhood anxiety is a significant source of distress for the family (Greco & Morris, 2005). Not only will anxiety

impact the child's relationship with their family but their relationships with their peers (Greco & Morris, 2005). When an individual has anxiety in childhood, they are at significant risk for additional mental disorders as they age (Rapee, 2009).

Current literature appears to support multiple risk factors for the development of childhood anxiety. The mechanism by which heritability impacts anxiety is not yet fully understood, however some research suggests that a gene variation in the serotonin transporter might influence anxiety in young people (Smoller et al., 2009). Research investigating genetic risk associated with temperamental precursors has found that inhibition and withdrawal in early years (toddler to pre-school age) is a consistent predictor of anxiety symptoms in later life (Rapee, 2009). Additionally, research on environmental and familial factors has found that stressful life events and peer relationships account for the variance in anxiety and that parental overprotection is the most consistent risk factor for anxiety (Rapee, 2009). However, particular factors associated with the child's family are found to be significant only in children who are temperamentally vulnerable.

1.2.3 Anxiety in Individuals with CHD

A study of adults with CHD found that 50% of participants met diagnostic criteria for mood or anxiety disorders currently or at some time in their life (Kovacs et al., 2009). This specialized population has been found to be at greater risk of anxiety disorders. As noted above, childhood anxiety can be continuous with adult anxiety (Rapee, 2015). In turn, exploration of anxiety in children with CHD is a logical extension of exploration of the phenomenon in adults. Meta-analysis of studies exploring the functioning of children and adolescents with CHD which found that those with CHD were more likely to exhibit internalizing symptoms (i.e., anxiety, depression, and withdrawal) than typically developing children and adolescents (Karsdorp et al.,

2007). It should be noted, however, that a longitudinal study from the Netherlands recently found that while the cohort reported high levels of psychopathology in childhood and adolescence (ages less than 15), as adults, the participants with CHD reported comparable or possibly below average levels of psychopathology to the general population (Opić et al, 2016). Furthermore, research on cardiac diseases has shown that the psychological experience of adults with CHD is unique compared to acquired heart diseases and thus we cannot necessarily generalize findings from other populations (Kovacs et al., 2009).

In this population, an area of specific concern is health anxiety (HA). This is defined as a concern with bodily symptoms and the belief that they may be a symptom of a larger illness (Taylor et al., 2001). Some level of health anxiety is normal and can be advantageous in seeking medical care for symptoms (Wright, 2002). More severe HA was once classified as a somatoform disorder, hypochondriasis, which is characterized by preoccupation with the body and the fear of disease [second edition; DSM-II; American Psychiatric Association (APA), 1986]. Changes in the understanding of health anxiety has caused a change in diagnostic criteria. Hypochondriasis is not in the current edition of the DSM (APA, 2013) and has instead been replaced with Somatic Symptom Disorder and Illness Anxiety Disorder.While a substantial literature base on health anxiety in adults exists (Wright & Asmundson, 2003; Bernstein et al., 1996), exploration of health anxiety in children and adolescents is relatively new (Campo & Reich, 1999). In particular, there is a very limited exploration of health anxiety in specialized child and adolescent health populations. However, previous research has shown that health anxiety is likely to develop in populations with serious illnesses (Warwick & Salkovskis, 1990). Most salient to the current proposal, children with CHD have been shown to have significantly higher levels of self-reported health anxiety when compared to typically developing children

(Oliver et al., 2018). However, previous studies with children and adolescents with CHD, severity of disease does not appear to have an impact on mental health outcomes (Kovacs et al., 2009; Jackson et al., 2016). Current literature provides evidence that a diagnosis of CHD plays a significant role in the individual's mental health. However, there is a lack of understanding of the physiological symptoms of CHD as they related to psychopathology. The present study hopes to contribute to the knowledge of what can be learned from physiological measures of health for mental health outcomes.

1.3 Heart Rate Variability (HRV)

HRV is emerging as an essential physiological measure of cardiac functioning due to the non-invasive method of measurement and the relative ease of interpretation. HRV is defined as the change in time intervals between consecutive heart beats (Camm et al., 1996). Normal HRV throughout a breathing cycle will increase on inspiration (inhalation) and decrease on expiration (exhalation). Thus, HRV reflects the autonomic control of the parasympathetic nervous system (PNS) which is responsible for visceral responses to stimuli (Thayer & Lane, 2000). This allows the individual to respond and adapt to their environment (Pittig et al., 2013).

1.3.1 Autonomic Control of HRV

The central autonomic network (CAN) allows the brain to control the visceromotor, neuroendocrine, and behavioural responses (Benarroch, 1993). The CAN output is primarily mediated through preganglionic sympathetic and parasympathetic neurons which in turn innervate the heart via the stellate ganglia and vagus nerve (Thayer & Lane, 2000). These two inputs are responsible for the complex beat-to-beat variability of a healthy heart rate (Thayer & Lane, 2000). Thus, HRV indicates the balance of function of the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS). The SNS influence on cardiac control is

much slower than the PNS (i.e., order of magnitude seconds and milliseconds, respectively; Saul, 1990) thus when PNS input is decreased response to stimuli is impaired or slowed (Thayer & Lane, 2000).

1.3.2 HRV and Anxiety

Previous research suggests that emotions are a response to stimuli in the environment and incorrect processing of this affective information can lead to psychopathological disorders such as generalized anxiety disorder (Thayer & Lane, 2000). In studies of HRV in adults, HRV was significantly decreased in all anxiety disorders (Pittig et al., 2013; Yeragani et al., 1990; Gorman & Sloan, 2000). Similarly, in non-anxious controls, HRV is decreased when participants are in an induced worry state (Thayer & Lane, 2000). This suggests that decreased HRV is involved in anxiety responses. Specifically, cardiac vagal tone is believed to facilitate organization of physiological resources and response selection, allowing for self-regulation and goal-directed behaviour (Thayer & Lane, 2000). Thus, if individuals have a decreased HRV they are more likely to have more anxious responses to their environment.

While there is limited research determining the physiological and psychological correlations for children and adolescents with CHD, it has been shown that children diagnosed with CHD have delayed maturation of the autonomic nervous system (ANS) prior to birth which causes decreased HRV in early postnatal measurements (Mulkey et al., 2019). Additionally, children and adolescents with CHD tend to have decreased HRV as compared to healthy controls (Heragu & Scott, 1999; Massin & Bernuth, 1998). This suggests that HRV is a possible physiological predictor of anxiety in this specialized medical population.

