

Heart rate variability profiles of Special Olympics athletes at rest, during submaximal
exercise, and in recovery

by

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of the Requirements for the Degree of

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Supervisory Committee

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Abstract

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The change in R-R intervals between adjacent heartbeats is referred to as Heart Rate Variability (HRV). HRV data provides information regarding an individual's Autonomic Nervous System (ANS), specifically the ANS's two branches, the Sympathetic Nervous System (SNS) and the Parasympathetic Nervous System (PNS). The HRV of a healthy, well-conditioned heart is large at rest, while low HRV is associated with adverse health outcomes such as diabetes, heart disease and early mortality. There has been a substantial amount of HRV research conducted with typically developing individuals. One group who is greatly underrepresented in research is individuals with intellectual disabilities. Currently, no studies have been undertaken with Special Olympics athletes. Therefore, the purpose of this study was to create HRV profiles at rest, during submaximal exercise, and at recovery of adult Special Olympic athletes. The study also sought to examine the impact that Down syndrome, age, sex, and medication have on HRV profiles. The current study found that although heart rate responded appropriately during the three testing conditions (rest, exercise, recovery) the athletes were sympathetically dominated across all three conditions, indicating an imbalance between the SNS and the PNS. In addition, male and female athletes were significantly different with regards to low frequency and high frequency power. It is possible that anxiety or excitement about the testing influenced some athletes, and future research should examine how additional protocol

familiarization could impact the HRV profiles within this population. Additionally, more research with larger sample sizes is needed to more fully understand the impact that age, etiology of intellectual disability, and medication use may be having on HRV profiles.

Table of Contents

Supervisory Committee	ii
Abstract	iii
Table of Contents	v
List of Tables	vii
List of Figures	viii
Acknowledgments	ix
Dedication	xi
Chapter 1 Introduction and Rationale	1
1.1) Purpose	7
1.2) Questions	7
1.3) Operational Definitions	8
1.3.1) Intellectual Disability	8
1.3.2) Heart Rate Variability	8
1.3.3) Modified Six Minute Walk Test (m6MWT)	8
1.3.4) R-R Intervals	8
1.3.5) Submaximal Exercise	8
1.3.6) Ventilatory Threshold	8
1.3.7) VO ₂ Peak	9
1.4 Assumptions	9
1.5 Limitations	9
Chapter 2 Literature Review	10
2.1) Heart Rate Variability	11
2.2) Heart Rate Variability in the General Population	12
2.2.1) Exercise in the General Population and Heart Rate Variability	15
2.2.2) Exercise Prescription and Heart Rate Variability	17
2.3) Heart Rate Variability and Health Outcomes	19
2.4) Measuring Heart Rate Variability	19
2.5) Medication and Heart Rate Variability	21
2.6) Intellectual Disability	24
2.7) Chronotropic Incompetence	26
2.8) Medication usage among individuals with ID	29
2.9) Validated Fitness Tests for People with Intellectual Disabilities	30
2.11) Intellectual Disabilities and Heart Rate Variability	32
2.12) Situating the Current Study	35
Chapter 3 Method	36
Study Design and Sampling Frame	36
Athletes	36
Measures	37
Polar Team 2 Heart Rate/HRV Monitors	37
Anthropometric Measurements	38

	vi
Modified 6 Minute Walk Test (m6MWT)	38
Medical Information Forms	39
Procedure	39
Administering the three testing conditions	41
Data Treatment and Analysis	42
Statistical Analyses	43
Chapter 4 Results	45
Sample	45
4.1 Research Question 1: What are the HRV profiles before, during, and after submaximal exercise?.....	46
4.2 Research Question 1b: How does age and sex impact the HRV profiles from rest to recovery of the Special Olympics athletes?	47
4.3 Research Question 1c: Are there significant differences between the athletes with Down syndrome athletes compared to the athletes without Down syndrome?	51
4.4 Research Question 2: How does medication impact the HRV profiles of the Special Olympics Athletes?	53
Chapter 5	54
HRV profiles of Special Olympics Athletes.....	54
Limitations	60
Conclusions and implications and future directions	61
References.....	63
Appendix A Table.....	71
Appendix B	74
Appendix C	75
Appendix D.....	77
Appendix E	77
Appendix F.....	80

List of Tables

Table 1 <i>Descriptive statistics for athlete characteristics</i>	37
Table 2 <i>Medication usage of the athletes (n=42)</i>	45
Table 3 <i>Distance completed during the m6MWT for athletes (n = 42)</i>	49
Table 4. <i>Descriptive statistics for athletes with DS, ID w/o DS, taking medication, and not taking medication.</i>	52

List of Figures

<i>Figure 1:</i> Extract of a model created by Fernhall, Goncalo, Mendonca, and Baynard (2013) illustrating the factors which are linked to low HRV.....	5
<i>Figure 2.</i> Flow diagram of recruitment process.....	36
<i>Figure 3.</i> HRV computer set up at testing site.....	37
<i>Figure 4.</i> Heart rate across the three testing conditions for all athletes ($n = 42$).....	46
<i>Figure 5.</i> LF and HF power(nu) across all three testing conditions.	47
<i>Figure 6.</i> LF (nu) of male and female athletes across the three conditions.....	48
<i>Figure 7.</i> HF (nu) of male and female athletes across the three conditions	48
<i>Figure 8.</i> LF(nu) of athletes under 35 and athletes 35 and over.....	50
<i>Figure 9.</i> HF(nu) of athletes under 35 and athletes 35 and over.	50
<i>Figure 10.</i> LF/HF of athletes under 35 and athletes 35 and over.	51

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Dedication

**Dedicated to my parents and all the amazing athletes throughout Special
Olympics BC and Special Olympics Canada.**

Chapter 1

Introduction and Rationale

Our body's autonomic nervous system (ANS) controls all involuntary physiological mechanisms. The ANS is divided into two branches: the sympathetic nervous system (SNS); and the parasympathetic nervous system (PNS). Together they ultimately work to maintain homeostasis by controlling involuntary bodily functions such as digestion, sweating, and respiration (Ernst, 1996).

The SNS is responsible for the physical phenomenon known as the "fight or flight" response (Ernst, 1996). One way the SNS helps the body respond to stress is by engaging the cardiovascular and cardiopulmonary systems. It causes an increase in heart rate, heart contractility, and bronchial dilation. Conversely, the body's PNS functions when an individual is at rest or the body is in a state of "idle" (Ernst, 1996). Within the cardiovascular and cardiopulmonary systems, the PNS is responsible for decreasing heart rate and heart contractility and causing bronchial constriction. In a way, these two systems work in harmony to maintain ideal health of the body's nervous and cardiovascular systems (Ernst, 1996). This harmonious balance is reflected by a body which responds appropriately to stress and which reposes at the correct time.

Since the early 1920's, physiologists have examined the workings of the ANS. Evidence continually showed that lethal cardiac arrhythmias were directly correlated with increased sympathetic activity and reduced vagal activity (Ernst, 1996). The establishment of this relationship led to the development of a quantitative marker of autonomic activity, known as Heart Rate Variability (HRV; Ernst, 1996). HRV is defined as the beat to beat variation in successive heart beats. It has become a prevalent, non-invasive marker of the body's

autonomic health. HRV data provide clinicians and researchers with several pieces of information:

- (1) the activity occurring within the cardiovascular system,
- (2) the activity of the body's sympathetic and parasympathetic neural pathways, and
- (3) the overall health of the human body.

Through extensive HRV analysis, it has been determined that a high degree of variability in heart rate is associated with optimal health (Ernst, 1996).

Both the SNS and PNS produce distinct frequency domains, which can be seen when HRV data are analyzed. The SNS produces low frequency (LF) oscillations, which reflect the magnitude of change in sympathetic output, ranging from 0.04 to 0.15 Hz. The PNS produces high frequency (HF) oscillations of magnitude, relative to the change in vagal output, ranging from 0.15-0.4 Hz (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). These two oscillation patterns provide information about the degree to which the heart is being controlled by either the SNS or PNS. HRV data also allow researchers and clinicians to calculate the LF/HF ratio. This ratio reflects the balance that exists between the two systems. In resting healthy adults, the ratio is between 1.5 and 2.0. An LF/HF ratio below 1.5 is associated with predominate vagal tone, while a ratio above 2.0 is an indicator of dominating sympathetic activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Neither a high or low ratio is desirable. A highly variable, and not monotonous, heart rate is associated with optimal health status (Ernst, 1996). When HRV is low, or one system

has more control over the other, there is an increased risk of illness, disease, and premature death (Ernst, 1996).

To be considered at a peak level of health, it is important that these two systems work in harmony with one another. If this is not occurring, an imbalance arises which exhausts the body and can eventually have detrimental effects on the ANS. This imbalance can be seen in ones' HRV data. It is important that this imbalance be corrected so that the systems can begin working at an ideal level. Exercise is one factor that has shown promise in improving HRV (Kiviniemi, Hautala, Kinnunen, & Tulppo, 2007; Kiviniemi et al., 2010; Levy et al., 1998). Regularly engaging in aerobic exercise such as running, bicycling, or walking has shown to not only maintain HRV but also improve HRV. Specifically, it improves parasympathetic dominance at rest which can have major health benefits (Levy et al., 1998). Aerobic activity is what is typically recommended or prescribed to improve HRV (Lazoglu, Glace, Gleim, & Coplan, 1996). However, even anaerobic activity is better than remaining sedentary. For example, Lazoglu et al. (1996) found that regular strength and resistance training helped to reverse declining HRV.

A population that may be at a greater risk of low HRV and the associated health issues are people with intellectual disabilities (Baynard et al., 2004; Chang et al., 2012; Mendonca & Pereira, 2010). An intellectual disability (ID) is defined as a disability originating before the age of 18 years which impedes intellectual function and behaviour. ID can also impact a person's social, cognitive, and adaptive skills (Schalock, Luckasson, & Shogren, 2007, p. 118). The etiology of ID is complex. Although there are several hundred known causes of ID, the etiology is unknown in 40%-60% of cases (Battaglia,

Bianchini, & Carey, 1999; Curry et al., 1997). In addition, more than one risk factor for ID (e.g. birth trauma, socio-economic factors, chromosomal abnormalities, child abuse and neglect) is apparent among approximately half of the population diagnosed as having an ID (Battaglia et al., 1999). Chromosomal deletions or duplications are a common cause of ID. For example, Down syndrome (DS) is predominately caused by trisomy of chromosome 21 (Roizen & Patterson, 2003) and is present in approximately 1 in 700 newborn children and Prader-Willi syndrome (incidence 1: 10,000 live births) arises from an abnormality in paternal 15q11-13 (Centers for Disease Control and Prevention, 2006).

There are few studies examining HRV and individuals with ID. However, the studies which do exist have shown that individuals with DS have low HRV. There are several factors which cause individuals with DS to have low HRV (see Figure 1). Individuals with DS have been found to exhibit chronotropic incompetence, which is an inability of the heart to appropriately respond to stress (Baynard et al., 2008; Fernhall et al., 2001). Chronotropic incompetence is associated with autonomic dysfunction and is defined as an individual's inability to reach 80% of their maximum heart rate (Ernst, 1996). In addition, individuals with DS have virtually no response to the catecholamine's epinephrine and norepinephrine during exercise (Fernhall et al., 2009). Both of these hormones are released by the SNS in order to increase heart rate in response to stress (Fernhall et al., 2009) but the heart rates of individuals with DS usually increase as a result of vagal withdrawal and not SNS activity (Baynard et al., 2004). These physiological functions all play an important role in HRV, and an attenuation of any, or in the case of individuals with DS all of physiological components, can cause low HRV.

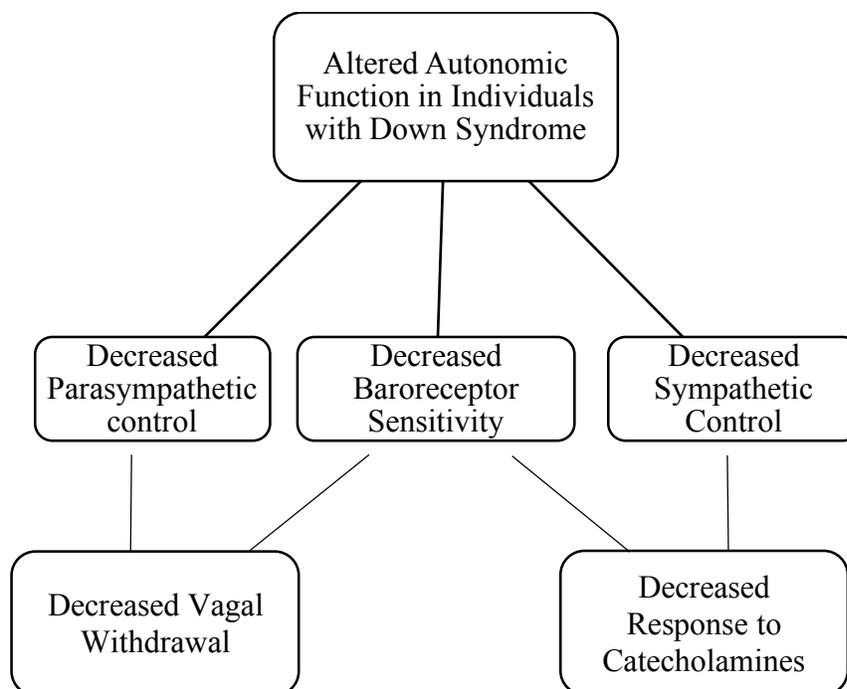


Figure 1: Extract of a model created by Fernhall, Goncalo, Mendonca, and Baynard (2013) illustrating the factors which are linked to low HRV.

Only two studies have investigated HRV in people with an ID without DS, and the results of these two studies are somewhat unclear because of the samples used in each of those studies. Baynard and colleagues (2004) compared HRV of two groups of individuals with an ID, one group with DS ($n = 16$) and one group without DS ($n = 15$). Although the group with DS had lower peak heart rates during exercise than the group without DS, Baynard et al. found that the autonomic control of the heart was not significantly different. As a group, individuals with ID without DS had a significant decrease in LF power from rest to exercise, which reflects a decrease in SNS domination. In fact, heart rate, HF power and LF power (as previously mentioned) all responded appropriately from rest to exercise. Moreover, there were no significant difference in any HRV indices between those with DS and those with ID without DS. However, Baynard et al. did not

collect HRV data during a recovery phase to see if HRV and HR returned to pre-exercise values. Further, individuals who were taking medication which may impact HR were excluded from the study. The findings of that study are also somewhat difficult to interpret since the total sample size was very small ($n = 31$) and the proportion of men and women in the DS and ID without DS groups was not equivalent.

The other study that appeared to include individuals with ID who did not have DS was conducted by Chang and colleagues (2012). These authors investigated the relationship between metabolic syndrome and HRV indices in individuals with ID ($n = 129$) during an annual health examination. The main findings from this study, with regards to HRV, were that the male participants with ID had higher HRV (LF/HF 3.02 ± 2.66) than females with ID (LF/HF 1.89 ± 1.62). These findings suggest a dominance of sympathetic activity among the men. Chang et al. also found that individuals with ID with metabolic syndrome had significantly lower HRV than those with ID without a metabolic syndrome. However, Chang and colleagues did not report the etiology of ID in their sample. So it is unclear whether individuals with DS, who tend to have a distinctive HRV profile (Baynard et al., 2004; Fernhall et al., 2013), were included in the sample and/or whether individuals with DS were equally distributed between the men and women, or between those with or without metabolic syndrome. Furthermore, although Chang and colleagues did not exclude individuals taking medications, the impact that medications might have had on HRV was not addressed.

