HEART RATE VARIABILITY IN PATIENTS WITH CORONARY ARTERY DISEASE: REPRODUCIBILITY, CIRCADIAN VARIABILITY AND THE EFFECTS OF STRESS

HEART RATE VARIABILITY IN PATIENTS WITH CORONARY ARTERY DISEASE: REPRODUCIBILITY, CIRCADIAN VARIABILITY AND THE EFFECTS OF STRESS

By

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ABSTRACT

The purpose of this study was to assess heart rate variability (HRV) in patients with coronary artery disease (CAD): reproducibility, circadian variability and the effects of stress (coronary angiogram). Sixty-one patients who had a coronary angiogram underwent 48-hour Holter monitoring during a period of high stress beginning 4-hours post-angiography (Day 1 and 2), and again two weeks later during a period of low stress (Day 3 and 4); both 24-hour time domain and power spectral measures were computed.

To determine reproducibility, intraclass correlation coefficients were calculated for both time and frequency domain indices on Days 3 and 4. The intraclass correlation coefficient for the standard deviation of normal RR-intervals over 24-hours (SDNN) was 0.91, while the standard deviation of the mean of all 5-minute segments of normal RR-intervals for 24-hours (SDANN) was 0.85. The most reproducible time domain measure was pNN50 (defined as the percentage of differences between adjacent normal RR-intervals that are greater than 50 ms computed over 24-hours) with an intraclass correlation coefficient of 0.95. As for the frequency domain measures including low frequency (LF) area, high frequency (HF) area, low frequency to high frequency area ratio (LF:HF area), LF central frequency (cf), and total area (TA), intraclass correlations were found to be the best at 0300-hours and the worst at 1500-hours.

Circadian pattern was determined on Day 4 of Holter monitoring. A main effect for time was found for heart rate (HR), LF area, HF area, and TA of the power spectra. Over a 24-hour period, HR, LF area, HF area and TA were the lowest at 0300-hours compared to all other times. There was also a main effect for myocardial infarction (MI) for the frequency domain indices LF area, HF area, LF:HF area ratio, and LFcf. Low frequency area and LF:HF area ratio were significantly elevated (both $p<0.05$), while both HF area ($p<0.05$) and LFcf ($p<0.01$) were reduced in patients with a prior MI compared to those with no MI. As well, a significant interaction between time of day and MI, and time of day and beta-blocker therapy was observed. Patients with coronary artery disease and a prior MI demonstrated a reduced circadian pattern over 24-hours for HR. Likewise, the circadian pattern of HR for those on beta-blockers was also attenuated.

The effects of stress was determined by comparing Day 1 to Day 4 of ambulatory Holter monitoring. The time domain measure SDNN was found to be significantly reduced during Day 1 (mean ± SEM; 111.67 ± 6.13 ms) compared to Day 4 (121.54 ± 6.94 ms; $p<0.05$). Patients with normal left ventricular function (LVF) showed a significant increase from Day 1 to 4 for both SDNN ($p<0.01$) and SDANN ($p<0.05$). In contrast, those with LV dysfunction had an attenuated response. Similarly, those CAD patients on beta-blockers demonstrated a significant increase for the time domain measure SDNN ($p<0.05$), unlike those

not on beta-blockers. In the frequency domain, LF:HF area was significantly greater on Day 1 (1.74 ± 0.09) compared to Day 4 (1.64 ± 0.09; $p<0.05$).

These findings suggest that HRV measures are reproducible, that a circadian pattern for HRV exists in patients with CAD, and that stress induced by an invasive procedure such as a coronary angiogram enhances sympathetic input to the SA node in the heart and thereby alters the sympathovagal balance, which is restored two weeks later.

DON'T QUIT
When things go wrong as they sometimes will,
When the road you're trudging seems all uphill,
When the funds are low, & the debts are high,
And you want to smile, but you have to sigh,
When care is pressing you down a bit-
Rest if you must, but
don't you quit.