1.3.3 Measures of HRV

HRV is a quantitative measure of autonomic activity which has been utilized in various fields for research and clinical studies (Dreifus et al, 1993). Specifically, this is the measure of the oscillation in the interval between consecutive heart beats (Camm et al., 1996). This can be visualized on the waves produced on an electrocardiogram (ECG) as the interval between consecutive R waves thus known as the RR interval or the RR variability (Camm et al., 1996). In the past, HRV measures have been used in an incredible variety of tests to predict outcomes such as fetal distress (Hon & Lee, 1965, as cited in Camm et al, 1996), autonomic neuropathy in diabetic patients (Ewing et al., 1985, as cited in Camm et al., 1996), and mortality following acute myocardial infarction (Kleiger et al, 1987, as cited in Camm et al, 1996). Since these early studies, instruments capable of measuring HRV have become readily available to not only researchers and clinicians but to the average consumer. However, as described by Camm et al. (1996), this data has the potential "for incorrect conclusions and for excessive or unfounded extrapolations". Thus, care must be taken in determining which measures are appropriate for use in studies which utilize HRV.

1.3.3.1 Time Domain Measurements.

A continuous ECG record will record waves which represent the electrical activation of the heart (Khan, 2008). When electrical activation spreads through the ventricular myocardium, the corresponding ECG waves will produce three sharp deflections which are labelled as Q or q, R or r, and S or s, this is called the QRS complex (Khan, 2008) This complex is also known as the normal complex and thus, the interval between consecutive QRS complexes is known as the normal-to-normal (NN) interval and is the result of sinus node depolarization (Camm et al., 1996). In calculation of NN intervals any so-called abnormal beats (i.e., a heartbeat originating

outside of the right atrium's sinoatrial node, an ectopic beat) is excluded (Shaffer & Ginsberg, 2017). This allows one to compute time-domain variables such as mean NN interval and range of NN interval length. However, if the RR interval is to be computed then all heartbeats will be included (Shaffer & Ginsberg, 2017). The instantaneous heart rate can be determined using the QRS complexes on the ECG record allowing the calculation of mean HR and variation in instantaneous heart rate (Camm et al., 1996).

Time domain methods of HRV measurement can be analyzed statistically or geometrically (Camm et al, 1996) however, in the present study, we only examined statistical time-domain measures. These can be derived directly from measurements of NN intervals and instantaneous heart rate, or from the differences between NN intervals (Camm et al, 1996). The first variable calculated is the standard deviation of the NN intervals (SDNN) which indicates the impact of cyclic components on HRV (Camm et al., 1996). SDNN is typically recorded over a 24-hour period since shorter recordings record shorter SDNN cycles (Camm et al., 1996). It is therefore inappropriate to compare SDNN recordings of different lengths (Camm et al., 1996) thus for the present study we obtained standardized recordings of five minutes. Using the calculated SDNN, the square root is taken to produce the SDSD.

Each of these calculations with the NN interval can also be completed for the RR interval, as noted above these are not interchangeable measurements. Additionally, from the differences of the successive RR intervals we can determine the square root of the mean squared differences (RMSSD), the number of RR intervals greater than 50ms (RR50), and the proportion of the total RR intervals that vary by more than 50ms (*p*RR50) by dividing the RR50 by the total number of recorded RR intervals (Camm et al., 1996). All of the time domain measurements

used in this paper estimate the high frequency variations in heart rate and thus are highly correlated (Camm et al., 1996).

1.3.3.2 Frequency Domain Measurements.

Frequency domain measurements are used to estimate the absolute or relative power distribution into four HR oscillation frequency bands; ultra-low-frequency (ULF), very-low-frequency (VLF), low-frequency (LF), and high-frequency (HF) (Camm et al, 1996). Power is defined as the signal energy within a specific frequency band (Shaffer & Ginsberg, 2017). The absolute power for a particular frequency is calculated by dividing milliseconds (ms) squared by cycles per second (ms^2/Hz) and relative power is then calculated by dividing the absolute power by the absolute power of the LF and HF bands combined and is given as the percentage of total HRV power (Shaffer & Ginsberg, 2017). Finally, the total power is calculated as the sum of the energy in the ULF, VLF, LF, and HF bands for the recording period (Shaffer & Ginsberg, 2017). In the present study we examined the normalized LF and HF absolute power measurements. In order to convert to normalized units (nu), the power of the given band is divided by total power minus the VLF power, multiplied by 100 (Camm et. Al, 1996). The participants were measured for a 5-minute period which typically contains 12-45 complete periods of oscillation from which we can calculate the ratio of LF to HF power (LF/HF ratio) to estimate the ratio of sympathetic nervous system and parasympathetic nervous system activity in this time (Shaffer & Ginsberg, 2017). In research which relates cardiac variability and psychopathology, the degree of autonomic control is often reported by the HF-HRV. HF-HRV represents the respiratory sinus arrhythmia (RSA) which is a measured index of the regular changes in heart rate (HR) due to modulation of breathing cycles by the PNS (Thayer & Lane, 2000).

1.4 Purpose

The aim of the present study was to explore the connection between physiological measures of cardiac functioning and measures of anxiety-related constructs in children with CHD as compared to typically developing controls. While currently available research suggests a connection between HRV and anxiety disorders in adults, at this time there are no studies examining this association in children with CHD. This is part of a larger gap in literature about the psychological functioning of children and adolescents with CHD. Therefore, in the current study we measured several measures of cardiac functioning (including both time domain and frequency domain methods) and measures of anxiety and anxiety-related constructs [including intolerance of uncertainty, anxiety sensitivity, health anxiety, and Diagnostic Statistical Manual of Mental Disorders-4th Ed. (DSM-IV; APA, 2013) anxiety symptom categories] of children with CHD. The information from this research will contribute to the understanding of the potential psychological concerns specific to children with CHD and provide direction for future research.

1.5 Hypotheses

Our hypotheses were fourfold. We hypothesized that (1) children with CHD would show lower primary time domain HRV measures (i.e., SDSD, RMSSD, pRR50) and primary frequency domain HRV measures (i.e., HF and LF) and higher LF/HF ratio than typically developing controls; (2) there would be a negative association between HRV variables and anxiety constructs [i.e., total and subscale scores (as appropriate) measures of health anxiety, anxiety sensitivity, intolerance of uncertainty, and DSM-IV (APA, 2013) anxiety disorder symptoms] in both study groups; (3) children with CHD would demonstrate higher HR at rest than typically developing controls; and (4) children with CHD would demonstrate higher levels of anxiety constructs [i.e., total and subscale scores (as appropriate) measures of health anxiety,

anxiety sensitivity, intolerance of uncertainty, and DSM-IV (APA, 2013) anxiety disorder symptoms] than typically developing controls.

1.6 Method

1.6.1 Participants

Children and adolescents with CHD were recruited through the Royal University Hospital Department of Cardiology, Saskatchewan Health Authority. Typically developing children were recruited from the community. A total of 81 children participated in the study (ages 7-16); 40 with CHD and 41 typically developing children.

The majority of children with CHD have been diagnosed with one medical condition (i.e., 70%, $n = 28$) while 12.5% reported two medical conditions, and 12.5% reported three or more. The most common CHD diagnosis was a Ventricular Septal Defect, 22.1% ($n = 9$). Descriptive frequencies were computed for the CHD diagnosis types (see Table 1). Several participants with CHD diagnoses reported additional health conditions (i.e., 27.5%, $n = 11$); 17.5% ($n = 7$) of participants reported one additional health condition, 2.5% ($n = 1$) of participants reported two additional health conditions, and 7.5% ($n = 3$)of participants reported three or more additional health conditions.