The literature in the area of HRV and persons with ID is formative. It appears that individuals with DS have altered autonomic function and low HRV in general, but the

HRV profile for individuals with ID who do not have DS is unclear. There are several important elements which have yet to be addressed by current research. Firstly, more work is needed for persons with ID who do not have DS. Secondly, no studies have investigated HRV in Special Olympics athletes. Special Olympics is an organization that provides an environment for individuals with ID to be physically active (Special Olympics, 2016). As such, it is possible that declining HRV could be mitigated by the exercise these athletes are engaging in. Thirdly, no studies have examined the impact that age may be having on the HRV profiles of individuals with ID. Lastly, despite the prevalence of medication usage in this population (Bohlman-Nielsen, Panzer, & Kindig, 2004), studies have either excluded individuals taking medication or have chosen not to address how it may be impacting HRV profiles. Therefore, this study will examine how age, medication, sex, and DS status affect HRV.

1.1) Purpose

The purpose of this study was to establish HRV profiles in Special Olympics athletes.

1.2) Questions

This study addresses the following questions:

1. What are the HRV profiles before, during, and after submaximal exercise?
2. Do age and sex impact the HRV profiles of Special Olympics athletes?
3. Are there any significant differences in the HRV profiles of the athletes with DS compared to the athletes without DS?
4. How does medication usage impact the HRV profiles of the Special Olympics athletes?

1.3) Operational Definitions

1.3.1) Intellectual Disability

A disability “characterized by significant limitations both in intellectual function and in adaptive behaviour as expressed in conceptual, social, and practical adaptive skills. This disability originates before the age 18” (Schalock et al., 2007, p. 118).

1.3.2) Heart Rate Variability

Variation of the beat-to-beat time in successive heart beats (Ernst, 2014, p.51).

1.3.3) Modified Six Minute Walk Test (m6MWT)

A submaximal exercise test used to assess aerobic endurance (Heyward, 2010). The m6MWT utilizes a pacer to motivate athletes (Nasuti, Temple & Stuart-Hill, 2013).

1.3.4) R-R Intervals

Distance between two successive R peaks of the QRS complex of an ECG wave (Ernst, 1996).

1.3.5) Submaximal Exercise

A type of exercise which is terminated before reaching ventilatory threshold or maximum HR. It is used to estimate VO_2 max or aerobic fitness (Heyward, 2010).

1.3.6) Ventilatory Threshold

Point at which there is an exponential increase in pulmonary ventilation relative to exercise intensity and rate of oxygen consumption (Heyward, 2010).

1.3.7) VO₂ Peak

A plateau in the human body where oxygen consumption is observed during maximal physical effort. It is a factor for determining an athlete's capacity to sustain maximal performance (Heyward, 2010).

1.4 Assumptions

In this research, it was presumed that the athletes would try their hardest during the m6MWT. Also, that all the information they provided on the medical information forms was correct.

It was also assumed that all athletes participating in the Functional Fitness Testing with Special Olympics had an ID.

1.5 Limitations

In this research, only athletes who were participating in the functional fitness testing were recruited. Therefore, the final sample is more representative of those athletes than of all Special Olympics athletes and/or all individuals with ID.

Chapter 2

Literature Review

Heart rate variability (HRV) is a popular measure of autonomic health and function. It can provide information regarding how efficiently an individual's heart is working, how the heart is responding to exercise, and how the individual is responding to training (Ernst, 1996). Research suggests that low HRV is associated with a multitude of negative health conditions including cardiovascular diseases, diabetes, obesity, and early mortality (Ernst, 1996).

The body of research on HRV has increased substantially over the last decade, however limited research has examined HRV in individuals with ID. Currently only seven studies have been conducted examining HRV in individuals with ID (see Appendix A). Of those studies, the majority have focused on HRV in individuals with DS (e.g. Mendonca, Pereira, & Fernhall, 2010; Pitetti, Millar, & Fernhall, 2000). Only one study has compared HRV of individuals with and without DS. Baynard and colleagues (2004) examined change in HRV from rest to submaximal exercise in these two groups. They noted differences in parasympathetic dominance at rest, with individuals with DS showing heightened vagal tone (Baynard et al., 2004). Aside from the lack of research on individuals with ID without DS, few studies in this topic area look at the impact of medication on HRV even though the majority of individuals in this population are taking medication (Park et al., 2016; Tsiouris et al., 2012). The results of the Baynard et al. study and the modicum of research to this point suggest a need to further investigate

HRV in individuals with ID without DS and to examine how medication may be impacting HRV profiles in this population.

The aim of this study was to examine HRV during submaximal exercise in adult Special Olympics athletes. Additionally, the effect of sex, age, and medication use on HRV profiles was examined. To provide context for the study, this review of literature has been presented in the following sections: (a) overview of HRV and exercise, (b) HRV measurement (c) medication, (d) chronotropic incompetence, (e) intellectual disabilities, medication usage, fitness measurements, (f) HRV research with this population, and (g) situating the current study.

2.1) Heart Rate Variability

HRV is defined as the beat-to-beat variation in consecutive heart beats (Ernst, 1996). HRV shows the body's response to changing external and internal stressors. Simply stated, as the body experiences any degree of stress (exercise, anxiety, nervousness) the body responds by increasing the heart rate. Likewise, a removal of the stressor causes the heart rate to decrease or return within a normal range. The autonomic nervous system (ANS) is responsible for involuntary body functions and controls both smooth and cardiac muscle (Ernst, 1996). Heart rate is controlled via two pathways of the ANS, the SNS and PNS. Each of these neural pathways plays distinct roles in the heart, with the SNS causing bronchial dilation within the lungs, increased contractility of the heart and increased heart rate, while the PNS decreases bronchial dilation in the lungs, decreases contractility in the heart and decreases heart rate. Although these two systems work in

collaboration (the SNS acting in times of stress, while the PNS in times of idle), as they work to maintain homeostasis within the human body (Ernst, 1996).

HRV reflects various physiological mechanisms which are occurring within the human body, but most importantly has been found to reflect the interplay between the sympathetic and parasympathetic branches of the ANS. When examined, HRV data display two distinct frequency domains, low and high frequency. Low frequency oscillations (LF), ranging from 0.04 to 0.15 hz, reflect sympathetic control over the heart, while high frequency oscillations (HF), ranging from 0.15 to 0.4 hz, reflect parasympathetic (or vagal) control over the heart (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). When observing HRV data, these two oscillations patterns provide information about the degree to which the heart is being controlled by either the SNS or PNS. Additionally, HRV data allow us to calculate the LF/HF ratio. This ratio reflects the balance that exists between the two systems. In typically developing healthy adults, the resting ratio is usually between 1.5-2.0. A LF/HF ratio below 1.5 is associated with predominate vagal tone, while above 2.0 is an indicator of dominating sympathetic activity (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

2.2) Heart Rate Variability in the General Population

Although a complex measure, HRV data have clinical significance (Ernst, 1996). Recognition of the importance of HRV as a clinical indicator led to the establishment of the “Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology.” The goal of the Task Force was to “...standardize

nomenclature and develop terms, specify standards of measurement, define physiological and pathophysiological correlates, describe currently appropriate clinical applications and identify areas for future research” (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996, p.151). The standards of measures created by the Task Force provided researchers and clinicians with the normative values that were previously discussed, 0.04-0.15 hz, 0.15 to 0.4 hz, and 1.5-2.0, for low, high frequency oscillations, and the LF/HF ratio, respectively. These values represent the current standard of measurement with which HRV data are compared. Since the establishment of these standards of measurement in 1996, the use of HRV in research has increased substantially. Most of the research which currently exists has been conducted in the general population.

One of the most widely known studies within the medical field is the Framingham Heart study. In the 1940’s, 1 in 2 American’s was dying from cardiovascular disease (Mahmood, Levy, Vasan, & Wang, 2014). Cardiovascular disease had become a widespread epidemic which required action by the American government. This need for understanding of cardiovascular disease lead to the establishment of the Framingham Heart Study, named after the location at which the epidemiological study was occurring (Framingham, Massachusetts). The Framingham study has now been running for 70 years now and has collected data on over 5,000 residents (Mahmood et al., 2014). In addition to basic demographic (sex, age etc) and anthropometric data (height, weight, BMI etc.), researchers also collected data on blood pressure, blood chemistry, lung function, health behaviours, and ECG tracings (Mahmood et al., 2014). In 1996, researchers chose to analyse HR data that had been collected, in order to examine HRV

among 2,722 of the participants. The participants' HR data was subdivided by age group: 40-49 years, 50-59 years, and 60-69 years. All groups had an LF/HF ratio that was significantly lower than the standardized 1.5, suggesting that the participants were parasympathetically dominated. However, the authors indicated that these data were confounded by negative health behaviours such as smoking, caffeine intake, and sedentary behaviours (Tsuji et al., 1996). All of these negative health behaviours had been previously known to negatively modify the various indices of HRV, including the LF/HF ratio (Ernst, 1996).

In contrast to the sample used in the Framingham Heart study, Yamasaki et al. (1996) examined heart rate data in a healthy population of males and females. Their aim was to investigate HRV in a population whose values were not skewed by external factors. The researchers excluded participants with diabetes, cardiovascular disease, a BMI of 25kg/m^2 or higher, or a neurological disorder. Yamasaki and colleagues' final sample was 105 healthy participants (63 males and 42 females). They analysed the R-R intervals, which show the distance between two R waves in the QRS complex, of 24 hour readings. Frequency domains (TF, LF, HF) and LF/HF ratio were outputted from the 24 hour readings and used for statistical analysis. Yamasaki and colleagues found that significant differences existed between the male and female participants in the study. For males, LF oscillations were elevated in the morning and afternoons, regardless of age. For females, the LF component was elevated in the afternoon and evening among all age groups. This shows that the daytime augmentation of the sympathetic nervous system may be slightly stunted in women. Aside from sex differences, the study showed that age played a major role in HRV. For both men and women HRV had a negative linear

relationship with age. However, the authors noted that sympathetic function decreased more with age than parasympathetic function (Yamasaki et al., 1996).

2.2.1) Exercise in the General Population and Heart Rate Variability

Physical activity refers to any movements carried out by skeletal muscles which require energy expenditure (Heyward, 2010). Evidence has shown that regular physical activity can decrease risk of developing cardiovascular disease, type 2 diabetes, and certain cancers. Canadian Society of Exercise Physiology (CSEP) recommends that adults perform a minimum of 150 minutes of moderate to vigorous physical activity per week (CSEP, 2014). So far, no research has examined whether meeting the minimum guidelines will improve HRV. However, research has shown that engaging in regular bouts of exercise which are planned, purposeful, and have the intention of improving or maintaining an individuals' physical fitness can create measurable improvements in ones' HRV.

In terms of dose, Levy et al. (1998) investigated how regular exercise at varying degrees of intensity could improve HRV. Specifically, Levy and colleagues were interested in seeing how a regular exercise regime could impact the natural decline of HRV (caused by aging) in healthy older and younger men. The researchers created a 6-month training program consisting of three different types of aerobic physical activities (walking, jogging, or cycling) which would be performed 4 to 5 times per week. The 13 older male participants (mean age = 68 years) and the 11 younger men (mean age = 28 years) worked at between 50% to 60% of their heart rate reserve (HRR) at the commencement of the program, and increased to 80% to 90% of HRR at month four. Although

adherence rate was not reported, the researchers stated that the findings reflected the 24 participants who had effectively completed the program. They found that the program positively affected both groups by increasing resting HRV, and in addition, somewhat reversed the age-related decline in HRV within the older male group (Levy et al., 1998). This study by Levy and colleagues (1998), supported earlier findings by de Meersman (1993) who compared the HRV of active and sedentary men. Age of the participants in the de Meersman study ranged from 15 to 83 years, and each of the 72 aerobically active participants was age and weight matched with a sedentary participant. It was hypothesized that age would play the biggest role on HRV, with older men, regardless of activity level, having significantly lower HRV. This was not the case. Regardless of age, the aerobically active groups had significantly higher HRV than their sedentary counterparts. Additionally, the aerobic activity mitigated age-related decline in HRV (de Meersman, 1993).

Aerobic exercise continues to be an excellent tool for training and improving HRV however, researchers have also investigated how traditional methods of anaerobic exercise can impact HRV. This is necessary as many individuals engage in anaerobic and/or aerobic exercise. Research has shown that when HRV is compared between a group of participants who regularly engage in their own aerobic exercise program, to a group of individuals who regularly engage in their own resistance training/isometric exercise, their HRV does not differ across a 24-hour period post exercise (Lazoglu et al., 1996). However, when compared to a sedentary population the regularly active groups have significantly greater HRV, regardless of exercise regime (Lazoglu, Glace, Gleim, & Coplan, 1996).

2.2.2) Exercise Prescription and Heart Rate Variability

HRV has become a popular method of prescribing exercise, monitoring training, and monitoring exercise recovery. Due to its non-invasive nature, researchers, clinicians, and exercise professionals have begun to test the impact of training specifically designed around an individual's day-to-day HRV measures. Kiviniemi and colleagues (2007) investigated how individualized HRV guided exercise training compared to predefined training in a group of healthy males. All participants were recruited from a local running club and only those who met the inclusion criteria (non-smokers, exercised 3+ times/week, did not have diabetes or CV disease, and were novice athletes) were included in the study. The predefined group, consisting of eight healthy, moderately fit males, completed a four-week training program which consisted of low to high intensity aerobic exercise based on guidelines from American College of Sports Medicine (ACSM). These guidelines provided the predefined group with a running plan which involved: running at low intensity (65% max HR) on two consecutive days, resting for a day, and then running at high intensity (85% max HR) for two consecutive days. Conversely, the HRV guided group, comprised of nine healthy, moderately fit males, participated in aerobic exercise which was based on daily measures of HRV. HRV was measured daily for five consecutive non-exercise days in order to get baseline values for each participant in the HRV guided group. For this group, training intensity was based on HF power readings done in the morning. If the morning reading showed that HF power was weaker than baseline, training intensity was moderate, when HF power was stable or had increased, training intensity was vigorous. Regardless of HF power measure, the HRV guided group never completed three vigorous intensity training sessions in a row (Kiviniemi et

al., 2007). From the post training measures, Kiviniemi and colleagues found that the HRV guided group had significant increases in their absolute and relative VO_2 peak, as well as training velocity at ventilatory threshold, while the predetermined group had no significant changes. These findings suggest that cardiorespiratory fitness can be effectively improved through HRV-guided exercise training. The greatest limitation of the 2007 study was the exclusion of female participants. This prompted Kiviniemi and colleagues (2010) to complete a similar study protocol with both male and female participants. The inclusion criteria were the same and participants undertook the same HRV guided training program as in the 2007 study. The major finding from the 2010 study was that there were no group differences between the HRV based exercise and pre guided training for female participants (Kiviniemi et al., 2010). The authors attributed this finding to differences in cardiac vagal recovery between men and women (Kiviniemi et al., 2010).

The intensity at which individuals train can impact HRV. Several studies have shown that when trained participants exercise at an intensity which is above ventilatory threshold, the autonomic rebalance during the recovery stage is significantly delayed (ventilatory threshold is defined as when ventilation starts to increase at a faster rate than oxygen consumption) (Casties et al., 2006; Seiler, Haugen, & Kuffel, 2007). This delay is seen less in low frequency power, and more in high frequency power, indicating that parasympathetic tone is stunted (Kaikkonen, Rusko, & Martinmäki, 2008). Therefore, it is speculated that exposing athletes (whether elite level, highly trained, or novice) to training which is above their ventilatory threshold (or 90-95% VO_2 max) may increase stress on the body so much that it can cause overtraining or burnout (Seiler, Haugen, &

Kuffel, 2007). This type of research has provided strength and conditioning experts with information regarding the intensity at which exercise should be prescribed to both novice and experienced athletes.