Success is failure turned inside out,
The silver tint of the clouds of doubt.
And you never can tell how close you are,
It may be near when it seems afar.
So, stick to the fight when you're hardest hit-
It's when things go wrong that you mustn't quit.
Author Unknown

DEDICATION

This thesis is dedicated to my mother, father and brother,

for if it weren't for the O'Leary 'clan', my accomplishments to date would not have been possible. Their constant encouragement, understanding, caring, patience, and most of all unlimited love, provided me with the emotional support and strength to succeed in every aspect of my life.

I would also like to dedicate this thesis to my mentor, Dr. Neil McCartney,

because of his patience, dedication, inspiration and commitment towards my success and happiness, these last two years as a Kinesiology Master's student at McMaster University have been the best two years of my entire university experience.

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GLOSSARY OF TERMS AND ABBREVIATIONS

Circadian Rhythm: Oscillations in heart rate with periods of approximately 24-hours.

Ectopic Beat: Heart beat that originates from a pacemaker site other than the SA node.

HF Area: Area under the heart rate spectral curve between 0.15-0.50 Hz. A measure of power in the high frequency (HF) band.

HRV: Heart rate variability

LF Area: Area under the heart rate spectral curve between 0.02-0.15 Hz. A measure of power in the low frequency (LF) band.

LFcf: Frequency at which the maximum power within the low frequency (LF) band is located.

LF:HF Area Ratio: Ratio of LF area to HF area. A measure of sympathovagal balance.

pNN50: Percentage of adjacent intervals between normal sinus conducted beats within a given heart rate data set that differ by more than 50 milliseconds.

Power Spectral Analysis: Technique that decomposes the heart rate signal into its component sine waves.

Respiratory Sinus Arrhythmia (RSA): Fluctuations in heart rate that occur concurrently with the respiratory cycle. In general, heart rate increases on inspiration and decreases on expiration.

SDANN: Standard deviation of the mean interval between normal sinus conducted beats in adjacent 5-minute segments of a given heart rate data set.

SDNN: Standard deviation of all intervals between normal sinus conducted heart beats within a given heart rate data set.

Total Area (TA): Area under the heart rate spectral curve between 0.02-0.5 Hz. A measure of power within the entire power spectra, including both the LF and HF band.

1.0 REVIEW OF LITERATURE

1.1 Regulation of Heart Rate

1.1.1 Introduction

In adults, the average heart rate (HR) at rest is approximately 70 beats/minute (Berne and Levy, 1997). During sleep HR can decrease by 10-20 beats/minute, while during emotional or physical stress, HR can increase well above 100 beats/minute. In trained athletes, resting HR is lower compared to normals, at approximately 50 beats/minute (Berne and Levy, 1997).

The heart is a *'mechanical pump'*, supplying the body with the nutrients it requires. The rate at which the heart *'pumps'* can be affected by certain local factors, such as temperature and tissue stretch. However, HR is primarily controlled by the influence of the autonomic nervous system (ANS) on the sinoatrial (SA) node (Berne and Levy, 1997; Guyton and Hall, 1996; Hockman, 1987).

The ANS consists of two divisions: 1.) the sympathetic nervous system (SNS) and 2.) the parasympathetic nervous system (PNS) and these two pathways work together to control HR at any given instant.

1.1.2 PNS

Parasympathetic pathways originate from the medulla oblongata, within either the dorsal motor nucleus, or the nucleus ambiguus. The fibres of the PNS

travel within the right and left vagi (Berne and Levy, 1997; Hockman, 1987). A majority of these fibres terminate at the SA node pacemaker, as well as the atrioventricular (AV) node, while others innervate the atrial and ventricular musculature, as well as coronary vessels (Figure 1) (Guyton and Hall, 1996; Hockman, 1987).