A pediatric cardiologist reviewed each of the participants with CHD to pre-screen for our exclusion criteria as follows: (1) cardiac surgery within the previous 6 months, (2) cyanotic CHD, (3) intellectual disability. Typically developing children were recruited for the control group via advertisements requesting healthy participants for a study investigating cardiovascular health and body comparison. One participant was not included for primary analyses since they did not complete the entire battery of measures.

1.6.2 Measures

1.6.2.1 Demographics (See Appendix A).

The parent or guardian of the participants completed a brief demographic information form for their children. This included questions regarding age, sex, date of birth, ethnicity, and place of residence. Additionally, the parent/legal guardian will be asked to provide the participant's medical history and the diagnoses for children with CHD.

1.6.2.2 Childhood Anxiety Sensitivity Index (CASI; Silverman, Fleisig, Rabian, & Peterson, 1993; See Appendix B).

The CASI is a self-report measure adapted from the ASI (Peterson & Reiss, 1987) to be completed by school-aged children (Silverman et al., 1991). The summative scores range from 18 to 54. Each of the 18 items is rated on a 3-point Likert scale ranging from 1 (none) to 3 (a lot). Higher total scores indicate higher levels of anxiety sensitivity (Silverman et al., 1991). The CASI incorporates three subscales of physical concerns (e.g., "It scares me when my heart beats fast."), social concerns (e.g., "Other kids can tell when I feel shaky."), and psychological concerns (e.g., "When I am afraid, I worry that I might be crazy."). This measure demonstrates good internal consistency for the total score (i.e., $\alpha = .75$) and test-retest reliability is acceptable (Silverman et al., 1991). CASI total score was employed in the current study. The current study demonstrated acceptable internal consistency for the CASI total score (i.e., $\alpha = .79$).

1.6.2.3 Childhood Illness Attitude Scales(CIAS; Wright & Asmundson, 2003; See Appendix C).

The CIAS is a self-report measure is used to measure health anxiety in school-aged children by assessing fears, beliefs, and attitudes related to health (Wright & Asmundson, 2005). Adapted from Kellner's (1987) Illness Attitude Scale (IAS), this is the first measure of health anxiety in children (Wright & Asmundson, 2003). This self-report measure includes 35

questions, most of which are rated on a 3-point Likert scale ranging from (1) “none of the time” to (3) “a lot of the time”. Other questions (items 29 through 32) examine the frequency of experiences, rated on a 3-point Likert scale, ranging from (1) zero times to (3) three or more times. Items 28 and 32 are open-ended questions that allow for collection of supplementary information (Wright & Asmundson, 2003). In scoring, it is recommended to exclude items 8, 11, and 25 (Wright & Asmundson, 2005) thus total scores range from 29 to 87. Higher scores indicate higher levels of health anxiety and illness behaviour. Included in this measure are four sub-scales of fears (e.g., “Are you worried that you might get really sick in the future?”), help-seeking (e.g., “When you have a strange feeling in your body, do you ask your mom or dad if you can go to the doctor?”), symptom effects (e.g., “. If you have pain, do you worry that it may be caused by a bad sickness?”), and treatment experiences (e.g., “How many times have you seen your doctor in the last year?”; Wright & Asmundson, 2005). The CIAS has demonstrated high test retest reliability (after 10-14-day interval, $r = 0.86$; Wright & Asmundson, 2003) and strong construct validity with associated measures ($r = 0.71$; Delparte et a., 2015). The CIAS total score has shown excellent internal consistency for total score ($\alpha = .88$ to .89; Wright & Asmundson, 2005; and $\alpha = .80$; Rask et al., 2015). The CIAS total score was employed in the current study. The current study demonstrated good internal consistency for the CIAS total score, (i.e., $\alpha = .81$).

1.6.2.4 Intolerance of Uncertainty Scale - Revised (IUS-R; Walker et al., 2010; See Appendix D).

The IUS-R is adapted from the 12-item version of the Intolerance of Uncertainty Scale (Carleton et al., 2007). This measure is designed to assess intolerance of uncertainty across the lifespan (i.e., comparisons are possible across children, adolescents, and adults; Carleton et al.,

2007; Freeston et al., 1994). Each of the 12 items on the IUS-R is rated on a 5-point Likert scale ranging from (1) “not at all like me” to (5) “entirely like me”. The total score ranges from 12 to 60, with higher scores indicating a higher degree of intolerance of uncertainty. The IUS-R includes two subscales; the prospective subscale (e.g., “When things happen suddenly, I get very upset”) and the inhibitory subscale (e.g., “When I’m not sure what to do I freeze”; Walker et al. 2010). The IUS-R total score has previously been shown to demonstrate good internal consistency (i.e., α = .81, Oliver et al., 2018; α = .87, Wright et al., 2016) The IUS-R total score was employed in the current study. The current study showed demonstrated acceptable internal consistency for the IUS-R total score (i.e., α = .79).

1.6.2.5 Spence Children’s Anxiety Scale (SCAS; Spence, 1998; See Appendix E).

The SCAS is a 44-item self-report measure is used to assess symptoms of DSM-IV (APA, 2013) anxiety clusters in children including separation anxiety, social phobia, obsessive-compulsive disorder, panic-agoraphobia, generalized anxiety, and fears of physical injury (Spence, 1998). Items are rated on a 4-point Likert scale, ranging from (1) never to 4 (always), with total scores ranging from 0 to 114. Higher scores indicate higher levels of anxiety. The SCAS includes six subscales, including separation anxiety, social phobia, obsessive-compulsive disorder, panic-agoraphobia, generalized anxiety, and fears of physical injury (Spence, 1998). The SCAS is shown to have high internal consistency with total score (α=.92, Essau et al., 2002; Spence, 1998; Spence et al., 2003). While test-retest reliability is acceptable for total score over a period of six months, test-retest reliability is poorer for the sub-scale totals (Spence, 1998; Spence et al., 2003). The SCAS total score was employed in the current study. The current study demonstrated excellent internal consistency (i.e., α = .90) for the SCAS total score.

1.6.3 Procedure

Consent was obtained from the parent/guardian of potential participants and assent was obtained from the participants. All child participants completed a battery of measures including CIAS, CASI, IUS-R, and SCAS. Trainees from Dr. Corey Tomczak Integrative Cardiovascular Physiology Laboratory (College of Kinesiology, University of Saskatchewan) administered the physiological cardiac measures. The participants with CHD and typically developing children completed these measures previously as part of a larger collaborative project between Dr. Kristi Wright and Drs. Corey Tomczak, Marta Erlandson, and Charissa Pockett based out of the University of Saskatchewan, the CHAMPS program (Children's Healthy Heart Activity Monitoring Program of Saskatchewan). Research assistants administered psychological measures to all child participants.