2.3) Heart Rate Variability and Health Outcomes

HRV data provide researchers with a snapshot of the ANS, and can give clinicians a clearer understanding of an individual's health. Abnormal HRV, which is usually seen in people with an autonomic imbalance is associated with a decrease in overall health. It is not healthy for either the SNS or the PNS to dominate as both situations can cause varying degrees of havoc on the human body (Ernst, 1996).

When the SNS is engaged it increases energy demands on the body. In the case of greater sympathetic tone, the energy demands of the system become excessive, exhausting the system and eventually leading to early death. Sympathetic domination may cause premature aging, early morbidity, and mortality usually caused by cardiovascular diseases (Malliani, Pagani, & Lombardi, 1994). Studies have also shown that increased low frequency oscillations predict the incidence of sudden cardiac death (Guzzetti et al., 2005; Porter et al., 1990). Likewise, a body which is controlled more by the PNS is more likely to have inflammation, diabetes, osteoporosis, and arthritis (Ershler & Keller, 2000). Obviously, neither system being dominant at the inappropriate time but rather a collaborative balance where either system works when needed, is indicative of greater health status.

2.4) Measuring Heart Rate Variability

Techniques to measure HRV have greatly improved over the last several decades due to advances in technology. Originally, HRV data had to be collected in a laboratory setting because portable ECG equipment was not available. However, the invention of the first portable heart rate monitor in the early 1980's allowed researchers to measure HRV outside of a clinical setting (Polar Global, n.d).

The literature currently shows two methods of collecting HRV data. The options are: through ECG or through pulse measurements. Currently, ECG is the only measure validated by the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology (1996). ECG wireless monitors are the most widely used measure of HRV and are the most common throughout the literature. ECG wireless monitors are attached to the mid chest using a band. They collect continuous ECG data while secured on the wearer. Today a variety of portable ECG monitors exist, however Polar Heart Rate monitors are amongst some of the most popular (Duffy, 2017). These wireless monitors allow for the “detection of R-R intervals with a resolution of 1ms” (Gamelin, Berthoin, & Bosquet, 2006, p.887). Gamelin and colleagues sought to validate the Polar wireless monitors (such as the Polar S810) by comparing them to traditional ECG recorders. Gamelin and associates found that the wireless polar monitors were able to collect data which is consistent with ECG recordings. However, the authors noted that the wireless polar monitors had some errors, specifically: (1) the wireless Polar monitors did not detect all R-R intervals, as a result of lack of contact between the elastic electrode belt and the skin and, (2) the Polar monitors overestimated the true number R-R intervals, as a result of picking up premature atrial contractions (premature atrial contraction are a premature heart contraction originating at

the atria and are a common phenomenon in adults). Despite these two measurement errors, Gamelin et al. (2006) reported that the frequency domain measures (LF, HF, VLF) between the polar wireless monitors and the ECG recorders were almost identical as they are not significantly different ($p > 0.05$) and were well correlated ($r > 0.97, p < 0.05$).

2.5) Medication and Heart Rate Variability

Medications affect the body in a variety of ways. Most medications are taken orally in a pill, capsule, or liquid form, where they are broken down within the digestive tract and absorbed into the blood stream. The medications will then bind to a target receptor site, where they either activate the receptors or suppress the activity of the receptor. There are several drugs which can affect the ANS and are classified based on their function and the branch of the ANS they act on (Becker, 2012). Drugs which act on the SNS are sympathomimetic/adrenergic drugs which mimic the effect of sympathetic nerve stimulation and sympatholytics which inhibit the SNS. There are two drugs which act on the PNS, parasympathomimetic/cholinergic which mimic the effect of parasympathetic nerve stimulation, and parasympatholytics which inhibit PNS activity (Becker, 2012).

The SNS has three main types of receptors: (1) Alpha, (2) Beta, and (3) Dopamine. Adrenergic drugs stimulate these receptors which can have an impact of the ANS and therefore HR and HRV. However, the main receptors which would affect HR and HRV would be Alpha 2 receptors, Beta 1 receptors, and Beta 2 receptors. Adrenergic drugs which affect these receptors do them one of two ways: (1) either directly attaching to the receptors on the target effector organs or (2) indirectly stimulating the receptors by causing a release of norepinephrine or preventing the reuptake of norepinephrine (Becker,

2012). Examples of adrenergic drugs which could impact HR and HRV would be epinephrine (increasing blood pressure, increasing HR and vasoconstricting), and isoproterenol (stimulates the heart). Both epinephrine and isoproterenol have been found to effect HRV measures by causing increased vagal tone (Arnold & Mcdevitt, 1984). This increased vagal tone can cause there to be an increase in high frequency oscillations in someone who would not otherwise have this issue.

In contrast, drugs working on the SNS which have sedating effects are antiadrenergic drugs (Becker, 2012). Although many antiadrenergic exist, only those which act on the Beta receptors will be highlighted as they are the only ones which may affect HR. Beta adrenergic blocking drugs or ‘beta blockers’ are a popular drug used to treat cardiac illnesses. Beta blockers work by preventing the receptors from responding to SNS stimulation. As such, beta blockers have been found to decrease heart rate, slow cardiac conduction, and decrease blood pressure (Becker, 2012).

Similarly, there are drugs which can stimulate the PNS and drugs which block the effects of the major neurotransmitter, acetylcholine. Anticholinergic drugs affect heart rate and HRV by binding to either muscarinic 2 receptors, which are located in the heart or by binding to nicotinic receptors (Haga, 2012). The anticholinergic drug which has the most evidence confirming that it impacts HRV, are anticholinergic drugs such as tricyclic antidepressants (Billman, 2013; O’Regan, Kenny, & Cronin, 2015; van Zyl, Hasegawa, & Nagata, 2008). It has been found that tricyclic antidepressants (TCA) can cause an increase in resting heart rate and a decrease in HRV, while other types of antidepressants

(SSRI's) cause less of an obvious effect (van Zyl et al., 2008). However, many SSRI's do act as a strong sedative which may impact an individual's HR and HRV.

Methylphenidate, more commonly known by the brand name Ritalin, is a drug prescribed to treat hyperactivity and ADHD in children and adults (Gerlach & Manfred, 2014). Methylphenidate acts on the Central Nervous System (CNS), increasing the effect of dopamine and noradrenaline by preventing reuptake by the brain's neurons. In this way, methylphenidate helps to increase the individuals' concentration and reduce negative behaviours such as excessive fidgeting (Gerlach & Manfred, 2014). Very little research exist which shows that methylphenidate can impact an individuals' HRV. However, research conducted with children and adolescents (under the age of 18) has shown that methylphenidate can increase blood pressure and pulse rate (Hammerness, 2011). Discussion of whether or not methylphenidate would have similar effects on adults would be entirely speculative.

Although used to treat mental illnesses such as bipolar and schizophrenia, second and third generation antipsychotics are popular for the treatment of aggression, agitation, irritability, and self-injurious behaviours (Gerlach & Manfred, 2014). Antipsychotics can greatly impact heart rate and HRV as they often bind to muscarinic receptors in the heart (Haga, 2012). Huang et al. (2013) predicted that antipsychotic drugs with high muscarinic affinity (HMA) were likely to cause a measurable change in high frequency oscillations. Common HMA antipsychotics are chlorpromazine, clozapine, and quetiapine. Huang and colleagues compared individuals who were on antipsychotics with low muscarinic affinity (LMA) vs. those on HMA. They found that those individuals

who were taking HMA had reduced low frequency power and high frequency power. Additionally, the Huang et al. found that LMA antipsychotics such as haloperidol and risperidone, were positively correlated with LF% and LF/HF ratio. This study provides reasonable evidence that antipsychotics do impact HRV.

Some drugs have been found to have a positive impact on HRV and cardiac function. Antiepileptic medications such as valproic acid and oxcarbazapine have been found to improve HRV among children with epilepsy (Hallioglu, Okuyaz, Mert, & Makharoblidze, 2008). However, these findings have not been examined among adults with epilepsy.

2.6) Intellectual Disability

“An intellectual disability (ID) is defined as a disability originating before the age of 18 which impedes intellectual function and behaviour as well as a person’s social, cognitive, and adaptive skills” (Schalock et al., 2007, p 118). Although the majority of ID’s do not have a specific etiology (Battaglia, Bianchini, & Carey, 1999), there are conditions which can cause an individual to have an ID. The most common of these conditions are Down syndrome, fetal alcohol syndrome, and fragile X syndrome. The most common of these three is Down syndrome which is a genetic condition occurring in utero whereby the child is born with three copies of chromosome 21 (Roizen, & Patterson, 2003). Down syndrome occurs in 1 in every 700 births, and it is estimated that approximately 6 million people worldwide have DS (Roizen & Patterson, 2003).

Individuals with ID will have cognitive impairment and/or delay, impaired social and communication skills, as well as motor impairments (Pitetti & Fernhall, 2005). In

addition, people with ID tend to have various other health conditions including heart defects (Freeman et al., 1998), digestive abnormalities (Roizen & Patterson, 2012), epilepsy (Beange, 2002), and obesity (Temple, Foley, & Lloyd, 2013). Furthermore, accelerated aging has been seen within individuals with DS which is predicted to be the cause of higher than normal percentages of Alzheimer's diagnoses within this population (Griffin, 1989).

Evidence is fairly consistent that individuals with ID tend to have low physical activity levels (Finlayson et al., 2009, Finlayson Turner, & Granat, 2011; Temple, 2010). Research has found that only about 9% of individuals with ID are sufficiently active i.e. meeting minimal physical activity guidelines of 150 minutes of physical activity per week (Dairo, Collett, Dawes, & Oskrochi, 2016); compared to about 23% in the typically developing population (Dairo, et al., 2016). Several factors affect physical activity levels among individuals with ID, including: severity of the ID, sex, age, and living arrangements (Dairo et al., 2016). However there is also evidence of variability in physical activity levels, and studies have shown that some individuals with ID are quite active (Finlayson et al., 2011; Temple, 2009; Temple, Anderson, & Walkley, 2000). Temple and colleagues found that the majority of the time spent active for these individuals was when they were walking as a means of transportation, typically to and from work, and/or placements. Further, Finlayson and colleagues (2011) conducted a similar study with 62 individuals with ID. Through the use of activity monitors, it was found that the participants walked an average of 8509 steps per day and 27% of the sample achieved 10,000 steps per day. The findings from studies like these suggest that

although a majority do not meet public health guidelines, some people with ID are more active than what is widely believed.

Along with generally low physical activity levels, individuals with ID have lower physical fitness levels (Fernhall & Pitetti, 2001); particularly cardiovascular fitness (Fernhall et al., 2001; Ohwada et al., 2005; van de Vliet et al., 2006). Persons with ID tend to have poor cardiovascular fitness and significantly lower VO_{2peak} and VO_{2max} results than control groups without ID (Fernhall et al. 2001; Ohwada et al. 2005). This is likely due to physical inactivity (Oppewal et al, 2013) and regularly engaging in activity which is not intense enough to improve or sustain cardiovascular fitness. In addition to all these factors effecting cardiovascular fitness, a majority of individuals with DS have the added disadvantage of having from chronotropic incompetence (Oppewal et al, 2013), which further limits the ability of their cardiovascular system respond to the physical demands of exercise.

2.7) Chronotropic Incompetence

The effect of the SNS on the heart is described as chronotropic. Stimulation is required in order for the SNS to impact the heart (Ernst, 1996). This stimulus is typically found through psychological or physical stress (like exercise). When an individual engages in exercise, the sympathetic nerves act to increase the heart rate by releasing the catecholamines epinephrine and norepinephrine, hormones which act to vasoconstrict the systemic arteries and veins (Ernst, 1996). These hormones bind to the sinoatrial node to increase heart rate. Through these various mechanisms, the SNS works to increase the heart rate in order to meet the new physiological stressor or demand (Ernst, 1996).

Chronotropic incompetence (CI) is defined as the inability of the heart rate to increase in response to activity or physiological stress. An individual is considered to be experiencing chronotropic incompetence when they are unable to reach 80% of their maximal heart rate (Brubaker & Kitzman, 2013). The inability to reach this heart rate is associated with early mortality and increased risk of cardiac death. Individuals who experience CI typically have an intolerance to exercise as they have reduced exercise cardiac output (Wilson, Rayos, Yeoh, & Gothard, 1989).

The underlying causes of CI are not fully known or entirely understood. It has been proposed that one or all of the physiological mechanisms which impact heart rate during exercise are affected and cause CI (Brubaker & Kitzman, 2013). Thus, an increase in vagal tone, a decrease in sympathetic modulation, and/or a decrease in the sinoatrial nodes sensitivity to catecholamines could be contributing to CI (Brubaker & Kitzman, 2013). Kawasaki et al. (2010) tried to identify which portion of the ANS was experiencing dysfunction and therefore causing CI. One hundred and seventy two healthy, typically developing participants had heart rate data collected on them during bouts of exercise and of that, 72 (41%) were unable to reach 80% of their maximal heart rate, indicating CI. Between those with CI and those without, the difference in autonomic functioning was evident post exercise, with sympathetic activation occurring instead of repression (Kawasaki et al., 2010).

There are several groups of individuals who have a higher likelihood of developing CI. The primary group to display CI are patients with heart disease or heart failure (Keteyian et al., 1999). In addition to having sustained damage to their cardiac muscle, many

patients will be put on a selection of medications including beta blockers, which have been found to limit the heart's ability to respond to cardiac stressors like aerobic exercise (Sersté et al, 2011).

The second group which tend to experience CI are those individuals who have DS. Guerra, Llorens, and Fernhall (2003) investigated chronotropic response to peak exercise in individuals with DS. The study consisted of 20 individuals with DS, and a control group of 20 individuals without DS. The study showed that all 20 participants with DS display CI. The individuals with DS also had peak heart rates which were 27 beats/min on average lower than the control group. Although these findings were significant, is it important to note that the experimental group consisted of a relatively sedentary population while the control group were individuals who all regularly participated in sport (Guerra et al., 2003). The discrepancies between these two groups could be due to the fact that the control group have hearts which are efficient and respond appropriately to exercise, while the hearts of the individuals with DS would be inept at responding to exercise due to a sedentary lifestyle (Heyward, 2010). As Fernhall and colleagues (2013, p.145) explained in a recent summary article of examining reduced work capacity of individuals with DS:

... a sedentary lifestyle and obesity contribute to the low work capacity but cannot explain most of the difference between individuals with and without DS. Therefore, low work capacity in persons with DS most certainly is caused by an alternative factor. ... this “unidentified factor” is altered autonomic function leading to chronotropic incompetence and reduced work capacity.

2.8) Medication usage among individuals with ID

Individuals with ID are much more likely to use medications than the general population (Bohlman-Nielsen, Panzer, & Kindig, 2004). This is due to many of the accompanying health issues that individuals with ID experience such as seizures, mental illness, and difficult behaviour. Currently the most widely prescribed medications within this group are psychotropics and anticonvulsants (Doan, Lennox, Gomez, & Ware, 2013).

People with ID can have destructive and aggressive behaviour. This can be a very difficult aspect of ID to manage (Harvey et al., 2009). However, it has been found that multiple therapy techniques (medicinal and behavioural) are the most appropriate and effective treatment options (Harvey et al., 2009). Psychotropic drugs are typically prescribed to manage negative behaviours such as self-injurious behaviour, hyperactivity, stereotypic behaviour, and aggression (Deb et al., 2008). Psychotropic drugs which may be prescribed include antipsychotics, antidepressants, anxiolytics, hypnotics/sedatives, and psychostimulants. Doan and colleagues (2013) found that 55% of Australians with ID were taking some type of psychotropic medication (35% taking antipsychotics and 20% taking antidepressants). Seizure disorders are another common medical problem within this population (Harris, 2006). It is estimated that anywhere from 16-26% of people with ID have a seizure disorder (McGrother et al., 2006). Anticonvulsants are typically prescribed to treat seizure disorders, particularly valproic acid and Carbamazepine (Harris, 2006).