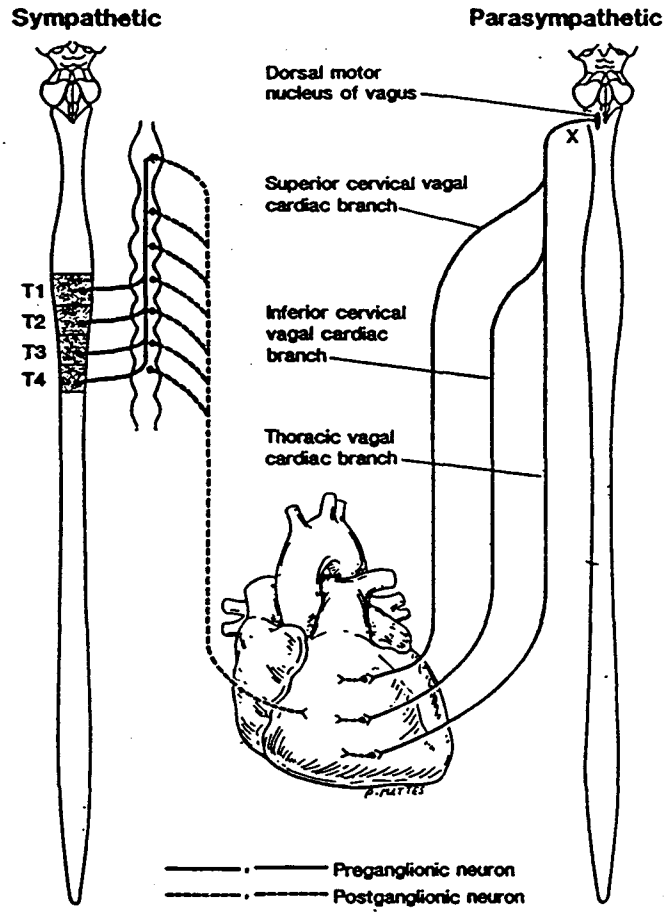


Figure 1: Diagram depicting both divisions of the ANS supply to the heart (from Hockman, 1987).

The neurotransmitter for the PNS is acetylcholine (ACh), which influences HR through cardiac muscarinic receptors (Berne and Levy, 1997; Braunwald, 1997; Guyton and Hall, 1996; Hockman, 1987).

The distribution of the right and left vagi to the heart differs. The right vagus nerve primarily affects the SA node, while the left mainly inhibits AV node conduction. However, efferent vagal fibres overlap, such that left and right vagi may suppress SA and AV function respectively (Berne and Levy, 1997; Hockman, 1987).

The effects of parasympathetic activity on heart function is transient in nature. Parasympathetic stimulation causes HR to decrease and attain steady-state within one or two cardiac cycles. Discontinuation of PNS activation causes HR to return quickly to its resting rate. Specialized potassium channels exist in the SA and AV nodes. These channels are directly linked to muscarinic receptors by a G protein and are quick to open as they do not require a second messenger system (i.e. adenylyl cyclase) to function following ACh release. As a result, hyperpolarization of the SA and AV nodes occurs quickly (Berne and Levy, 1997; Braunwald, 1997; Guyton and Hall, 1996). In addition, the abundance and quick release of ACh from postganglionic nerve endings, as well as the large amount of cholinesterase concentrated in both the SA and AV nodes, allows for the rapid release and hydrolyzation of ACh respectively. Therefore, the above two physiological mechanisms permit the PNS to control

HR on a beat-to-beat basis (Berne and Levy, 1997; Warner and Cox, 1962). In fact, PNS influence on HR dominates over SNS effects (Levy, 1971). This is due to the ability of ACh, released from neighbouring vagal nerves, to inhibit SNS neurotransmitter (norepinephrine; NE) release at the presynaptic level, thus suppressing SNS influence on HR (Berne and Levy, 1997; Levy, 1971; Levy and Zieske, 1969).

1.1.3 SNS

Sympathetic fibres originate in the intermediolateral columns of the upper five or six thoracic and lower one or two cervical segments of the spinal cord (Berne and Levy, 1997). The SNS fibres terminate on the SA node, conduction system of the heart, atria, ventricles, and coronary vessels (Figure 1) (Berne and Levy, 1997; Guyton and Hall, 1996; Hockman, 1987). The neurotransmitter for the SNS is NE, and the corresponding cardiac receptors are beta-adrenergic (Berne and Levy, 1997; Braunwald, 1997; Guyton and Hall, 1996; Hockman, 1987).