1.7 Results

1.7.1 Descriptive Statistics

Descriptive statistics were computed for demographic information and questionnaire total scores (see Tables 1 and 2). Eighty-one children ages 7 to 16 years (mean age = 11.7, *SD* = 2.38) participated in the present study (42 females; mean age = 11.39, *SD* = 2.56 and 38 males; mean age = 11.97, *SD* = 2.17). There was no significant difference in age across gender, t (78) = -1.10, p = .275. There was also no significant age differences across our participant groups, t(78) = -0.63, p = .528. Participants with CHD reported a variety of diagnoses (see Table 1). In addition to CHD diagnoses, several participants had additional medical conditions.

1.7.2 Group Differences in Anxiety Measures

A series of univariate analysis of variances (ANOVA) were conducted to assess for potential group differences across total scores of anxiety measures (see Table 2). The results

Table 1

Demographic Information

	CHD Group		Typically Developing Group	
Characteristic	*n*	*%*	*n*	*%*
Gender				
Male	19	47.5	19	46.3
Female	21	52.5	22	53.7
Other	-	-	-	-
Medical and Mental Conditions				
Attention-Deficit/Hyperactivity Disorder	2	3.8	-	-
Autism (high-functioning)	1	1.9	-	-
Brain Tumour	1	1.9	-	-
Celiac Disease	1	1.9	-	-
Diaphragm surgery	1	1.9	-	-
DiGeorge syndrome	1	1.9	-	-
Eczema	1	1.9	-	-
Eye Condition	1	1.9	-	-
Gastroesophageal Reflux Disease	1	1.9	-	-
Gastrostomy-tube feed	1	1.9	-	-
High blood pressure	1	1.9	-	-
Hypertension	1	1.9	-	-
Osteomyelitis	1	1.9	-	-
Sensory Processing Disorder	1	1.9	-	-
Stroke (one in medical history)	1	1.9	-	-
Thyroid condition	1	1.9	-	-

Tracheobronchial Malacia	1	1.9	-	-
Vocal Paralysis	1	1.9	-	-
CHD Medical Condition				
Atrial Septal Defect	3	5.7	-	-
Aortic stenosis	3	5.7	-	-
Coarctation of the aorta	5	9.4	-	-
Double inlet left ventricle	1	1.9	-	-
Double outlet right ventricle	2	3.8	-	-
Ebstein's anomaly	1	1.9	-	-
Hypoplastic left heart syndrome	3	5.7	-	-
Interrupted Aortic Arch	2	3.8	-	-
Left Atrial Isomerism	1	1.9	-	-
Mitral Atresia	1	1.9	-	-
Pulmonary Atresia	1	1.9	-	-
Pulmonary stenosis	4	7.5	-	-
Prolapsed Valve	1	1.9	-	-
Right Aortic Arch (repaired)	1	1.9	-	-
Tetralogy of Fallot	8	15.1	-	-
Transposition of the Great Arteries	3	5.7	-	-
Tricuspid regurgitation	1	1.9	-	-
Tricuspid/pulmonary atresia	2	3.8	-	-
Truncus Arteriosus	1	1.9	-	-
Ventricular Septal Defect	9	17.0	-	-

Note. Demographic information for children with CHD (n = 40) and typically developing children (n = 41).

Table 2

Anxiety and Anxiety-related Constructs Across Groups

	CHD Group	Typically Developing Group		
Measure	M (SD)	M (SD)	F	*p*
CASI Total Score	27.41 (5.16)	28.20 (5.19)	.472	.494
CIAS Total Score	52.59 (7.99)	51.44 (6.40)	.508	.478
IUS-R Total Score	26.75 (7.76)	25.36 (6.12)	.804	.373
SCAS Total Score	23.22 (11.73)	23.00 (13.64)	.006	.937

Note. Statistical analyses for children with CHD ($n = 40$) and typically developing children ($n = 41$). CASI = Children's Anxiety Sensitivity Index; CIAS = Childhood Illness Attitude Scales; IUS-R = Intolerance of Uncertainty Scale - Revised; SCAS = Spence Children's Anxiety Scale. * $p < .05$. ** $p < .001$.

showed non-significant differences for all anxiety measures: total scores of the CASI for children with CHD (M = 27.41, SD = 5.15) and typically developing children (M = 28.20, SD = 5.19), F (1,80) = .472, p = .494; total scores of the CIAS for children with CHD (M = 52.59, SD = 7.99) and typically developing children (M = 51.44, SD = 6.40), F (1,80) = .508, p = .478; total scores of the IUS-R for children with CHD (M = 26.75, SD = 7.76) and typically developing children (M = 25.36, SD = 6.12), F (1,80) = .804, p = .373; total scores of the SCAS for children with CHD (M = 23.22, SD =11.73) and typically developing children (M = 23.00, SD = 13.64), F (1,80) = .006, p = .937.

1.7.3 Group Differences in HRV Measures

A series of univariate ANOVAs were conducted to assess for potential group differences across the number of heart beats analyzed, the number of normal heart beats analyzed, and the number of ectopic beats analyzed (see Table 3). Results showed that the children with CHD had significantly greater total number of heart bears in the recording period than the typically developing children, F (1,79) = 6.76, p = .01, η^2 = .08. Children with CHD had significantly greater number of included normal beats than the typically developing children, F (1,79) = 6.76, p = .01, η^2 = .08.

1.7.3.1 Time domain measures.

A series of univariate ANOVAs were conducted to assess for potential group differences across primary time domain methods of measuring HRV (see Table 3). Results showed several significant differences. Children with CHD showed a significantly lower number of recorded beats in the time period, F (1,79) = 6.76, p = .011. Children with CHD showed significantly lower measures SDSD, , F (1,79) = 14.67, p = .000, RMSSD , F (1,79) = 14.68, p < .001, and pRR50 , F (1,79) = 20.73, p < .001.

Table 3

HRV Measures Across Groups

	CHD Group	Typically Developing Group		
	M (SD)	M (SD)	F	*p*
Analyzed beats (n)	383.55 (82.31)	345.1 (44.15)	6.76	.011
Normal beats analyzed (n)	383.55 (82.31)	345.51 (44.15)	6.76	.011
Time Domain HRV				
Heart rate (beats/min)	75.47 (13.57)	70.4 (8.7)	4.01	.079
RR (ms)	824.84 (159.41)	789.46 (241.32)	0.60	.269
SDSD (ms)	52.61 (47.48)	93.48 (48.53)	14.67	.000
RMSSD (ms)	52.53 (47.40)	93.35 (48.45)	14.68	.000
pRR50 (%)	23.88 (28.11)	48.15 (19.14)	20.73	.000
Frequency Domain HRV				
LF (nu)	45.95 (19.90)	37.17 (13.72)	5.36	.023
HF (nu)	50.3 (18.14)	60.84 (12.60)	8.52	.005
LF/HF	1.33 (1.52)	0.69 (0.40)	6.83	.013

Note. Statistical analyses for children with CHD (n = 40) and typically developing children (n = 41) of a five-minute time period. RR = Average R-R interval; SDSD = Standard deviation of standard deviation of R-R interval; RMSSD = Root mean square of standard deviation of R-R interval; pRR50 = percent of R-R intervals greater than 50ms; LF = Low-frequency band absolute power; HF = High-frequency band absolute power; LF/HF = ratio of absolute power of low-frequency band to high-frequency band.