Individuals with DS have different health issues than individuals with ID without DS. This is likely due to accelerated aging, congenital heart defects, and higher rates of obesity (Van Schrojenstein Lantman-de valk et al., 1997). Kerins, Petrovic, Bruden, and Gruman (2008) performed a retrospective chart review of 141 individuals with DS to investigate medication usage. It was found that thyroid supplements, antianxiety/antidepressants, and anticonvulsants were most commonly prescribed. This population also tends to take vitamins and minerals such as D, E, and calcium (Kerins et al., 2008).

2.9) Validated Fitness Tests for People with Intellectual Disabilities

Testing the fitness level of people with ID poses a series of barriers for both the researchers and the participants which are not typically found with people who do not have an ID. A person with an ID may not be able to complete a maximal effort test such as a beep test or a Wingate cycle test (Seidl, 1998). Difficulties in providing maximal effort during fitness testing include: poor motivation, a lack of task understanding, and low fitness and physical activity levels (Pitetti & Fernhall, 2005); as well as motor and sensory processing difficulties (Seidl, 1998). The lack of motivation and task understanding are the biggest reasons that individual's with an ID tend to have difficulty completing cardiovascular fitness testing. First, due to lower than normal IQ, they may not properly interpret an abstract construct such as what it means to "work your hardest". Additionally, they may not be motivated to complete high-intensity activity required to complete a test (Pitetti & Fernhall, 2005; Rintala, McCubbin, & Dunn, 1995). Keeping this and other factors in mind, testing methodologies have been modified so they are more appropriate for people with ID.

There are a multitude of tests which are used to assess different aspects of cardiovascular fitness in individuals with ID including VO_2 max, aerobic endurance, functional capacity and anaerobic fitness. Graded exercise tests (GXT) involve a multistage submaximal or maximal exercise test which requires the participant to workout at different workloads across multiple stages. A GXT is typically used to measure VO_2 max (Heyward, 2010). The graded treadmill test has been used throughout the literature with people with ID (Baynard et al., 2004; Fernhall et al., 2001; Guerra et al., 2003; Mendonca, Pereira, & Fernhall., 2011). However, as the GXT cannot be used in the field, tests validated against the GXT are commonly used. One tests that has good psychometric properties and is well tolerated by individuals with ID is the modified 6-minute walk test (m6MWT; Nasuti, Stuart-Hill, & Temple, 2013).

The m6MWT was adapted from the 6MWT originally designed by Balke (1963) to assess functional capacity in elderly populations. However, since its development it has been used with a wide variety of populations including patients with joint replacements (Focht, Rejeski, Ambrosius, Katula, & Messier, 2005), heart failure (O'Keefe, Lye, Donnellan, & Carmichael, 1998), and individuals with ID (Nasuti et al., 2013). The m6MWT is very similar to the 6MWT in that it is a practical, simple, and an inexpensive measure of aerobic endurance. The main difference between the protocol for the 6MWT and the m6MWT is the use of a pacer to help participants maintain their focus and tempo. The use of a pacer is an important addition in fitness testing protocols when researchers are assessing individuals with ID (Pitetti, & Fernhall., 2005; Rintala et al., 1992). This modification helps to address the issue of task understanding and motivation which may occur when testing this population. Nasuti and colleagues (2013) assessed the validity

and reliability of the m6MWT with individuals with ID. While performing the m6MWT no participants dropped out prematurely and 12 of 13 were able to reach 85% of their predicted maximal heart rate. Nasuti et al. found that the m6MWT had high test-retest reliability (ICC = 0.98) and has acceptable concurrent validity (adjusted $R^2 = .67$, $p < .001$) with peak oxygen used.

There are numerous practical benefits of using the m6MWT to measure cardiovascular fitness and HRV in people with ID. First, the m6MWT can be done in a relatively small space and if set up properly, multiple tests can occur at one time. Also, walking is the most common type of physical activity engaged in by adults with ID so they are usually comfortable with this type of test (Draheim et al., 2002; Temple, & Walkley, 2003).

2.11) Intellectual Disabilities and Heart Rate Variability

HRV data has been collected in many populations because it is easy to collect, is predictive of mortality, morbidity, and various diseases (Ernst, 1996), and can be used to prescribe and monitor training (Kiviniemi et al., 2010). However, one population which is significantly underrepresented in current literature are individuals with ID. Currently, close to 3,000 studies have been published looking at HRV, and only seven of those observe HRV in people with ID (see Appendix A). The lack of research could be due to barriers that are attached with researching special populations (Pitetti & Fernhall, 2005). Additionally, heart rate data collected within this population is thought to be easily misinterpreted due to confounding factors such as medication use, obesity, and high levels of sedentary behaviour (Ernst, 1996).

Chang et al. (2012) investigated the prevalence of metabolic syndrome in individuals with ID as well as short term HRV. The authors found that a sex difference existed with regards to HRV in individuals with ID. Women exhibited lower heart rate variability than men and also had lower values in LF, HF VLF, and LF/HF ratio. This finding is also consistent with the general population as healthy women typically have lower HRV than their male counterparts (Ernst, 1996). When the participants with ID were sex compared to the general population, both HF and LF/HF ratio were significantly lower ($p < 0.001$). The female participants with ID had 5.18 and 1.89 mean HF and LF/HF ratio, respectively. While in the general population, women have an HF of 6.44, and an LF/HF ratio of 3.69. In comparison, the male participants with ID had a 5.48 and 3.02 mean HF and LF/HF ratio, respectively. The general male population has an HF of 6.18 and an LF/HF ratio of 4.39 (Chang et al., 2012). However, as previously mentioned, Chang and colleagues did not report the etiology of ID in their sample. So it is unclear whether individuals with DS, who tend to have a distinctive HRV profile (Baynard et al., 2004; Fernhall, Goncalo, Mendonca, & Baynard, 2013), were included in the sample and/or whether individuals with DS were equally distributed between the men and women in their study, thereby confounding these results.

Only two studies have examined response to exercise and HRV in individuals with ID. A study conducted by Mendonca, Pereira, and Fernhall (2010) assessed cardiac autonomic response during submaximal exercise in individuals with DS. To do this, the researchers recruited 13 participants with DS and 12 without disability. The participants without disability acted as a control as they were sex, age and BMI matched to a participant with DS. Both the experimental and control group performed the graded treadmill test, a

validated measure of cardiovascular fitness for both populations with and without DS (Pitetti, Millar, & Fernhall, 2000). Results from the study showed that the group with DS exhibited lower heart rate during exercise than the control group. Additionally, the individuals with DS had a greater increase of LF oscillations from rest to 45% VO_2 than the control group, which would indicate heightened sympathetic modulation. These findings suggest that individuals with DS cardiac autonomic function adjusts differently during exercise (Mendonca, Pereira, & Fernhall, 2010).

Prior to Mendonca and colleagues' (2010) study, Baynard et al. (2004) compared resting HRV, exercise HRV, and how the ANS affected the SA node at rest and during submaximal exercise in individuals with DS and individuals with ID without DS. A total of 31 participants were recruited, 15 with ID without DS and 16 with DS. Baynard et al. found that absolute HF power was higher in individuals with DS at rest (1418.1, $p < 0.05$) compared to those with ID without DS (579.9, $p < 0.05$). The results of this study suggest that at rest the parasympathetic system is far more dominant in individuals with DS than their peers with ID by without DS. Aside from differences in HF power and RMSSD, the groups did not differ during any stage of submaximal exercise which suggests that the groups exhibit similar autonomic control when moving from rest to exercise (Baynard et al., 2004). However, it is also possible that the study was underpowered and additionally the proportion of men and women in the DS and ID without DS groups differed. As sex has been shown to influence HRV (Ernst, 1996), the unique contribution of DS status on HRV is likely obscured.

The current research shows that there is a need for more investigation into individuals with ID and not just individuals with DS. Further, only the study by Baynard and colleagues (2004) looks at HRV during exercise in individuals with ID without DS. This shows that a large portion of individuals with ID are grossly under represented.

2.12) Situating the Current Study

HRV is an important research and clinical tool and provides a great degree of information on the inner workings of an individual's body and their overall health. There is a paucity of research on HRV in individuals with ID without DS, and only one study investigating HRV during exercise in individuals with ID without DS. While it is clear that medication use can influence HRV, studies to date have excluded individuals who were taking medication, despite the fact that the majority of individuals with ID are taking medications. Investigating HRV at rest, during exercise, and post exercise in individuals with ID is worthwhile as it has never been done and will help to inform our understanding of cardiac autonomic control as well as providing an indication of response to various kinds of training and recovery. Therefore, the aim of this study is to establish HRV profiles in adult Special Olympics athletes.

Chapter 3 Method

Study Design and Sampling Frame

Following ethics approval from the University of Victoria (see Appendix B), athletes were recruited from Special Olympics British Columbia (SOBC) locals on Vancouver Island and the lower mainland. Eligible athletes were: (1) 18 years of age and older, (2) participating in the SOBC Functional Fitness Testing (FFT), (3) comfortable laying

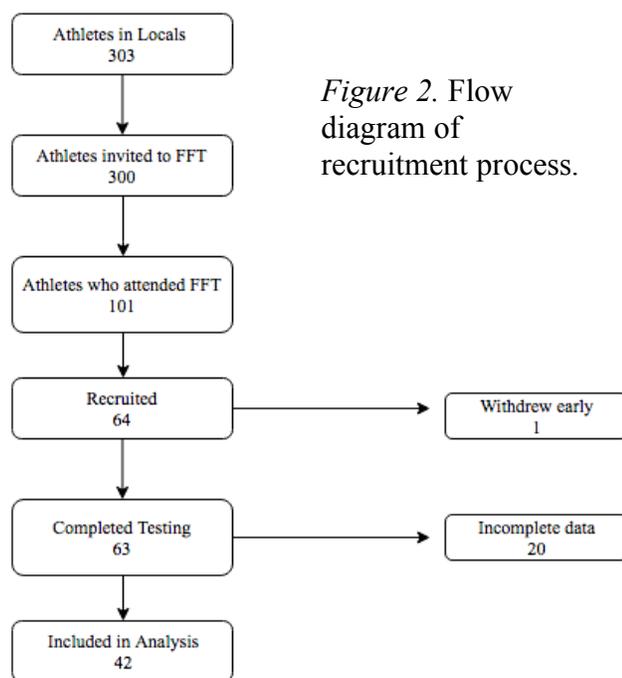


Figure 2. Flow diagram of recruitment process.

supine for 10 minutes, and (4) comfortable completing the m6MWT.

The primary investigator recruited athletes and obtained informed consent and assent (where appropriate) prior to, or during, the SOBC FFT sessions.

Athletes

Figure 2 shows the recruitment flow into this study. Thirty athletes were recruited in May/June 2016, but one chose to withdraw, and 33 athletes chose to participate in November 2016. Data were incomplete for 20 of the 63 athletes, likely as a result of the electrode belt not having sufficient or consistent contact with the skin. The final sample

was $n = 42$ (Males: $n = 23$, 54.7 % Females: $n = 19$, 36.3 %). Descriptive statistics for several athlete characteristics are shown in Table 1.

Table 1

Descriptive statistics of athlete characteristics

Variables (units)	Male ($n = 23$)			Female ($n = 19$)		
	Mean	SD	Range	Mean	SD	Range
Age(years)	37.5	12.3	21-69	33.5	11.6	18-57
Height(m)	1.7	1.2	1.4-1.9	1.5	0.9	1.4-1.7
Weight(kg)	79.3	18.6	44.1-133.4	75.4	25.3	43.7-135.4
BMI(kg/m ²)	26.7	6.7	21-40	30.0	1.7	21-40

Measures

Polar Team 2 Heart Rate/HRV Monitors

Heart rate data were obtained using Polar Team2 heart rate monitors (Polar USA, Lake Success, NY). The Polar heart rate monitors were attached to the mid-chest using an elastic chest strap. Electrodes on the chest strap allowed for real time measurement of heart rate, which was stored on the monitor for future download to the Polar Team2 software on a dedicated laptop computer on site (see Figure 3). Once downloaded into the software program, the data

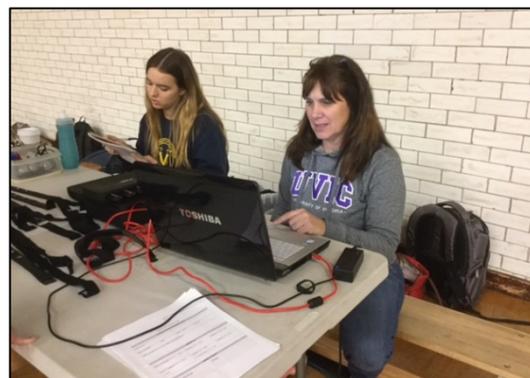


Figure 3. HRV computer set up at testing site.

were displayed as heart rate in beat to beat intervals (R-R intervals). Once these data were in R-R intervals, they were exported into Kubios 2.0, an HRV software program, for analysis. Previous research has demonstrated that R-R intervals from the Polar heart rate monitors have strong concurrent validity with 'gold standard' ECG R-R intervals ($r = 0.97, p < 0.05$) (Gamelin et al., 2005).

Anthropometric Measurements

Athlete weight was measured using a standard physician scale (Congenital Scale Corporation, Bridgeview, IL) and the Forest (n.d) protocol. Athletes removed their shoes and anything in their pockets prior to stepping on the scale. Weight was measured to the nearest 0.1 kg. The Rockenbach et al. (2010) protocol was used to measure height. Athletes were asked to remove their shoes and stand with their shoulder blades and buttocks against the back of the stadiometer and were then instructed to stand erect, as still as possible and look straight ahead. The headpiece was moved to the most superior portion of the head. Height was recorded to the nearest 0.1cm (Appendix C).

Modified 6 Minute Walk Test (m6MWT)

The test that was used to elicit exercise stress was the m6MWT (Nasuti et al., 2013). The m6MWT is an altered version of the 6-minute walk test which is used to measure aerobic fitness in adults (Heyward, 2010). The m6MWT was shown to have adequate validity ($R^2 = 0.67$) and high test-retest reliability (ICC = 0.98) in the population (Nasuti et al., 2013). The m6MWT includes a pacer who walks 1-2 meters ahead of the participant in order to encourage them to keep pace/going and provide standardized phrases of encouragement every 15 seconds. The test was conducted in a gymnasium along a

straight 20m or 30m path marked by two orange cones, while the starting line was marked by yellow floor tape. Additionally, each 2 metre increment was marked using yellow floor tape. Due to environmental constraints, two distances were used at the different testing locations. The first 30 athletes completed the test along 30 metre path, while the last 12 athletes completed the test along a 20 metre path. Although a 20m path was not included in the original validation study by Nasuti et al., more recently Elder, Alston, Stuart-Hill, and Temple (2014) demonstrated that the 20m version of the m6MWT accounted for between 60.5% – 83.9% of the shared variance in the m6MWT, and the test-retest reliability (ICC) of the 20m m6MWT was 0.87.

Medical Information Forms

Since many confounding factors can affect HRV data (Ernst, 1996), specific demographic and medical information were collected. Designed by the primary investigator (PI), information on sex, age, medication use, and medical diagnoses were collected for each participant (Appendix C).