Similar to the PNS, the left and right sympathetic fibres are distributed to the heart differently. Fibres on the left are thought to be distributed to the left and right ventricles, having a pronounced effect on myocardial contractility, while fibres on the right side are distributed predominantly to the SA node and atria having a significant effect on HR (Berne and Levy, 1997; Hockman, 1987).

The time course for sympathetic stimulation is slow compared to the transient influence of the PNS. An increase in HR in response to sympathetic activation, and the attainment of steady-state occurs much more slowly (Berne and Levy, 1997; Warner and Cox, 1962). The two factors responsible for the gradual onset of SNS HR response are: 1.) the dependency of the SNS on the accumulation of the intracellular second messenger cyclic adenosine monophosphate (cAMP), and 2.) the less abundant and slow release of NE compared to ACh from postganglionic nerve endings, even during intense SNS activity (Berne and Levy, 1997; Guyton and Hall, 1996).

1.1.4 Control by Higher Centres

Dramatic alterations in cardiac rate, rhythm and contractility have been observed in response to experimental stimulation of various areas in the brain. Cardiac regulation centres have been found to be located in the various lobes of the cerebral cortex, as well as the thalamus and hypothalamus. Cardiac reactions to excitement, anxiety and other emotional states, stem from the cortical and diencephalic centres, while effects of temperature have been found to be elicited by the hypothalamic centres. In addition, a majority of the sympathetic fibres have been found to descend the brainstem ipsilaterally (Berne and Levy, 1997).

1.1.5 Cardiac Reflexes

The ANS functions both as a positive feedforward (central command) and negative feedback (reflexes from peripheral receptors) control system. Both central command and various reflexes interact to influence ANS function (Berne and Levy, 1997). For example, changes in blood pressure (BP) can elicit changes in HR through pressure, or stretch receptors, located in the carotid sinuses and aortic arch. These receptors are specifically known as baroreceptors (Berne and Levy, 1997). Increases and decreases in BP cause reciprocal changes in HR (Cornish et al., 1989). Baroreflex activity is often assessed by a standard injection of phenylephrine, a drug which increases BP (Vann Jones and Bannister, 1988; Sleight, 1979). To decrease HR, in response to an increase in BP, the baroreflex increases PNS activity, while simultaneously decreasing SNS activity (Kollai and Koizumi, 1989). The neural pathways which are traveled begin at the level of the baroreceptors. These bodies sense a change in BP and in turn send afferent impulses to the cardiovascular control centre located in the medulla, increasing PNS activity and inhibiting SNS activity. Parasympathetic efferent impulses are then sent down the right vagi to the SA node decreasing HR.

Heart rate can also be influenced by respiration. This is called respiratory sinus arrhythmia (RSA). The influence of respiration causes an increase in HR during inspiration and a subsequent decrease during expiration. It has been

observed that efferent SNS activity occurs synchronously with phrenic nerve discharge, initiating inspiratory diaphragmatic contraction. In contrast, vagus nerve activity occurred during expiration (Kollai and Koizumi, 1979).

Other reflexes which may indirectly affect HR include the Bainbridge reflex, as well as chemoreceptor and ventricular receptor mediated reflexes. The Bainbridge reflex causes an increase in HR during inspiration. Upon inspiration, a decrease in intrathoracic pressure causes an accelerated venous return and a subsequent increase in atrial pressure and stimulation of the atrial receptors located in venoatrial junctions. As a result HR increases, while upon expiration HR decreases as the atria are unloaded and pressure returns to normal (Berne and Levy, 1997).

In summary, HR is controlled by ANS modulation. Sympathetic activity increases HR, while parasympathetic function decreases it. These two branches of the ANS work together, under *"accentuated antagonism"*, to control HR (Levy, 1971). Several cardiac reflexes including baroreceptor reflexes and respiratory cardiac arrhythmia, may also possibly play a role in HR modulation.