1.7.3.2 Frequency domain measures.

A series of univariate ANOVAs were conducted to assess for potential group differences across primary frequency domain methods of measuring HRV (see Table 3). Significant differences between children with CHD and typically developing children were observed across all frequency domain variables, LF, F (1,79) = 5.36, p = .023, HF, F (1,79) = 58.52, p = .005, and LF/HF, F (1,79) = 6.83, p = .013.

1.7.4 Associations Between HRV, Anxiety, and Anxiety-related Constructs

Bivariate correlations were computed between HRV measures and total scores of anxiety measures (see Table 4). Correlation results showed statistically significant associations between some variables and can be observed on Table 4.

1.7.4.1 Children with CHD.

Results demonstrated a statistically significant association between frequency domain HRV measures and anxiety constructs including HF and SCAS total score, r (80) = .42, p = .007. Significant associations were also found between HF and IUS-R total score, r (80) = .32, p = .046, as well as between HF and CASI total score, r (80) = .36, p = .024. Results also demonstrated a statistically significant association between LF and SCAS total score, r (80) = -.38, p = .016, as well as LF and CASI total score, r (80) = -.34, p = .031. No significant associations were observed between time domain HRV measures and anxiety constructs for children with CHD.

1.7.4.2 Typically Developing Children.

A statistically significant association was found between frequency domain HRV measure pRR50 and CIAS total score, r (80) = -.41, p = .008. No other significant associations were found for frequency domain measures for typically developing children. For time domain

Table 4

Associations Between Measures of HRV and Total Scores of Anxiety Measures Across Groups

	Heart rate (beats / min)	RR (ms)	SDSD (ms)	RMSSD (ms)	pRR50 (ms)	LF (nu)	HF (nu)	LF/HF (%)	SCAS total	CIAS total	IUS-R total	CASI total
Heart rate (beats / min)	1	-.97**	-.68**	-.68**	-.69**	.27	-.22	.27	-.15	-.16	-.08	-.21
RR (ms)	.18	1	.70**	.70**	.71**	-.31	.24	-.29	.12	.16	.05	.18
SDSD (ms)	.58**	-.02	1	1.00**	.95**	-.49**	.44**	-.37**	.13	.16	-.13	.12
RMSSD (ms)	.58**	-.02	1.00**	1	.95**	-.49**	.44**	-.37*	.13	.16	-.13	.12
pRR50 (%)	-.70**	.05	.90**	.90**	1	-.54**	.50**	-.37*	.15	.08	-.05	.13
LF (nu)	.35*	-.07	-.59**	-.59**	-.54**	1	-.98**	.82**	-.38*	-.09	-.26	-.34*
HF (nu)	-.30	.10	.53**	.53**	.50**	-.99**	1	-.80**	.42**	.09	.32*	.36*
LF/HF (%)	.30	-.04	-.51**	-.51**	-.51**	.97**	-.97**	1	-.34	-.14	-.27	-.28
SCAS	.27	.03	-.23	-.23	-.27	.26	-.24	.24	1	.35*	.44**	.65**
CIAS	.35*	.06	-.33*	-.33*	-.41**	.19	-.18	.12	.48**	1	.15	.72**
IUS-R	.28	-.13	-.07	-.07	-.08	.11	-.09	.09	.65**	.44**	1	.45**
CASI	.11	.01	-.11	-.11	-.13	.20	-.20	.22	.74**	.50**	.62**	1

Note. Correlation coefficients for children with CHD ($n = 40$) are above the diagonal and typically developing children ($n = 41$) are below the diagonal. RR = Average R-R interval; SDSD = Standard deviation of standard deviation of R-R interval; RMSSD = Root mean square

of standard deviation of R-R interval; LF = Low-frequency band absolute power; HF = High-frequency band absolute power; LF/HF = ratio of absolute power of low-frequency band to high-frequency band; CASI = Children's Anxiety Sensitivity Index; CIAS = Childhood Illness Attitude Scales; IUS-R = Intolerance of Uncertainty Scale - Revised; SCAS = Spence Children's Anxiety Scale. * $p < .05$. ** $p < .001$.

HRV measures, CIAS total score was found to be significantly associated with three, time domain HRV measures: average heart rate, r (80) = .35, p = .024; SDSD, r (80) = -.33, p = .033; and RMSSD, r (80) = -.33, p = .033.

2.0 Discussion

CHD impacts many children around the world. Just in the province where the present study took place, Saskatchewan, there are approximately 2,000 children who have been diagnosed with CHD (Jim Pattison Foundation, 2016). While the primary concern for health care providers is management of the CHD diagnosis, technological advances have made the diagnosis of CHD no longer necessarily fatal. Thus, researchers and clinicians alike have shifted their focus to mental health and QoL for individuals who have been diagnosed with CHD.

While anxiety has been studied in typically developing children and adolescents and in adults with CHD, there is a limited body of literature available specific to children and adolescents with CHD. This area of research is growing quickly, however, the present study was the first to examine the association between HRV variables and anxiety measures for children and adolescents with CHD. The purpose of this study was to examine how self-reported anxiety and associated constructs may be associated with different measures of HRV in order to expand the base of knowledge about this population and possibly inform future intervention or care plans. We hypothesized that (1) children with CHD would show lower primary time domain HRV measures (i.e., SDSD, RMSSD, pRR50) and primary frequency domain HRV measures (i.e., HF and LF) and higher LF/HF ratio than typically developing controls; (2) there would be a negative association between HRV variables and anxiety constructs in both study groups; (3) children with CHD would demonstrate higher HR at rest than typically developing controls; and

(4) children with CHD would demonstrate higher levels of anxiety constructs than typically developing controls.

The results provided almost complete support for our first hypothesis; children would show lower primary time domain HRV measures (i.e., SDSD, RMSSD, pRR50) and primary frequency domain HRV measures (i.e., HF and LF) and higher LF/HF ration than typically developing children. Specifically, children with CHD showed significantly lower time domain HRV across SDSD, RMSSD, and pRR50 measures than typically developing children. This finding is consistent with research regarding HRV in children with CHD which shows an overall reduction in HRV as compared to typically developing children (Massin & Bernuth, 1998; Heragu & Scott, 1999). Findings were mixes as it pertained to the frequency domain HRV measures. Specifically, as expected children with CHD had lower HF than typically developing children and had a higher LF/HF ratio. It was not expected that the LF would be higher in our CHD group. However, it is suggested that since short-term measurements such as the ones used in the present study are not sufficient to draw conclusions about autonomic input (Heathers, 2014). To combat this, previous studies with HRV in children with CHD have used 24-hour Holter monitors (Massin & Bernuth, 1998). It has, however, been shown that the accuracy and precision of HRV from Holter monitors are reliant on artefact content of that monitor (i.e., electric cardiac potentials on the body surface which interfere with readings; Akintola et al., 2016).