Procedure

All procedures associated with data collection were performed by research assistants (RAs) who had been trained by the PI. RAs were recruited via email by the Exercise Science, Physical and Health Education (EPHE) graduate secretary on behalf of the PI and were undergraduate or graduate students within EPHE. A total of three training sessions, each completed 1 week prior to data collection sessions, occurred to coincide with the three data collection days. During each training session, of approximately one

hour in duration, RAs were instructed on how to attach the heart rate monitors, complete the rest and recovery conditions, and administer the m6MWT.

The FFT sessions were organized and administered by SOBC to test athletes' fitness levels. These sessions occur approximately four times per year across BC and are used to help coaches and athletes track athlete fitness and set goals. The FFT sessions attract large numbers of athletes, which provided an opportunity to recruit a relatively large sample size for the current study. All athletes who had indicated that they would be participating in FFT were informed about the research that was occurring and provided with consent/assent forms by coordinators of the relevant SOBC locals. The PI also attended local Special Olympics practices to provide interested athletes with consent and/or assent forms. Athletes were given time to review the consent form, but were also given the option to review it with their family members and/or primary caregiver. Once informed consent (and assent, in some instances) was given, athletes were reminded to attend the FFT as per usual.

When athletes arrived at the FFT, they were greeted by a volunteer. The athletes were reminded of what they were required to do and asked if they still would like to participate. If they agreed, a RA would record their first name and unique participant code (i.e. 001, 002 etc.) onto a master spreadsheet. The participant code was used to label all of their documents including the medical information form (Appendix D) and the pacer data sheet (Appendix C). If the athletes did not have their consent/assent forms, a research assistant would help them to read through and complete all forms including: (1) Consent Form (Appendix E), (2) Assent Form if necessary (Appendix F), and (3) Medical Information Form.

Once all necessary documentation was complete, athletes had their height and weight measured and recorded by a research assistant and were fitted with a heart rate monitor in a private area. Once the PI had ensured that the monitor was working properly, the RA took the athlete through the three testing conditions.

Administering the three testing conditions

Athletes completed three testing conditions: a 10-minute supine rest; the m6MWT; and a 10-minute supine recovery. Data collection for one participant took approximately 30 minutes and was completed with the help of two RAs. For the 10-minute supine rest, the athlete was taken to a quiet location where a mat and pillow was available for them to lay on. They were instructed to lie as still as they could for 10 minutes.

Once the resting condition was finished, the athletes were taken to complete the m6MWT. One RA, designated as the pacer, completed a familiarization session with the athlete including an explanation of the test i.e. “You will walk 20m/30m as fast as you can.” “You will walk around the cones”, a demonstration of one full lap of the test, and practice of one full lap with the athlete. Once instructions and familiarization were complete, the RAs again confirmed that the athlete wanted to participate in the m6MWT. If the athlete agreed, the pacer helped them line up at the 0 metre mark, and then began the test by saying the standardized phrase, “Ready, set go!”. Both RAs (the pacer and the lap recorder) would begin their timers. The pacer provided standardized phrases of encouragement every 15 seconds (e.g. “Good job!” “Keep up the good work.”) while remaining 1-2 meters ahead of the participant. The lap recorder would remain stationary

at the 0 metre mark for the duration of the test and recorded each completed lap and the extra distance travelled at the completion of the test, by marking the back of the athlete's foot with a piece of tape at the heel (Nasuti et al., 2013).

When the m6MWT was complete, the athlete was taken to a mat where she/he was asked to lay supine and as quietly as possible for another 10 minutes for the collection of passive recovery heart rate data. After the 10-minute recovery was completed, the heart rate monitors were removed and athletes were provided with a juice box and a small gift certificate as a thank you.

Data Treatment and Analysis

To analyze the HRV data, the software program Kubios (version 2.0) was used. Kubios is an advanced and easy to use HRV analysis software which is able to support several different R-R interval data formats including outputs time-domain, frequency-domain and non linear HRV parameters (Tarvainen et al., 2014). Although Kubios provides a variety of outputs, for this study the non parametric spectrum frequency domains, referred to as the Fast Fourier Transform (FFT), was used. The FFT calculates the frequency domains (i.e. LF and HF) by examining the relative portion of different frequency areas in the time series (Ernst, 1996). The FFT was used instead of the autoregressive (AR) frequency domains as AR tends to take out "outliers" which may otherwise be part of the frequency domain, therefore causing the data to be misinterpreted (Ernst, 1996).

Once heart rate data were collected, each participant's data was downloaded and analyzed using Polar Team2 software and Kubios HRV analysis software. Data were first inputted into the Polar Team2 software as beat-to-beat intervals and then transferred into Notepad,

where each individual data point was listed. The file from Notepad was then opened in the Kubios HRV 2.0 analysis software. In order to remove extreme data points, the artifact filter in Kubios was set to strong as per protocol from Huikuri et al. (1992). Setting the artifact filter to strong removed any excess 'noise' or any premature beats that the heart rate monitors may have picked up. Kubios provided output data on LF, HF, VLF, and the LF/HF ratio for each participant. HR and the HRV indices, specifically LF(nu), HF(nu) and LF/HF ratio from the last five minutes of each component (rest, exercise, and recovery) were used for statistical analysis. Using normalized units as opposed to ms^2 eliminates the VLF domain and, as there is no definitive evidence supporting what the VLF domain represents, it was excluded as to avoid confounding the results. These data, along with response to exercise data, were entered into and organized using Microsoft Excel on a secure computer which was only accessible to the PI.

Statistical Analyses

All analyses were completed using SPSS Statistics Version 22. Descriptive statistics HRV and HR were computed. A series of repeated measures analysis of variance (ANOVA) were used to compare the change over time from rest to exercise, exercise to recovery, and rest to recovery in HRV measures to elucidate the HRV profiles of the adult Special Olympics athletes.

The impact of age and sex (between group factors) on the HRV profiles of the Special Olympics athletes, was addressed using a mixed ANOVA comparing the HRV indices and HR for males and females, and athletes 35 years and under and athletes over 35 years. The two age groups were chosen as they closely matched age divisions in previous

research (Gregoire, 1996). Additionally, to assess fitness levels between sexes, an independent t-test was used to compare distance completed during the m6MWT of males and females.

A mixed ANOVA was used to determine if the HRV profiles of the Down syndrome athletes differ from those without DS ($n = 35$). DS was the between factor group (DS or non-DS). A mixed ANOVA was used to assess a sex and age matched non-DS group ($n = 7$) and the group with DS across HRV indices.

A mixed ANOVA was used to determine if HRV profiles of athletes taking medication with athletes not taking medication (between factor group was medication use) and if those athletes taking medication differed from those not taking medication. Due to the fact that antiepileptic medications have been found to increase HRV, the four athletes taking antiepileptic were removed from the taking medication group. Additionally, a mixed ANOVA, where the between factors group was Type of medication, was used to compare four medication groups:

- (1) Not taking medication;
- (2) Taking SSRI/Ritalin/Antipsychotic;
- (3) Taking Thyroid Medication; and
- (4) Taking an Antiepileptic.

These groups were divided as SSRI/Ritalin/Antipsychotics have all been to found either impact HRV or impact HR (Marano et al., 2011), while thyroid medications and antiepileptic medications have not been associated with any modifications to HRV or HR.

Chapter 4 Results

Sample

Forty-two athletes completed this study. The self-report/guardian report data on the medical information sheets showed that of those forty-two athletes, seven had Down syndrome, four had autism, five had epilepsy, one had Williams syndrome, and two had diabetes. The remaining 23 athletes had an ID with no other specific diagnosis. Thirteen of the 42 athletes were taking one or more medications. Six were taking an SSRI/SNRI, four were taking an antipsychotic, three were taking medication for hypothyroidism, four were taking medications for treatment of epilepsy and seizures, and two were taking medication to treat ADHD (Table 3). All athletes were currently participating in Special Olympics. Special Olympics activities included swimming, rhythmic gymnastics, track and field, soccer, bocce ball, golf, and power lifting.

Table 2

Medication usage of the athletes (n=42)

Medication	<i>n</i>	Percent
Not taking medication	28	66.6
SSRI	2	4.7
Antiepileptic	4	9.5
Synthroid	3	7.1
Ritalin	1	2.3
SSRI & Antipsychotic	2	4.7
SSRI, Synthroid, & Antipsychotic	1	2.3
SSRI, Antipsychotic & Ritalin	1	2.3

4.1 Research Question 1: What are the HRV profiles before, during, and after submaximal exercise?

Figure 4 shows that the HR responded as expected, with a pre-exercise heart rate of 77bpm increasing to an average of 132bpm during the m6MWT, and then recovering to 84bpm. A repeated measures ANOVA revealed that there was a significant main effect of time on heart rate, $F(2,40) = 237.82$, $p < 0.001$. Post hoc comparisons using the Bonferroni correction indicated HR changed significantly from rest to exercise, rest to recovery, and exercise to recovery (see Figure 4).

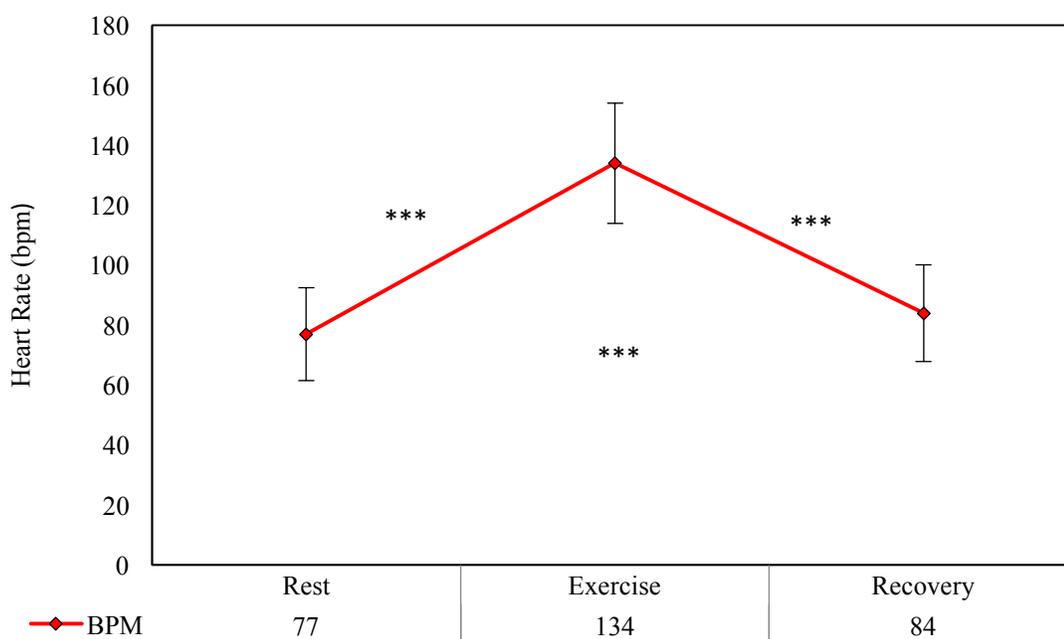


Figure 4. Heart rate across the three testing conditions for all athletes ($n = 42$).

Note. ***Significant differences at $p < .001$.

As shown in Figure 5, there was no significant effect of time on the LF power output(nu) for the athletes, $F(2,40) = 1.752$, $p = 0.185$. Further, there was no significant change

across time for HF(nu), $F(2,40) = 1.756, p = 0.186$. The repeated measures ANOVA also showed that there was no main effect of time on the LF/HF ratio $F(2,40) = 2.463, p = 0.098$. However, the values of the LF/HF ratio were relatively high during all three conditions, 3.7 (SD = 0.6) at rest, 5.3 (SD = 0.7) during exercise, and 5.2 (SD = 0.9) in recovery.

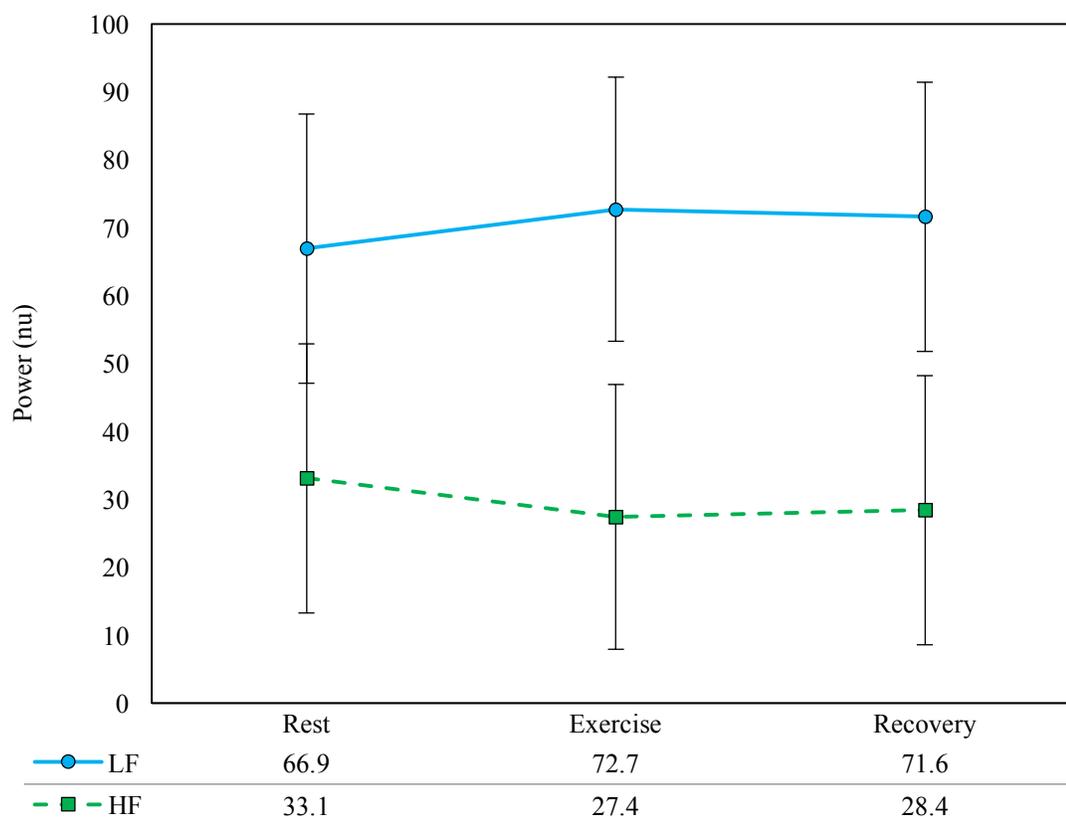


Figure 5. LF and HF power(nu) across all three testing conditions.

4.2 Research Question 1b: How does age and sex impact the HRV profiles from rest to recovery of the Special Olympics athletes?

A mixed ANOVA was employed to compare HR, LF(nu), HF(nu), and the LF/HF ratio in the male and female athletes. The mixed ANOVA revealed that there was a significant main effect of sex on LF (nu) $F(1,40) = 5.154, p = 0.029$; and HF(nu) $F(1,40) = 5.151, p$

= 0.029 (see Figure 6 and Figure 7). However, there was no main effect of sex on the LF/HF ratio, $F(1,40) = 2.177, p = 0.148$.