1.2 Heart Rate Variability

1.2.1 Background

In the eighteenth century, Stephen Hales was the first to recognize beat-to-beat changes in both HR and BP, as a result of changing respiratory inputs (Akselrod et al., 1981). The clinical importance of beat-to-beat variation of HR,

referred to as *"normal sinus arrhythmia"*, as an indicator of cardiovascular function, was first demonstrated in a study by Hon and Lee (1963). While monitoring fetal HR during childbirth, these investigators found that in all instances of fetal death, sustained, very regular tachycardia was evident 30-40 minutes preceding the event (Hon and Lee, 1963). This finding led to additional investigations on HR fluctuations, as well as novel findings on beat-to-beat fluctuations of arterial BP, stroke volume, and electrocardiograph (ECG) signal morphology (Blader and Hughson, 1996; Malik and Camm, 1993; Saul, 1990; Akselrod et al., 1985).

Today, heart rate variability (HRV) has been used as a noninvasive tool for the recording of sympathovagal balance and ANS modulation of the cardiovascular system (Kamath and Fallen, 1993; Malliani et al., 1991). The theoretical basis for such a measure to represent internal cardiovascular function, originates from the idea that *'homeostasis'* (a process by which system variables are maintained within a relatively narrow range by system control elements) governs all physiological systems. By quantifying spontaneous fluctuations of HR, HRV has the ability to reflect continuous sympathetic and parasympathetic modulation on the SA node (Saul, 1990).

Heart rate variability has been used to assess the effects of orthostatic stress (Saul et al., 1991; Fallen et al., 1988; Pagani et al., 1986; Pomeranz et al., 1985), lower body negative pressure (Blader et al., 1995; Butler et al., 1994),

controlled respiration (Brown et al., 1993; Hirsch and Bishop, 1981; Angelone and Coulter, 1964), pharmacological blockade (van Ravenswaaij-Arts et al., 1993; Binkley et al., 1991; Saul et al., 1991; Rimoldi et al., 1990; Pagani et al., 1986; Pomeranz et al., 1985; Akselrod et al., 1985 & 1981), as well as vagal nerve stimulation (Kamath et al., 1992) and stellectomy (Pagani et al., 1986) on sympathovagal balance. As well, the effects of age (Ryan et al., 1994; Kamath and Fallen, 1993; Ziegler et al., 1992; O'Brien et al., 1986), gender (Ryan et al., 1994; Kamath and Fallen, 1993) and physical activity (Furlan et al., 1993; Adamopoulos et al., 1992; Dixon et al., 1992) on HRV, and the clinical role of HRV in diseased states such as diabetic autonomic neuropathy (van Ravenswaaij-Arts et al., 1993; Bellavere et al., 1992; Ewing et al., 1991), coronary artery disease (CAD) (Airaksinen et al., 1994a; Bigger et al., 1991; Hayano et al., 1990), congestive heart failure (CHF) (Casolo et al., 1995; Sleight et al., 1995; Szabó et al., 1995; Coumel et al., 1991), post-myocardial infarction (MI) (Lombardi et al., 1996a & b and 1987; Huang et al., 1995; Hermosillo et al., 1993) and in transplant patients (Hughson et al., 1995; Kamath and Fallen, 1993) has been assessed.

Heart rate variability measures can be defined as the oscillation in the interval between consecutive heart beats, as well as the oscillations between consecutive instantaneous heart rates (Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology,

1996). With technological advancement, many commercial computerized devices automatically compute HRV parameters, making it a relatively simple procedure to incorporate into clinical research and practice.