Our results showed a significant difference in the LF/HF ratio between study groups. This ratio represents the amount of control the sympathetic nervous system versus the parasympathetic nervous system exerts on cardiac functioning. The sympathetic nervous system is responsible for alertness, ability to respond to the environment, and stress responses, indicated

by HF-HRV measures (Thayer & Lane, 2000). In contrast, the parasympathetic nervous system is responsible for maintaining homeostasis and restful states, indicated by LF-HRV measures Thayer & Lane, 2000). Our results show that typically developing children demonstrate greater control by the sympathetic nervous system than children with CHD (i.e., LF/HF ratio is lower), consistent with our hypothesis.

Results partially supported the second hypothesis, that there would be a negative association between primary indices of HRV and anxiety constructs in both study groups. HF-HRV reflects autonomic control of cardiac functioning and thus it is suggested that children with decreased HF-HRV are less able to adapt and respond to their environment (Thayer & Lane, 2000). Negative associations were seen between anxiety constructs and HRV measures for children with CHD however, they were not found to be statistically significant. For typically developing children, significant associations were found only between HRV measures and CIAS total score. Research shows a significant correlation between frequency domain measures of HRV, specifically HF-HRV, and increased levels of anxiety (Thayer & Lane, 2000; Liao et al., 2015; Chalmers et al., 2014). However, the conditions of measurement must be considered when discussing HRV measurements (Shaffer & Ginsberg, 2017). Cardiac measurements of children with CHD were conducted during the CHAMPS camp over a period of several days of exercise, mindfulness, and education, while typically developing children were brought to a lab-setting for measurements only. It has been shown that even a single session of exercise can result in a significant decrease in anxiety constructs (i.e., anxiety sensitivity; LeBouthiller et al., 2014). Thus, it stands to reason that there may have been an impact of the measurement conditions on children with CHD which could reduce demonstrated levels of anxiety.

Results do not support our third hypothesis, that children with CHD would demonstrate significantly higher HR at rest than typically developing controls. Though children with CHD did appear to demonstrate higher HR, the average BPM was not significantly different from the typically developing children. Current anxiety literature utilizes time domain HRV measurements less often than frequency domain measurements. Perhaps this is due to the less clear interpretation of time-domain HRV measures (Camm et al., 1996). However, as shown in our results, it is possible that there is in fact not a significant difference in average BPM despite changes in HRV. Future research may choose to observe other measures of time domain HRV rather than HR at rest and average BPM.

Results from our study do not support our fourth hypothesis, that children with CHD would demonstrate higher levels of anxiety constructs than typically developing controls. Our results did not show a significant difference in anxiety constructs between the two groups. This is inconsistent with previous research which has found that individuals with CHD tend to have higher levels of anxiety compared to a typically developing population (Kovacs et al., 2009; Oliver et al., 2018). It is possible that the limited sample size of children with CHD in Saskatchewan is not sufficient to observe the same patterns of results.

2.1 Limitations

There are several limitations of the present study which merit consideration. Firstly, due to specific established selection criteria the sample size of participants was relatively small (i.e., 40 children with CHD and 41 typically developing children) and thus the findings of the present study may not be able to generalize to the larger population and analyses may lack sufficient power. However, this study is part of an ongoing data collection project and this may facilitate recruiting more participants which will improve generalizability of our results. Thus, this may

allow greater understanding of the correlation between psychological and physiological phenomena of children diagnosed with CHD.

Secondly, because of the variety of diagnoses under the broad category of CHD the presence of intervention and degree of intervention vary greatly. For example, a few of the children with CHD have received corrective surgery or have a pacemaker, both of which may impact the physiological measures which are important variables in the present study. Future studies may consider the level of medical intervention and control for this in calculating group differences.

Third, the exclusion criteria of the present study limit the representativeness of the sample. Children who are excluded from the present study include those with cyanotic CHD, those who had surgery within the previous month, and those with an intellectual disability. Thus, the children with more severe, cyanotic CHD were excluded as well as those with an intellectual disability and thus could not complete our psychological measures. With our currently employed methodology we are requiring self-report measures of anxiety and anxiety-related constructs to be completed in order for anxiety concerns to be assessed. We would not be able to use this methodology if we were to include those with intellectual disability as they might not be able to reliably complete the measures. An option going forward would be to have parents and caregivers complete observer-rated measures of the constructs of interest. The latter modifications may allow for a more representative sample of children with CHD. This would allow for greater insight into the phenomena for this group.

Fourth, data was collected by participants whose parents agreed to participate on a voluntary basis. Approximately 2,000 children in Saskatchewan have been diagnosed with CHD. Our relatively small sample size suggests that we may be missing important data from

participants who meet the inclusion criteria but are unable to or have declined to participate. It is possible that there is a difference between parents and children who did not participate (e.g., socioeconomic factors impacting their ability to attend CHAMPS camp, or more engaged with health concerns). Therefore, this portion of the population may have been missed in the present study.

Lastly, as is common in psychological studies the data collection for anxiety measures was conducted with self-report measures. Research assistants were available to provide assistance in a non-directive manner (i.e., provide explanation for the items on the measure when required). However, it is possible that they biased the participants in answering or that the parent present at time of self-report influenced the child's answers. Additionally, social desirability response bias (i.e., responding in a way which corresponds to socially desirable norms; Uziel, 2010) could have played a role in how children responded to items on the questionnaire. Previous studies have suggested that programs which provide health education to children may encourage children to respond in more socially desirable way with respect to their health (Miller et. Al, 2014). Thus, it is possible that through the programming available at the CHAMPS camp children became more aware of which answers were more socially desirable and this impacted their scores on anxiety measures. In future studies, researchers may want to have children answer questionnaires before the camp begins and independent of their parents.

2.2 Future Directions

This was the first study to examine the relationship between cardiac variability and anxiety symptoms in children with CHD. The findings from this study will contribute to the growing body of knowledge about the psychopathology of this specific population. Specifically, this information can contribute to the understanding of risk factors for children with CHD for

developing anxiety. Possibly, a protocol can be designed which can utilize the information from this study to give an indication of whether psychological interventions may be appropriate. Additionally, this study was conducted as part of the CHAMPS program for chronic disease management in this population. With the information from this study, revisions or further studies can be designed to benefit the children who participate.