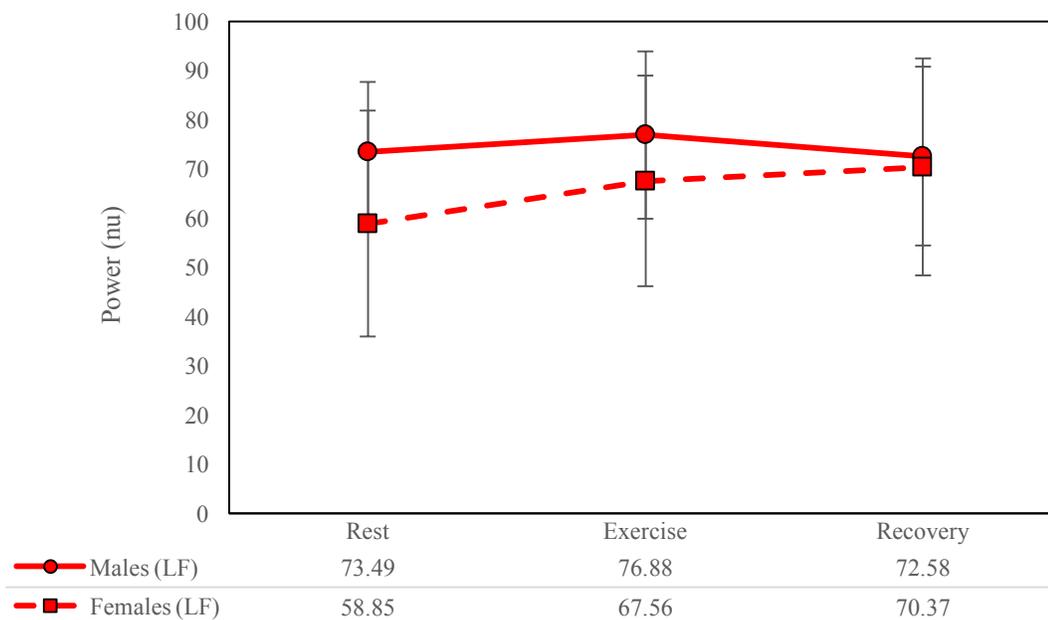


Figure 6. LF (nu) of male and female athletes across the three conditions

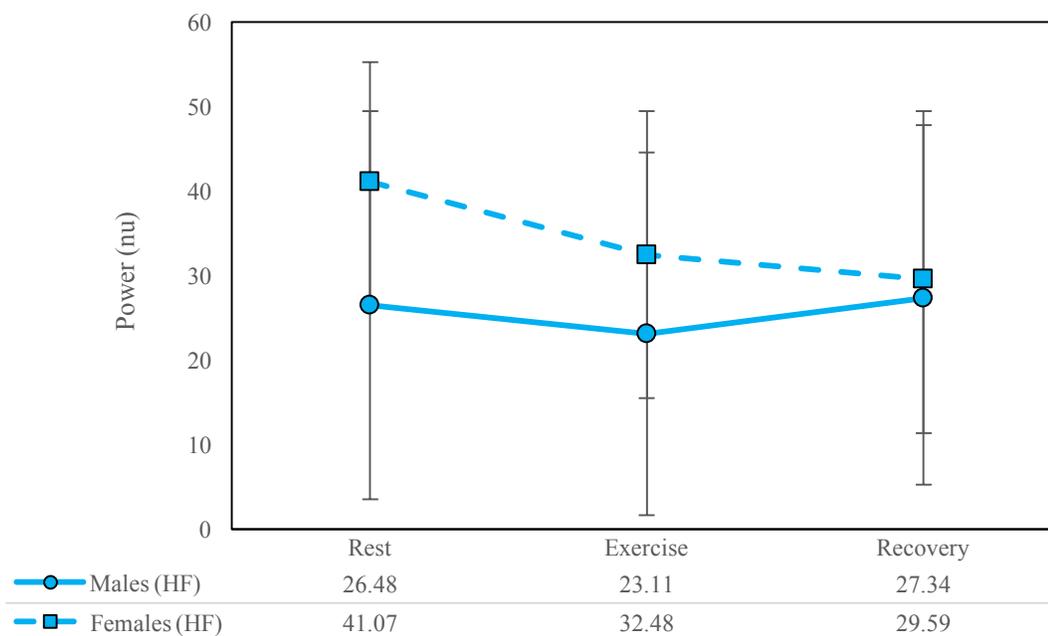


Figure 7. HF (nu) of male and female athletes across the three conditions

An independent t-test ($t(40) = 1.269, p = 0.212$) revealed that there was no significant difference between in distance walked by the male ($M = 587.7\text{m}, SD = 84.14$) and female ($M = 553.53, SD = 20.70$) athletes (see Table 3).

Table 3

Distance completed during the m6MWT for athletes (n = 42)

Variables (units)	Male (n = 23)			Female (n = 19)		
	Mean	SD	Range	Mean	SD	Range
Distance completed (m)	587.7	17.5	441.2-802.4	553.5	20.7	332.1-681.8

To assess the difference between the 35 and under group and the over 35 years' group a mixed ANOVA was employed. The mixed ANOVA revealed that there was no main effect of age on LF(nu) $F(1,40) = 0.82, p = 0.775$, HF(nu) $F(1,40) = 0.82, p = 0.776$ LF/HF $F(1,40) = 2.004, p = 0.165$ (see Figures 8, 9, & 10). The mixed ANOVA also showed that the athletes under the age of 35 at rest ($M = 75, SD = 11.82$), during exercise ($M = 136, SD = 17.8$) and at recovery ($M = 85, SD = 12.3$) did not have significantly different heart rates from those athletes 35 and over at rest ($M = 79, SD = 18.8$), during exercise ($M = 130, SD = 22.3$), or during recovery ($M = 84, SD = 19.8$). This indicates that there was no main effect of age on HR.

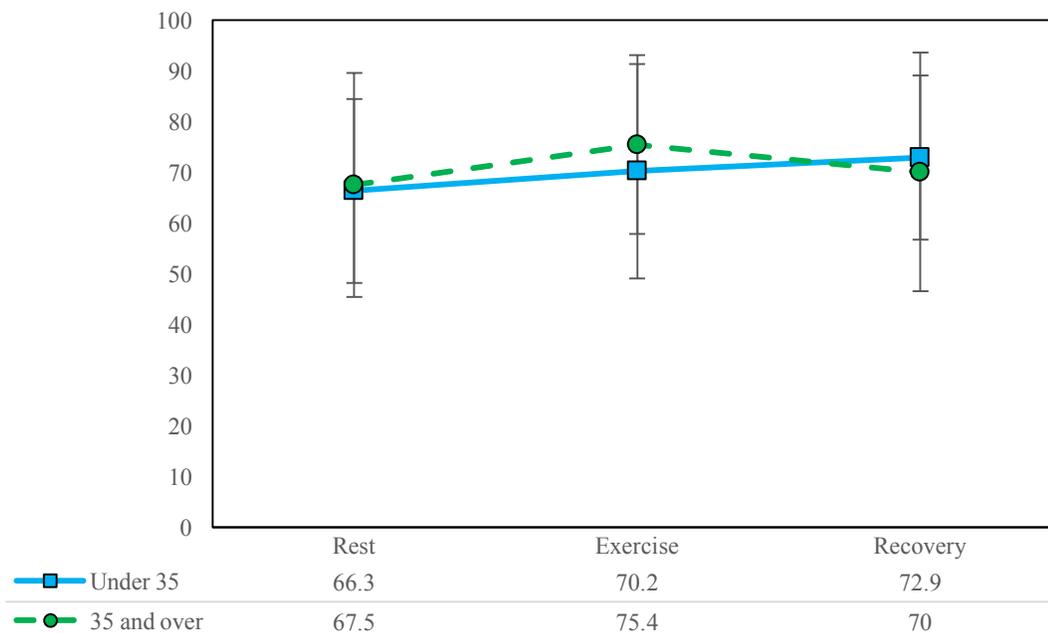


Figure 8. LF(nu) of athletes under 35 and athletes 35 and over.

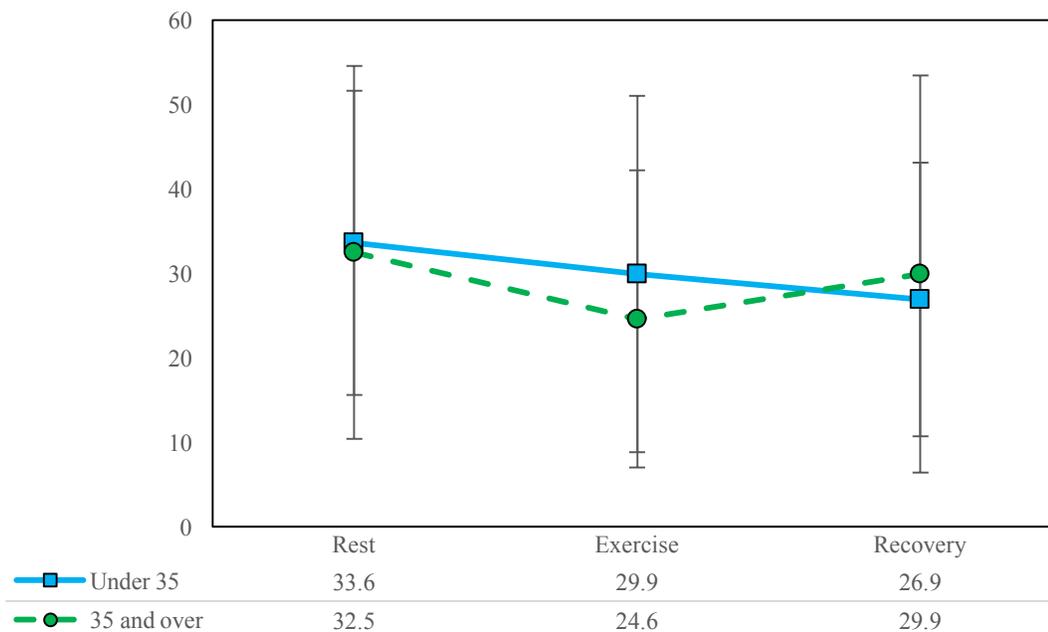


Figure 9. HF(nu) of athletes under 35 and athletes 35 and over.

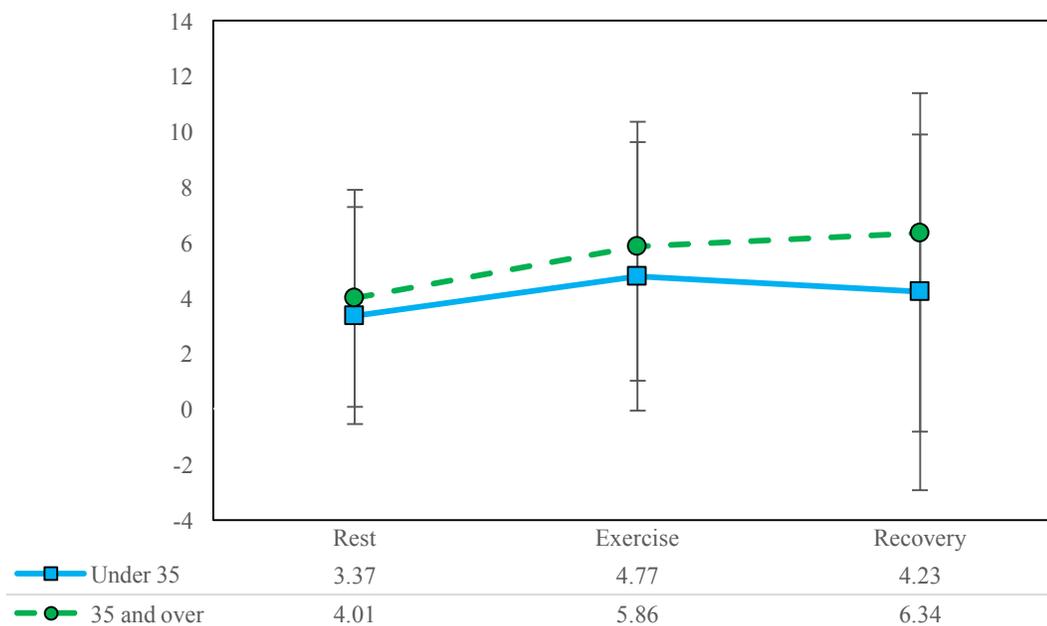


Figure 10. LF/HF of athletes under 35 and athletes 35 and over.

4.3 Research Question 1c: Are there significant differences between the athletes with Down syndrome athletes compared to the athletes without Down syndrome?

Table 4 highlights the means and standard deviations of the athletes with DS and those without DS with ID. A mixed ANOVA was conducted to compare the mean values of HR, LF(nu), HF(nu), and LF/HF in the athletes with DS ($n = 7$) and the athletes without DS ($n = 35$). There was no main effect of DS on HR $F(1,40) = 1.471, p = 0.232$, LF(nu) $F(1,40) = 1.724, p = 0.197$, HF(nu) $F(1,40) = 1.709, p = 0.199$, or the LF/HF $F(1,40) = 0.092, p = 0.763$. When these analyses were repeated with an age and sex matched group with ID without DS ($M=34$ years, $SD=15.4$) to the 7 DS athletes ($M=33$ years, $SD=13.4$), again there was no significant difference between the two groups in HR $F(1,12) = 1.865, p = 0.197$, LF(nu) $F(1,12) = 0.641, p = 0.439$, or HF(nu) $F(1,12) = 0.653, p = 0.435$.

Table 4.

Descriptive statistics for athletes with DS, ID w/o DS, taking medication, and not taking medication.

Variables	Down syndrome status				Medication status subgroups				
	DS (n = 7)	ID w/o DS (n = 35)	TM – {aep} (n = 9)	TM + {aep} (n = 13)	NtM (n = 29)	Med 1 (n = 4)	Med 2 (n = 3)	Med 3 (n = 8)	
HR	Rest	68 (± 11.8)	78 (±15.7)	78 (± 11.6)	78 (± 17.1)	76 (±15.0)	78 (± 28.4)	72 (± 4.6)	76 (± 15.4)
	Exercise	126 (± 24.2)	135 (±19.3)	138 (± 19.3)	138 (±1 6.5)	131 (± 21.4)	138 (± 9.7)	139 (± 19.0)	134 (± 19.8)
	Recovery	80 (± 15.4)	85 (± 16.4)	84 (±12.9)	85.5 (± 16.8)	83 (± 16.0)	88 (± 25.8)	83 (± 13.1)	80 (± 15.9)
LF	Rest	60.5 (± 23.5)	68.1 (± 19.4)	59.9 (± 27.7)	64.4 (± 23.9)	67.9 (± 18.1)	74.4 (± 7.8)	70.5 (± 12.0)	56.8 (± 27.9)
	Exercise	66.3 (± 21.4)	73.9 (± 19.1)	71.9 (±22.9)	75.1 (± 21.2)	71.6 (± 18.9)	81.9 (± 17.4)	61.8 (± 27.3)	77.2 (± 19.8)
	Recovery	66.7 (± 21.2)	72.5 (± 19.7)	63.9 (±24.9)	69.3 (± 22.18)	72.6 (±19.0)	81.5 (± 5.2)	71.4 (± 13.4)	63.4 (± 25.2)
HF	Rest	39.4 (± 23.5)	31.8 (± 19.1)	39.9 (± 27.7)	35.5 (± 23.9)	31.9 (± 18.0)	25.6 (± 7.8)	29.4 (± 12.0)	43.1 (± 28.0)
	Exercise	33.7 (± 21.4)	26.1 (± 19.1)	28.0 (± 22.9)	24.9 (± 21.2)	28.4 (± 18.9)	18.1 (± 17.4)	38.2 (± 27.3)	22.8 (± 19.6)
	Recovery	33.2 (± 21.2)	27.4 (± 19.7)	35.9 (± 25.0)	30.55 (± 22.2)	27.4 (± 19.0)	18.5 (± 5.2)	28.6 (± 16.4)	36.4 (± 25.3)
LF/HF	Rest	3.9 (± 5.7)	3.6 (± 3.5)	3.2 (± 4.05)	3.2 (± 2.9)	3.9 (± 4.2)	3.1 (± 1.1)	2.9 (± 1.9)	3.0 (± 3.9)
	Exercise	3.5 (± 3.1)	5.6 (± 4.8)	5.5 (± 4.6)	6.6(± 5.4)	4.7 (± 4.2)	9.0 (± 7.0)	3.4 (± 4.2)	6.8 (± 5.2)
	Recovery	5.81 (± 9.3)	5.12 (± 4.7)	5.3 (± 5.8)	4.2 (±3.8)	5.7 (± 6.2)	4.8 (± 1.7)	3.4 (± 2.2)	3.8 (± 4.7)

Note. DS, Down syndrome; ID, Intellectual disability; TM, Taking medication; NtM, not taking medication; aep, antiepileptic; Med 1, athletes taking antiepileptics; Med 2, athletes taking synthroid; Med 3, athletes taking SSRI/SNRI, antipsychotic, and/or Ritalin.