Over the years, much clinical research has looked at HRV in patients with heart disease. Despite a large number of studies completed to date, a number of unanswered questions in the literature still exist. The clinical significance of HRV stems from its ability to predict mortality in post-MI patients. The lower a patients HRV, the higher the risk of mortality (Bigger et al., 1992a; Farrell et al., 1991; Kleiger et al., 1987). However, the incorporation of HRV as a prognostic tool in the clinical setting depends on its reproducibility. Studies have failed to agree on whether such a measure of ANS function is reproducible in patients with heart disease (Nolan et al., 1996; Kautzner et al., 1995; Bigger et al., 1992b). Although circadian rhythm is well defined in normals (Huikuri et al., 1990; Mølgaard et al., 1991), studies on patients with heart disease reveal conflicting results (Huikuri et al., 1994; Lombardi et al., 1992; Casolo et al., 1991). The effects of left ventricular function (LVF) on HRV measures has also sparked some debate as to whether increasing severity of dysfunction decreases HRV (Casolo et al., 1995; Nolan et al., 1992; Saul et al., 1988). In addition, HRV in CAD patients participating in beta-blocker therapy has failed to agree on whether this drug increases or decreases HRV (Burger et al., 1996; Niemelä et al., 1994; Cook et al., 1991). Finally, despite numerous studies focusing on HRV

during physical stressors, none have observed the effects of a psychologically and emotionally stressful real life event on HRV in patients with heart disease.

It is apparent that there are many unanswered questions in the literature regarding HRV in patients with varying degrees of heart disease. These include information about HRV reproducibility and circadian variability, the effects of a psychologically and emotionally stressful real life event and the influences of LVF, beta-blocker therapy and MI status.

1.2.2 Frequency Domain Analysis of HRV

Sympathovagal balance is tonically and phasically modulated by three major factors: 1.) central neural integration; 2.) peripheral inhibitory reflex mechanisms (negative feedback) and 3.) peripheral excitatory reflex mechanisms (positive feedback) (Cerutti et al., 1995; Malliani et al., 1991; Saul, 1990). In order to determine ANS modulation, a method which has the ability to quantify the state of the ANS in both physiological and pathological conditions is required (Malik, 1995; Malik and Camm, 1993; Kamath and Fallen, 1993). Measures of beat-to-beat changes in HR, in response to both stationary conditions and a variety of external stimuli, may provide an objective, noninvasive view of the role of the autonomic system in regulating cardiac function (Cerutti et al., 1995; Kamath and Fallen, 1993). Frequency domain measures, derived from a mathematically based methodology known as power spectral analysis, involves the decomposition of HR or RR-interval tachograms

into sine waves of varying amplitudes and frequencies. The summation of these sine waves produces several individual power spectral peaks, demonstrating how power (variance) is distributed as a function of frequency (Task Force, 1996; Parati et al., 1996; Pieper and Hammill, 1995; Kamath and Fallen, 1993). There are two power spectral analysis models to choose from, either fast Fourier transform (FFT) or autoregressive (AR) modeling analysis (Task Force, 1996; Cerutti et al., 1995; Pieper and Hammill, 1995; Öri et al., 1992). Through the use of these models, individual power spectral plots consisting of 2.2-minute recording intervals are computed, reflecting the amplitude of the sine waves squared as a function of frequency (Kamath and Fallen, 1993).

Several important technical requirements, assumptions and recommendations must be followed in order to obtain reproducible and reliable power spectral measures in the frequency domain. Traditional spectral analysis requires that the signal be statistically stationary (in other words, the probability function of the signal over time must remain constant). Therefore, during dynamic conditions, power spectral analysis, in the frequency domain, must rely on relatively short recording periods of 2-6 minutes (Task Force, 1996; Kamath and Fallen, 1993). Additional requirements focus on the ideas that the signal must be sufficiently long, sampled at an adequate rate, and random in nature (referring to the inability of a mathematical formula to define HR pattern) (Task Force, 1996; Cerutti et al., 1995; Kamath and Fallen, 1993; Öri et al., 1992). As

for the raw ECG signal, the choice of a QRS fiducial point is critical (as it must be stable and noise independent). As well, the elimination of ectopic beats and artifacts must be done using a proper interpolation technique, as to avoid an excessive number of compensatory delays characteristic of ectopic beats that may contaminate the power spectrum (Task Force, 1996; Parati et al., 1995; Kamath and Fallen, 1995 & 1993; Öri et al., 1992).