While available literature has examined HRV and anxiety constructs in various ways, this study is the first to examine the connection between HRV measures and anxiety in this specialized population. Future studies may want to further examine the anxiety constructs utilized in this study, specifically the subscales included in the anxiety measures and how these may correlate with physiological changes. Additionally, as mentioned above, there is debate in literature about the appropriateness use of short-term recordings of HRV (Heathers, 2014; Massin & Bernuth, 1998). Future studies may want to utilize longer recordings to determine whether this makes a difference in observed HRV measures. Further, the use of longer-term recordings may reduce the impact of context on the HRV measures.

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Appendix A

Parent/Guardian Demographics

University of Saskatchewan
CHAMPS – Children's Healthy Heart Camp in Saskatchewan College of Kinesiology
General Health History and Demographics Questionnaire

1. Which gender do you identify with?

Female

Male

Transgender Female

Transgender Male

Trans/Non-Binary

Not listed _____

Prefer not to Answer

2. How old are you?

Age: _____

3. What is your ethnicity?

_____White/Caucasian _____Black/African _____Hispanic

_____Asian _____Aboriginal/First Nations _____Middle Eastern

_____Mixed Ethnicity _____Other (please specify)

4. Where do you live?

_____urban setting _____rural setting

Child Demographics

University of Saskatchewan
CHAMPS – Children's Healthy Heart Camp in Saskatchewan College of Kinesiology
General Health History and Demographics Questionnaire

1. Which gender does your child identify with?

Female

Male

Transgender Female

Transgender Male

Trans/Non-Binary

Not listed _____

Prefer not to Answer

2. How old is your child?

Age: _____

3. What is your child's ethnicity?

_____White/Caucasian _____Black/African _____Hispanic

_____Asian _____Aboriginal/First Nations _____Middle Eastern

_____Mixed Ethnicity _____Other (please specify)

4. Where does your live?

_____urban setting _____rural setting

University of Saskatchewan
CHAMPS – Children's Healthy Heart Camp in Saskatchewan College of Kinesiology

General Health History Questionnaire

MEDICAL HISTORY

Date: _____

3.

4.

5.

Birth weight (g):_____

Gestational age (months):_____

Do you have a congenital heart defect? ❑Yes ❑No

If yes, Type?_____ Surgical treatment?_____

Please list any other medical conditions: _____

_____ _____

6. Are you currently taking any medications? ❑No ❑ Yes
If yes, what medication(s) are you taking and what are they for?

Medications For _____ _____
_____ _____ _____
_____

BONE RELATED HISTORY

7. Have you ever had any problems with your bones such as fractures?

❑No ❑ Yes

If yes, how many fractures have you had? _____ Please list the type of fracture and approximate date.

Type _____ _____ _____

Date _____ _____

Appendix B

Children's Anxiety Sensitivity Index (CASI)

Directions: A number of statements which boys and girls use to describe themselves are given below. Read each statement carefully and put an X on the line in front of the words that describe you. There are no right or wrong answers. Remember, find the words that best describe you.

1. I don't want other people to know when I feel afraid.
None
Some
A lot

2. When I cannot keep my mind on my school work I worry that I might be going crazy.
None
Some
A lot

3. It scares me when I feel "shaky".
None
Some
A lot

4. It scares me when I feel like I am going to faint.
None
Some
A lot

5. It is important for me to stay in control of my feelings.
None
Some
A lot

6. It scares me when my heart beats fast.
None
Some
A lot

7. It embarrasses me when my stomach growls (makes noise).
None
Some
A lot

8. It scares me when I feel like I am going to throw up.
None
Some
A lot

9. When I notice that my heart is beating fast, I worry that there might be something wrong with me.
None
Some

A lot

10. It scares me when I have trouble getting my breath.
None
Some
A lot

11. When my stomach hurts, I worry that I might be really sick.
None
Some
A lot

12. It scares me when I can't keep my mind on my schoolwork.
None
Some
A lot

13. Other kids can tell when I feel shaky.
None
Some
A lot

14. Unusual feelings in my body scare me.
None
Some
A lot

15. When I am afraid, I worry that I might be crazy.
None
Some
A lot

16. It scares me when I feel nervous.
None
Some
A lot

17. I don't like to let my feelings show.
None
Some
A lot

18. Funny feelings in my body scare me.
None
Some
A lot

Appendix C

Childhood Illness Attitude Scales (CIAS)

Directions: Below are a number of questions. Read each question carefully and put an X on the line in front of the words that best answers the question. There are no right or wrong answers. Remember, find the words that best answers the question.

Question			
1. Do you worry about your health?	___ None of the time	___ Sometimes	___ A lot of the time
2. Are you worried that you might get really sick in the future?	___ None of the time	___ Sometimes	___ A lot of the time
3. Does the thought of being sick scare you?	___ None of the time	___ Sometimes	___ A lot of the time
4. If you have pain, do you worry that it may be caused by a bad sickness?	___ None of the time	___ Sometimes	___ A lot of the time
5. If pain lasts for a week or more, do you tell your mom or dad?	___ None of the time	___ Sometimes	___ A lot of the time
6. If pain lasts for a week or more, do you ask your mom or dad if you can go to the doctor?	___ None of the time	___ Sometimes	___ A lot of the time
7. If pain lasts for a week or more, do you believe that you have a bad sickness?	___ None of the time	___ Sometimes	___ A lot of the time
8. Do you try not to have habits that may be bad for you, such as smoking, drinking, or drugs?	___ None of the time	___ Sometimes	___ A lot of the time
9. Do you try not to eat foods that may not be good for you (such as junk food)?	___ None of the time	___ Sometimes	___ A lot of the time
10. Do you check your body to find out if there is something wrong?	___ None of the time	___ Sometimes	___ A lot of the time
11. Do you believe that you are really sick, but the doctors do not know why?	___ None of the time	___ Sometimes	___ A lot of the time
12. When you feel sick, do you tell your mom or dad?	___ None of the time	___ Sometimes	___ A lot of the time
13. When you feel sick, do you ask your mom or dad if you can go to the doctor?	___ None of the time	___ Sometimes	___ A lot of the time

14. Do you ask your mom or dad for medicine?	___ None of the time	___ Sometimes	___ A lot of the time
15. When your doctor tells you that you are not sick, do you not believe him/her?	___ None of the time	___ Sometimes	___ A lot of the time
16. If a doctor tells you what he/she found, do you soon begin to believe that you might have another sickness?	___ None of the time	___ Sometimes	___ A lot of the time
17. Are you afraid of news that reminds you of death?	___ None of the time	___ Sometimes	___ A lot of the time
18. Does the thought of dying scare you?	___ None of the time	___ Sometimes	___ A lot of the time
19. Are you afraid that you might die soon?	___ None of the time	___ Sometimes	___ A lot of the time
20. Are you afraid that you might have cancer?	___ None of the time	___ Sometimes	___ A lot of the time
21. Are you afraid that you have something wrong with your heart?	___ None of the time	___ Sometimes	___ A lot of the time
22. Are you afraid that you have another bad sickness?	___ None of the time	___ Sometimes	___ A lot of the time
Which sickness?_____			
23. When you read or hear about a sickness, do you think that you might have that sickness?	___ None of the time	___ Sometimes	___ A lot of the time
24. When you have a strange feeling in your body, do you find it hard to think about something else?	___ None of the time	___ Sometimes	___ A lot of the time
25. When you have a strange feeling in your body, do you worry about it?	___ None of the time	___ Sometimes	___ A lot of the time
26. When you have a strange feeling in your body, do you tell your mom or dad?	___ None of the time	___ Sometimes	___ A lot of the time
27. When you have a strange feeling in your body, do you ask your mom or dad if you can go to the doctor?	___ None of the time	___ Sometimes	___ A lot of the time
28. Has your doctor told you that you have a sickness?	___Yes	___ No	