4.4 Research Question 2: How does medication impact the HRV profiles of the Special Olympics Athletes?

Table 4 highlights the means and standard deviations of those athletes taking medication and those not taking medications. A mixed ANOVA was used to compare the mean values of HR, LF(nu), HF(nu), and LF/HF of those who were taking medication to those who were not. There was no main effect of medication on HR $F(1,40) = 0.524, p = 0.473$, LF(nu) $F(1, 40) = 0.065, p = 0.800$, HF(nu) $F(1,40) = 0.040, p = 0.808$, or LF/HF $F(1,40) = .032, p = 0.858$. Additionally, when the four medication groups were compared using a mixed ANOVA there was no main effect of medication on HR $F(1,38) = 0.117, p = 0.950$, LF(nu) $F(1,38) = 0.985, p = 0.410$, HF(nu) $F(1,38) = 0.417, p = 0.969$, or LF/HF $F(1,38) = 0.259, p = 0.854$.

Chapter 5

Discussion

The primary aim of this study was to establish HRV profiles of male and female Special Olympics athletes, with an ID. Additionally, the study sought to examine the differences in HRV indices between individuals with and without DS, and determine the impact of age, sex and medication use could have on HRV. In the following sections the study findings are explained and discussed as they relate to contemporary literature. Strengths and limitations of this study have been considered and finally, future directions will be examined.

HRV profiles of Special Olympics Athletes

The first research question was: What are the HRV profiles of adult Special Olympics athletes before, during and after submaximal exercise? To address this first research question LF(nu), HF(nu), LF/HF, and HR(bpm) were examined for the entire sample. During the testing conditions, heart rate responded as expected, showing appropriate pre-exercise values (50-80 bpm) (Hayward, 2010). Heart rate significantly increased during the m6MWT and significantly decreased (almost returning to pre-exercise values) during passive recovery. Despite this anticipated response from the heart, the LF (nu) was elevated across all three conditions and no significant differences existed from rest to exercise to recovery. The elevated LF (nu) is indicative of the sympathetic nervous system being highly active throughout all testing conditions. Meanwhile the HF(nu)/vagal tone was suppressed across all three conditions, and there were no significant changes over time (as illustrated in Figure 2). This imbalance between the SNS and PNS was further seen in the LF/HF ratio across the three testing conditions, as it

was abnormally high. These findings differ greatly from what is theorized by HRV experts. Typically, when the body is at rest, a high degree of vagal modulation should be apparent, which is indicated by a high HF(nu); while during exercise the sympathetic nervous system should be dominant, as indicated by elevated LF(nu) (Ernst, 1996). Research conducted with the general population have found that healthy individuals do follow this pattern (Arai et al., 1989). Arai and colleagues examined HRV before, during and after exercise in healthy adults. The testing protocol involved having participants sit before exercise, complete a 4 minute exercise bout, and 15 minute supine recovery. Arai and colleagues found that HRV was high before exercise. During exercise, high frequency power progressively decreased and during recovery, low frequency power increased again. The researchers also found that the values in the recovery condition (i.e. high and low frequency power) were lower than pre-exercise values (Arai et al., 1989).

The current study's findings are inconsistent with Arai and colleagues as this study showed that low frequency values did not return to pre-exercise values during the recovery phase of the test. The results from this study suggest the following: (1) PNS is not appropriately acting on the sinoatrial (SA) node; (2) there is inappropriate sympathetic withdrawal and; (3) some form of autonomic dysfunction is occurring. A possible explanation for the findings in this study is that the autonomic dysfunction occurring in the athletes is due to an abnormality in the frontal lobe of the brain, which is the structure that is affected when an individual has an ID (Muñoz-Ruata et al., 2013). This connection between structural abnormalities in the frontal lobe and autonomic dysfunction was made by Woo and colleagues (2005). They found that patients with cardiac

illness had a reduction of grey matter in the cerebral cortex, which was thought to be causing autonomic dysfunction.

In addition to the abnormal LF(nu) and HF(nu), the LF/HF was extremely high across the three testing conditions. This study's findings regarding LF/HF are inconsistent with the findings of Baynard and colleagues (2004), who found that a group of 15 individuals with ID displayed a LF/HF that was approximately 2.5 at rest while the participants from this study had a LF/HF ratio at rest which was closer to 3.7. Further, Baynard et al. (2004) found that during two bouts of submaximal exercise, the athletes with ID displayed an LF/HF of approximately 2.8 (bout 1), and 3.0 (bout 2). In addition to the hypothesis previously stated (i.e. structural abnormalities in the frontal lobe causing autonomic dysfunction), these vast differences between the current study and the one from Baynard and colleagues could be due to the physical differences between the two populations. The 42 athletes in the current study were slightly heavier than the 15 athletes in the Baynard et al. study, and also had slightly higher BMI's which might account for the discrepancies as high (over 25) BMI's are associated with low HRV (Sheema & Malipatel, 2015). It could be suggested that the lack of response of the PNS (and the subsequent abnormal LF(nu), HF(nu) and LF/HF values) during the rest and recovery conditions was a result of a short resting period. However, engaging in a 10-minute supine rest has been found to provide the body with enough time to get into a resting state (Heyward, 2010). This rest/recovery protocol has been used with populations who have ID. Additionally, Kannankeril et al. (2004) found that, in the general population, within the first minute of recovery from exercise, parasympathetic domination begins to impact the heart rate. This parasympathetic domination increases 4 minutes into recovery and then stabilizes. Based on this, it was assumed that the analysis of the

last five minutes of the 10-minute rest and recovery condition provided adequate time for an increase in vagal tone to be observed. However, it is possible that this is not enough time for this individuals with ID. Future research is needed to see if a longer rest/recovery period would allow for a greater degree of vagal modulation to occur.

Sex: The second research question of this study explored the impact sex and age had on the HRV profiles of the athletes. These two factors were important to examine as they have both been found to cause a reduction in HRV (Ernst, 1996). Notably, there was a main effect of sex with regards to both LF(nu) and HF(nu). The male athletes LF(nu) decreased slightly from rest to recovery, while the female athletes LF(nu) increased from rest to recovery (as illustrated in Figure 3). These findings are consistent with previous research, which has shown that male athletes with ID had higher HRV than the female athletes with ID (Chang et al., 2012). Additionally, the female athletes in the current study seemed to have heightened SNS activity, indicated by the increase in low frequency power from rest to recovery. There are several possible reasons that these sex differences are seen in the current study. It may be due to the fact that the female athletes had slightly higher body mass indices ($BMI = \text{body weight}/\text{height}^2$) than the male athletes. This thought is supported by findings of Sheema and Malipatel (2015), who found that high BMI in women is associated with sympathetic over activity and a sympathovagal imbalance (Sheema & Malipatel, 2015). It could be assumed that the sex difference is due to the fact that three of the female athletes were on medications which are known to reduce HRV, specifically SSRI's/SNRI's and antipsychotics (Huang et al., 2013; van Zyl, et al., 2008). Of the 19 females in this study, one was taking an SSRI/SNRI and two were taking both an SSRI/SNRI

and an antipsychotic. However, when these three athletes were removed from analysis, the female athletes still followed the same linear trend for both LF(nu) and HF(nu)

Age: Results from the study showed that age did not have any impact on the athletes' HR. Research has reported a negatively linear relationship between age and HRV in typically developing males and females (Yamasaki et al., 1996). However, the current study showed that the under 35 age group and over 35 age group did not differ in any HRV indices. No studies have examined at age-based differences in individuals with ID. However, studies with the general population have continued to show that as people age, their HRV decreases (De Meersman, 1993; Gregoire et al., 1996; Tsuji et al., 1996; Reardon & Malik, 1996). Based on this information, it was anticipated that these two age groups would have differed. It is possible that the older athletes had not begun to experience age related decline in HRV. Reardon and Malik (1996) suggested that age-related decline in HRV was caused by two possible mechanisms: (1) reduced autonomic activity; and (2) reduced responsiveness to external stress. As the current study has already shown that this population has a dysfunction within the autonomic nervous system, and stunted vagal tone, it is possible that one or both of these mechanisms were already occurring in the athletes, regardless of their age. More research with a detailed examination of age related HRV decline in individuals with ID is needed.

Down syndrome: The third question in this study was: are there significant differences between the athletes with DS compared to the athletes without DS? Although not significantly different, the HR values of the athletes with DS were lower (68, 126, and 81bpm) compared to those without DS (78, 134, 84bpm) at rest, during exercise, and in recovery, respectively. These findings are similar to earlier studies with individuals with DS, which showed that individuals

with DS and individuals with ID without DS did not have significantly different heart rates at rest (Baynard, 2004). However, the lower heart rates of the athletes with DS supports the developing body of research showing that individuals with DS tend to have chronotropic incompetence (Baynard, 2004; Guerra, Llorens, & Fernhall, 2003; Mendaconoa, Pereira & Fernhall, 2011). Chronotropic incompetence reduces the ability of the heart to increase appropriately relative to the stress (Brubaker & Kitzman, 2013), which is illustrated by this study's athletes having low heart rates across the three conditions.

When the HRV indices and heart rate were compared between age and sex matched groups of the athletes with DS and athletes without DS, there were no differences across the three testing conditions. Only one other study has compared HRV during submaximal exercise in individuals with DS and individuals with ID without DS. Baynard and colleagues (2004) used the graded treadmill test to examine HRV in 16 individuals with DS and 15 with ID without DS. The authors found that at rest, HF(nu) was significantly higher in the group with DS; but LF(nu) and the LF/HF ratio were not significantly different between the two groups. However, the differences between the two groups disappeared once submaximal exercise began. The authors concluded that at rest, the individuals with DS have greater parasympathetic activity on the SA node. The findings from the current study have some differing results. The current study shows that no difference exists across the three testing conditions with regards to any HRV indices (LF(nu), HF(nu), and LF/HF). It is postulated that the difference, between the current study and the Baynard et al. (2004) study, could be a result of the current study having a larger sample of individuals with ID without DS. Also, the current study was able to sex and age match the seven

DS athletes with seven athletes without DS which the Baynard et al. (2004) study was not able to do.

Medication use: The final research question was examining the extent to which medication use in the athletes was impacting HRV profiles. It was found that HR and the HRV indices were not significantly different between the athletes taking medication and the athletes not taking medication. Further, there were no significant differences when the athletes were subdivided into four groups: not using medication; on thyroid medication; on an antiepileptic; and taking Ritalin, an SSRI/SNRI and/or an antipsychotic. Over half of the athletes who were taking medication were taking an SSRI/SNRI, an antipsychotic, and/or Ritalin. All of these medications have been found to have cardiologic side effects, such as increase in heart rate (Marano et al., 2011). Although these effects have been seen in the literature, no differences existed between the athletes taking medication and those not taking medication. This is possible because few of these medications are acting directly on the ANS, and therefore were not causing any measurable differences in HRV. Further, the fact that the four groups did not differ could be a result of uneven sample size, however, the mixed ANOVA is a robust test and is able typically able to manage the wide range of sample sizes (Field, 2013).

Limitations

A limitation of this study was that the standardized pretest physical fitness instructions were not enforced. This included making sure the athletes refrained from eating, smoking, or drinking caffeine three hours prior to testing (Heyward, 2010). Additionally, many of the athletes completed portions of their functional fitness testing prior to participating in the research study

which could have put stress on their systems. Typically, it is important to enforce this types of pretest instructions in order to obtain the best test results possible. However, due to the fact that many athletes in this study were recruited the day of the study, it was not possible to implement these standards. Finally, the final sample was more representative of those athletes who were regularly participating in Special Olympics and less representative of the entire population of adults with ID.

Conclusions and implications and future directions

The findings from this study show that adults with ID display signs of autonomic dysfunction as shown by alterations in the HRV profiles. Despite the fact that the heart rate responded as expected across the three testing conditions, the athletes had very low HRV indicated by lack of vagal tone and stunted sympathetic withdrawal. The finding that the sympathetic nervous system was highly active across the three testing conditions is cause for concern as the individuals' bodies continued to be in a state of stress. Future research should examine catecholamine levels in conjunction with HRV data to see if these are elevated as well. Furthermore, the athletes showed lack of vagal tone at rest and recovery, indicating an attenuated response from the parasympathetic nervous system. Although a 10 minute rest and recovery period is said to be an adequate length of time for the body to enter a state of "idle", it may not have been long enough (Heyward, 2010). It is necessary that future research has athletes complete a longer passive rest and recovery period to ensure that PNS has enough time to act on the SA node.

Unexpectedly, no differences were found regarding any HRV components between the DS athletes and the non DS athletes, despite previous research stating that individuals with DS have

chronotropic incompetence (Baynard et al., 2004). It is unclear why these two groups did not differ on any HRV indices. But, this is the first study to age and sex match individuals with DS. Additional research is needed to examine how adults who are typically developing respond to this testing protocol compared to a group of sex, age, height and weight matched adults with Down syndrome.

Although 13 of the 42 athletes were taking some type of medication, the athletes on medication (excluding four athletes on antiepileptics) and those not on medication did not differ on any HRV components. This is despite the fact that several of the medications they were taking are known to negatively impact HRV. Also, no research has been conducted examining the impact that several of the medications (specifically Synthroid) could be having on HRV. As such, is it impossible to get a true understanding of why these groups did not differ. Although the current study's sample sizes were small and differed, these findings are encouraging as future research may no longer need to exclude individuals. This is important because a high percentage of individuals with ID are taking medication (Bohlman-Nielsen, Panzer, & Kindig, 2004), so eliminating them creates research which is not truly representative of the population and the health conditions they are experiencing.