If yes, what sickness?_____

29. How many times have you seen your doctor in the last year?	___ 0 times	___ 1-2 times	___ 3 or more times
30. How many doctors have you seen in the past year?	___ 0	___ 1-2	___ 3 or more
31. How often have you been treated (had to take medicine or had surgery) during the past year?	___ 0 times	___ 1-2 times	___ 3 or more times

32. If you have had treatments in the last year, what were they?
_____

The next three questions concern feelings in your body (for example, pain, aches, pressure in your body, breathing problems, being tired etc.)

33. Do strange feelings in your body stop you from going to school?	___ None of the time	___ Sometimes	___ A lot of the time
34. Do strange feelings in your body stop you from enjoying yourself?	___ None of the time	___ Sometimes	___ A lot of the time
35. Do strange feelings in your body stop you from keeping your mind on what you are doing?	___ None of the time	___ Sometimes	___ A lot of the time

Appendix D

Intolerance of Uncertainty Scale

Below are a series of statements. Please read each statement carefully and circle which box best describes you.

1	**When things happen suddenly, I get very upset**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
2	**It bothers me when there are things I don't know**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
3	**People should always think about what will happen next. This will stop bad things from happening**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
4	**Even if you plan things really well, one little thing can ruin it**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
5	**I always want to know what will happen to me in the future**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
6	**I can't stand it when things happen suddenly**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
7	**I should always be prepared before things happen**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
8	**Feeling unsure stops me from doing most things**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
9	**When I'm not sure what to do I freeze**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
10	**When I don't know what will happen, I can't do things very well**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
11	**The smallest concern can stop me from doing things**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me
12	**I must get away from all things I am unsure of**	Not at all like me	A bit like me	Moderately like me	Very like me	Entirely like me

Original Questionnaire: Freeston, M. H., Rheaume, J., Letarte, H., Dugas, M. J., & et al. (1994). Why do people worry? *Personality and Individual Differences, 17*(6), 791-802.

Appendix E

SPENCE CHILDREN'S ANXIETY SCALE

PLEASE PUT A CIRCLE AROUND THE WORD THAT SHOWS HOW OFTEN EACH OF THESE THINGS HAPPEN TO YOU. THERE ARE NO RIGHT OR WRONG ANSWERS.

1. I worry about this.....……. Never Sometimes Often Always

2. I am scared of the dark.....……..……...Never Sometimes Often Always

3. When I have a problem, I get a funny feeling in my stomach Never Sometimes Often Always

4. I feel afraid.....…...…….Never Sometimes Often Always

5. I would feel afraid of being on my own at home.....….....Never Sometimes Often Always

6. I feel scared when I have to take a test.....…….Never Sometimes Often Always

7. I feel afraid if I have to use public toilets or bathroom...…Never Sometimes Often Always

8. I worry about being away from my parents.....……. Never Sometimes Often Always

9. I feel afraid that I will make a fool of myself in front of people...Never Sometimes Often Always

10. I worry that I will do badly at my school work.....…….Never Sometimes Often Always

11. I am popular amongst other kids my own age....…….…….Never Sometimes Often Always

12. I worry that something awful will happen to someone in my family.....Never Sometimes Often Always

13. I suddenly feel as if I can't breathe when there is no reason for this.....Never Sometimes Often Always

14. I have to keep checking that I have done things right (like the switchis off, or the door is locked).....…….……..Never Sometimes Often Always

15. I feel scared if I have to sleep on my own.....……..……Never Sometimes Often Always

16. I have trouble going to school in the mornings because I feel nervous

or afraid.....…….…….……Never Sometimes Often Always

17. I am good at sports.....….….....Never Sometimes Often Always

18. I am scared of dogs.....….……..Never Sometimes Often Always

19. I can't seem to get bad or silly thoughts out of my head…Never Sometimes Often Always

20. When I have a problem, my heart beats really fast.....…….……..Never Sometimes

Often Always

21. I suddenly start to tremble or shake when there is no reason for this.....Never Sometimes

Often Always

22. I worry that something bad will happen to me....…..……..Never Sometimes Often Always

23. I am scared of going to the doctors or dentists.....…..……Never Sometimes Often Always

24. When I have a problem, I feel shaky.....…….…….Never Sometimes Often Always

25. I am scared of being in high places or lifts (elevators).….Never Sometimes Often Always

26. I am a good person.....…….…….....Never Sometimes Often Always

27. I have to think of special thoughts to stop bad things from happening

(like numbers or words).....…….…….…..……Never Sometimes Often Always

28 I feel scared if I have to travel in the car, or on a Bus or a train.....Never Sometimes

Often Always

29. I worry what other people think of me.....….……..Never Sometimes Often Always

30. I am afraid of being in crowded places (like shopping centres, the

movies, buses, busy playgrounds)..…….…….…….……Never Sometimes Often Always

31. I feel happy.....……...Never Sometimes Often Always

32. All of a sudden I feel really scared for no reason at all…..Never Sometimes Often Always

33. I am scared of insects or spiders.....…….Never Sometimes Often Always

34. I suddenly become dizzy or faint when there is no reason for this.....Never Sometimes Often Always

35. I feel afraid if I have to talk in front of my class.....…..…..Never Sometimes Often Always

36. My heart suddenly starts to beat too quickly for no reason...Never Sometimes Often Always

37. I worry that I will suddenly get a scared feeling when there is nothing to be afraid of.....……..... Never Sometimes Often Always

38. I like myself.....…….…….Never Sometimes Often Always

39. I am afraid of being in small closed places, like tunnels or small rooms……..Never Sometimes Often Always

40. I have to do some things over and over again (like washing my hands, cleaning or putting things in a certain order)…….. Never Sometimes Often Always

41. I get bothered by bad or silly thoughts or pictures in my mind……. Never Sometimes Often Always

42. I have to do some things in just the right way to stop bad things happening.....……... Never Sometimes Often Always

43. I am proud of my school work.....…..…..… Never Sometimes Often Always

44. I would feel scared if I had to stay away from home overnight…….Never Sometimes Often Always

45. Is there something else that you are really afraid of?....……..…..…. YES NO

Please write down what it is

_____

_____

_____

_____

How often are you afraid of this thing?.....…..…… Never Sometimes Often Always