Future research in this area would benefit from having a larger sample size. A larger sample size would allow concurrent prediction of changes in HRV based the four variables the current study examined (DS, age, sex, and medication),

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Appendix A Table

Data extraction for experimental studies in HRV in intellectual disabilities (participant characteristics, design and results)

Primary Author/Year/Country	Aim	Participants	Design/Method	Results	Notes
Baynard et al. 2004 United States of America	1) Determine whether autonomic dysfunction explains CI, and 2) Compare HRV at rest and during exercise of individuals with ID with and without DS	31 adults with ID; 16 with DS (men = 62.5%, Mage= 20.9 ± 0.9y) 15 without DS (men = 53%, Mage= 19.7 ± 2.3y)	XS HR data collected using wireless heart rate monitors. HR data collected during: 5 minute rest 4 minute GXT test CI determined if participant was unable to reach 80% of their max HR	DS group demonstrated: Significantly lower peak heart rate among DS (161 beats/min) vs. group w/o DS (178 beats/min) LF power (ms ²) NS between two groups at rest or during exercise 1) At rest: 1264 (DS) vs 884 (w/o DS) 2) Submax: 203.5 (DS) vs. 370 (w/o DS) LF/HF ratio NS between two groups at rest or during exercise 1) At rest: 1.81 (DS) vs 2.28 (w/o DS) 2) Submax: 2.61 (DS) vs 3.09 (w/o DS)	Exclusion criteria: CHD, metabolic disease, orthopedic problems, use of medication that could alter HR
Chang et al. 2012 Taiwan	1) Assess the prevalence of metabolic syndrome in adults with ID, and 2) Determine the difference in short-term HRV between healthy and ID	129 adults with ID; men = 56.6% Mage: Men = 33.27y ± 9.32, women = 32.66y ± 8.54	XS HR data collected using SA-3000P HR data collected during: 5min during a supine rest	Sympathetic predominance in male participants 1) LF (ms ²) = 5.69 ± 1.17 Men w/ ID had significantly higher LF/HF than women w/ ID 1) Men = 3.02 ± 2.66 2) Women = 1.89 ± 1.62	Medication usage was not reported

<p>Iellamo et al. 2005</p> <p>Italy</p>	<p>Investigated the HRV response to active standing in subjects with DS to test the hypothesis that all the mechanisms of neural cardiac regulation are impaired in this patient population</p>	<p>20 adults;</p> <p>10 with DS, men =40%, Mage=26.3y ± 2.3)</p> <p>10 TD* without DS, men = 40%, Mage=26.1y ± 4.0</p>	<p>XS</p> <p>Recorded using a precordial chest lead</p> <p>Heart rate data collected during</p> <p>1)10 min supine rest</p> <p>2)10 min standing Δ from cond 1 to 2</p>	<p>During the supine rest: Group differences NS LF (nu): 51.3 (DS) vs. 53.6 (TD) HF (nu): 34.6 (DS) vs. 38.1 (TD)</p> <p>During the standing: TD: significant increase in LF(nu) 53.6 - 82.7 and significant decrease in HF(nu) 38.1 - 14.9.</p> <p>DS: change NS for both LF(nu) 51.3- 64.3 and HF(nu) 34.6 - 18.7</p>	<p>Medication usage was not reported</p> <p>Both individuals with DS and without DS were not involved in “regular physical activity”</p> <p>SD for HRV indices not reported</p>
<p>Mendonca, Pereira, & Fernhall, 2011</p> <p>Portugal and the United States of America</p>	<p>Evaluate cardiac autonomic response through HRV, in response to submaximal exercise</p>	<p>25 adults;</p> <p>13 with DS, men = 69.3% (Mage=34.9 y ±1.1)</p> <p>12 TD, men = 66.6%, Mage 34.8y ± 2.0)</p>	<p>XS</p> <p>Heart rate data was collected using Polar RS 800 G3 HR monitor.</p> <p>Heart rate data was collected during a GXT test</p>	<p>Raw LF and LF/HF ratio were significantly different between the participants with DS and TD</p> <p>During exercise: 1) LF power and LF/HF was significantly higher among DS vs. TD</p> <p>Post exercise: 1) LF/HF returned to pre exercise values during recovery in TD 2) Incomplete recovery of HF power in both groups</p>	<p>Excluded: smokers, CHD, ambulatory, musculoskeletal, visual or auditory problems</p> <p>All sedentary or lightly active (30m exercise 1-2/w)</p> <p>Medication usage NR</p> <p>HRV values NR but graphed</p>

Giagkoudaki et al., 2010 Greece	Investigate whether an exercise program was effective in improving HRV indices in people with DS	20 adults; 10 with DS, women =60% Mage=24.2y ± 5.1) 10 TD (but sedentary) women = 60%, Mage=23.3 y, ± 4.6)	XS Initial evaluation All subjects wore a 24 hour ECG holter monitor Exercise:6m training program; mainly aerobic exercises	Participants with DS exhibited ANS dysfunction (LF/HF ratio of 2.45 vs 1.71 in group without DS)	Exclusion criteria: Smoking, taking medications which could affect ANS activity, cardiovascular disease
Mendonca, Pereira, & Fernhall, 2013 Portugal and the United States of America	Effect of a 12w aerobic and resistance training program on resting cardiac autonomic function and HRR after peak exercise in people with and without DS	25 adults; 13 with DS, men = 23%, Mage=36.5 y ± 1.5) 12 TD control men = 25% Mage =38.7 y ± 2.4	XS Heart rate data was collected while in a supine position at Baseline and post-training (12 weeks later)	Increase in HF (nu) power in participants with DS(40 to 45) and TD (30 to 40) after completing the 12 week training program Decrease in LF(nu) power in participants with (60 to 55) and without DS (70 to 60) after exercise training	Exclusion criteria: Unable to ambulate, musculoskeletal, visual or auditory problems, involved in any ex. training in the last 6 m None taking any medication
Meule et al., 2013 Germany	Effect of specific emotional regulation strategies on the relationship between HRV and quality of life	35 with ID and concomitant visual impairment, men = 45.7% Mage = 35.03y ± 7.94	XS Measured using Polar RS800CX Collected while the participant was at rest, with a total duration of 10 minutes	HRV significantly predicted emotional regulation (adj $r^2 = 0.10$) Could not say if HRV was generally lower than those without ID due to lack of a control group	HRV values were not reported Four on meds for hypertension but the impact of medication was not addressed

Note. ID, acknowledged as having an intellectual disability, but without specific diagnoses; DS, Down syndrome; XS, cross-sectional design; GXT, graded treadmill test; CI, chronotropic incompetence. *TD not explicitly stated.

Appendix B

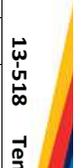


Office of Research Services | Human Research Ethics Board
 Administrative Services Building Rm B202 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
 T 250-472-4545 | F 250-721-8960 | uvic.ca/research | ethics@uvic.ca

Modification of an Approved Protocol

PRINCIPAL INVESTIGATOR: Vivienne Temple	ETHICS PROTOCOL NUMBER 13-518
UVic STATUS: Faculty	ORIGINAL APPROVAL DATE: 23-Jan-14
UVic DEPARTMENT: EPHE	MODIFIED ON: 19-May-16
	APPROVAL EXPIRY DATE: 22-Jan-17
PROJECT TITLE: Heart rate response to exercise and health among Special Olympics Athletes	
RESEARCH TEAM MEMBER Dr. Lynne Stuart-Hill (UVic), Dr. Pauli Rintala (University of Jyväskylä), Laura St. John (Graduate Student UVic)	
DECLARED PROJECT FUNDING: Special Olympics Canada	
ADDITIONAL COMMENTS: Previous Title: 'Validation of the Six-Minute Walk Test for Special Olympics Athletes'	
CONDITIONS OF APPROVAL	
<p>This Certificate of Approval is valid for the above term provided there is no change in the protocol.</p> <p>Modifications To make any changes to the approved research procedures in your study, please submit a "Request for Modification" form. You must receive ethics approval before proceeding with your modified protocol.</p> <p>Renewals Your ethics approval must be current for the period during which you are recruiting participants or collecting data. To renew your protocol, please submit a "Request for Renewal" form before the expiry date on your certificate. You will be sent an emailed reminder prompting you to renew your protocol about six weeks before your expiry date.</p> <p>Project Closures When you have completed all data collection activities and will have no further contact with participants, please notify the Human Research Ethics Board by submitting a "Notice of Project Completion" form.</p>	
Certification	
<p>This certifies that the UVic Human Research Ethics Board has examined this research protocol and concluded that, in all respects, the proposed research meets the appropriate standards of ethics as outlined by the University of Victoria Research Regulations Involving Human Participants.</p>	

13-518 Tem



Appendix C

Date: _____ Location: _____ Participant Code: _____

6 Minute Walk Test – Pacer Data Sheet

Height _____ cm	Weight _____ kg	Heart Rate Monitor Number
Start time Rest		End Time Rest
Start Time 6MWT		End Time 6MWT
Laps Completed		
Distance at end of 6MWT		
Stoppages, if applicable (Time of stop, and length)	Stop #1 @ ____ min ____ sec Length of stop: Stop #2 @ ____ min ____ sec Length of stop: Stop #3 @ ____ min ____ sec Length of stop: Stop #4 @ ____ min ____ sec Length of stop: Stop #5 @ ____ min ____ sec Length of stop:	
Recovery Time Start		Recovery Time End

Appendix D

Participant Code (For researchers to fill in only)

Medical Information Forms

PARTICIPANTS INFORMATION

Full Name:		
Date of Birth:	Age:	Sex: <input type="checkbox"/> Male <input type="checkbox"/> Female
What sport(s) are you currently participating in?		

MEDICAL

Down Syndrome: <input type="checkbox"/> Yes <input type="checkbox"/> No	Seizures: <input type="checkbox"/> Yes <input type="checkbox"/> No	Diabetes : <input type="checkbox"/> Yes <input type="checkbox"/> No
Heart Condition: <input type="checkbox"/> Yes <input type="checkbox"/> No	Autism: <input type="checkbox"/> Yes <input type="checkbox"/> No	Asthma: <input type="checkbox"/> Yes <input type="checkbox"/> No
Explain:	Cerebral Palsy: <input type="checkbox"/> Yes <input type="checkbox"/> No	

MEDICATIONS

Name of Medication(s)	Dosage

Appendix E

Heart rate response to exercise and health among Special Olympics Athletes

Special Olympics Victoria athletes, aged 18 to 60, are invited to participate in a study entitled *Heart rate response to exercise and health among Special Olympics Athletes* that is being conducted by Laura St.John who is a graduate student at the University of Victoria, Dr. Vivienne Temple and Dr. Stuart-Hill, who are professors at the University of Victoria, and Dr Pauli Rintala who is a visiting professor at the University of Victoria from Finland.

If you have further questions, you may contact Laura by telephoning (250) 208-0405 or by emailing lstjohn@uvic.ca or contact Vivienne by telephone at (250) 208-0826 or by emailing vtemple@uvic.ca.

Purpose and Objectives

The aim of this study is to see how the rhythm of your heart changes from rest to exercise. We also want to know if the rhythm of your heart is affected by your level of fitness, your medications, and any health conditions noted on your Special Olympics British Columbia (SOBC) Athlete Medical Form.

Importance of this Research

Measuring fitness can be hard for some Special Olympics athletes because some tests, like the beep test, are hard. If a short walking test and measuring the rhythm of your heart can be used it will let more athletes do a fitness test and we will get more information to help monitor health and help coaches plan training programs and show athlete improvement.

What is Involved?

If you agree to be in this project, you will be asked to do these things:

1. You will do a survey about your need for support with a research assistant. You will also participate in a weight and height measurement. Then you will wear a heart rate monitor for 10 minutes while laying on a mat. The heart rate monitor will be attached with an elastic belt around the mid region of your chest, directly on your skin.
2. Researchers will show you how to do the Six-Minute Walk Test, and you will complete the test with a research assistant walking with you and we will monitor your heart rate throughout the walk and for 5 minutes after the walk. You will also spit into a cup. Your spit will tell us how stressed you are.
3. Provide the researchers with the following information: your age, the sports you play, the medications you use, and whether you have diabetes, asthma, seizures, Down syndrome, and/or a heart condition.

Monitoring your heart rate and participating in the Six-Minute Walk Test (1 and 2 above) will occur at the SOBC functional fitness testing in your region.

Inconvenience

Participation in this study may cause some inconvenience to you because the study will make use of about one hour of your time.

Risks

It is possible that while you are participating in the study, you may feel embarrassed, get tired, get red or bothered skin from the heart rate monitor, become thirsty, or you may fall while walking.

In order to make sure you are safe, we will have someone with their CPR C certification in the gym while you are doing your tests.

Benefits to You

- You will learn how to do the six-minute walk test.
- You will receive a juice box and a small gift certificate for participating.

Voluntary Participation

It is important that you understand that you don't have to participate in this project if you don't want to and you can stop at any time. You can tell any one of the researchers that you want to quit and you can. You will still keep your juice box and gift certificate and this won't affect your Special Olympics participation.

If you decide to stop being in the project, you can decide if the information we have already collected can be used in our research, or you want it destroyed. If you decide we can use the information, we will write you a letter asking to use the information and the letter will be mailed to you. You can sign the letter and mail it back to us if you are comfortable with us using the information. If we do not receive a signed letter in return, we will throw away the information.

Anonymity and Confidentiality

The research team will not tell anyone you are in the study; however other athletes may know that you are in the study because they will see you in the gymnasium used for the SOBC Functional Fitness Tests. SOBC will give us the information about your health and medications from your SOBC Athlete Medical Form, but when we put that information into the computer it will not have your name on it. Your information will be kept safe in a locked cabinet and on a password protected computer for a long time in case the researchers want to look at it again. In five years, the information will be destroyed.

Dissemination of Results

After we have collected the information from many different athletes, we will share what we learned about heart rate rhythm, the Six-Minute Walk Test, and health. We will talk about it at meetings so other people learn about our project. We will write about it a professional magazine. However, your name will not be used, so no one will know you were in the study.

In addition, you may check the ethical approval of this study, or raise any concerns you might have, by contacting the Human Research Ethics Office at the University of Victoria (250-472-4545 or ethics@uvic.ca).

Your signature below shows that you understand and agree with what is written in this form, and

Name of Participant

Participant [Guardian] Signature

Date

that you have had the opportunity to have your questions answered by the researchers.

Appendix F



University
of Victoria

School of Exercise Science,
Physical & Health Education

PARTICIPANT ASSENT FORM

Heart rate response to exercise and health among Special Olympics Athletes

I agree to work with Laura, Vivienne, Pauli and Lynne who work at the University of Victoria on a project about the rhythm of my heart and how it changes when I exercise and if any medications I take and my health changes the rhythm of my heart. At the Special Olympics Functional Fitness testing day, the things I will do in this project are:

1. I will be weighed and measured for my height.
2. I will answer some questions about what kind of support I need every day.
3. I will lay still for 10 minutes while wearing a heart rate monitor.
4. I will do a Six-Minute Walk Test while the researchers watch how fast my heart is beating.
5. I will wear the heart rate monitor for 5 more minutes after the Six-Minute Walk Test.
6. I will spit into a cup.
7. The researchers will also ask my parent, guardian, or caregiver about the sports I play, my age, and about my health.

I understand that none of the things I will be asked to do will hurt me, but I may feel embarrassed, tired, thirsty, get a little bit of red skin, and could fall while I walk. The tests will also take some time to do.

To make sure I am safe, someone who knows about basic first aid will be in the gym while I am doing tests. The building where I do the tests will also have people who know about first aid in it. I will receive a juice box and gift certificate for participating.

I understand that I don't have to participate in this project if I don't want to, and I can stop at any time. I can tell any one of the researchers that I want to quit and I can. I will still keep the juice box and gift certificate that I have already been given, and this won't affect my Special Olympics participation.

If I decide to quit, the researchers will ask me if they can use my scores. If I tell them that they can, they will send my caregiver/parent a letter asking if they can use the scores that they got from the time that I was there. If I am okay with them using my scores, my caregiver/parent and I will sign the letter and send it back to the researchers. If I am not okay with my scores being used, I do not have to mail the letter back, and my scores will be thrown away.

All of my scores, numbers, and other information collected from me will not be shared with anyone except for the researchers. No one will be able to know my name, but some people who know me may see me at the Functional Fitness Tests and realize that I am participating in the study. After five years, all of my scores, numbers, and other information will be destroyed.

The researchers will share what they learned about heart rate rhythm, the Six-Minute Walk Test, and health at meetings and in professional journals but my name will not be used, so no one will know I was in the study. The researchers will also share the information with me.

If I have any questions, my parent/guardian/service provider or I can call Vivienne at 250-208-0826 or email her at vtemple@uvic.ca.

Your signature below shows that you understand and agree with what is written in this form, and that you have had the opportunity to have your questions answered by the researchers.

Name of Participant

Participant Signature

Date