Power spectral analysis of beat-to-beat fluctuations in HR have been shown to yield three prominent spectral components ranging in frequency between 0-0.40 Hz (Barron and Lesh, 1996; Fetsch et al., 1996; Parati et al., 1995; Coumel and Leenhardt, 1991). In a pioneering study by Chess and others (1979), three spectral components were revealed in decerebrated cats and labeled as P_1 (1.5-2.5 cycles/minute), P_2 (6-10 cycles/minute) and P_3 (respiratory frequency). In a later study by Akselrod et al. (1981), these same three spectral peaks were observed. However, these investigators labeled them as very low frequency (VLF; 0.04 Hz), low frequency (LF; 0.12 Hz) and high frequency (HF; 0.38 Hz) respectively. Blocking muscarinic receptors with glycopyrrolate in conscious dogs resulted in a decrease in both LF and HF peak areas, while combined SNS beta-adrenergic blockade and PNS muscarinic blockade resulted in a metronome-like heart beat at respiratory frequency. Simultaneous manipulation of arterial pressure, increasing pressure under SNS blockade and decreasing it under PNS blockade, caused LF peak area to increase under both

conditions. From these observations, the researchers concluded that HF peak was the result of both vagal modulation and respiratory sinus arrhythmia; while LF peak reflected baroreflex control of both SNS and PNS modulation, and VLF was believed to be influenced by the renin-angiotensin-aldosterone system, as well as thermoregulatory control mechanisms as suggested in an earlier study by Sayers and colleagues (Akselrod et al., 1985 & 1981; Sayers et al., 1973).

A number of more recent studies support the above findings. For example, a subsequent study by Pomeranz et al. (1985) found that by blocking PNS activity with atropine in healthy male volunteers, HF and LF peak areas decreased. The effects of orthostatic stress (supine to standing erect) have been found to result in an increase in LF peak power and a reciprocal decrease in HF peak power, as well as a leftward shift in LF central frequency (cf) (Fallen et al., 1988; Pagani et al., 1986). By combining orthostatic stress with atropine administration, a 'pure' sympathetic autonomic state revealed a marked reduction in frequencies greater than 0.1 Hz (LF peak frequency), whereas a 'pure' vagal state, achieved through the combination of supine position and propranolol, resulted in a higher magnitude of all frequencies (Saul et al., 1991).

Invasive studies, such as the implantation of a vagal nerve stimulator, demonstrated an increase in HF peak power and a decrease in LF:HF peak and area ratios during chronic stimulation. However, following the elimination of vagal stimulation, LF peak power, as well as both LF:HF peak and area ratios

increased, along with a LFcf shift reflecting SNS predominance (Kamath et al., 1992). Bilateral stellectomy was observed to inhibit SNS modulation, as LF power failed to increase following nitroglycerin infusion (Rimoldi et al., 1990).

The findings of the above studies tend to suggest to researchers that frequency domain spectral components reflect not only autonomic modulation of HR, but PNS and SNS *"tone"* (or level of activity) under various conditions. However, this is not absolutely correct. Efferent vagal impulses of cardiac parasympathetic activity are very short and discrete, and are in fact much faster than that of the power spectra HF peak (Task Force, 1996; Kamath and Fallen, 1993; Malik and Camm, 1993). In addition, the areas under the power spectra peaks have not been found to directly correlate with synaptic neurotransmitter concentrations for either of the ANS branches. Therefore, frequency domain measures, derived from power spectral analysis, are not direct measures of neuronal traffic. High frequency power reflects vagal modulation in response to physiological inputs (i.e. respiration), causing short-term fluctuations in HR and not vagal *'tone'* per se. The measure of LF:HF has been recently thought to be an adequate marker for sympathovagal balance, as opposed to each individual frequency component representing a branch(s) of the ANS (Malliani et al., 1994; Malik and Camm, 1993). In addition, the non-harmonic VLF component is rarely included in power spectral analysis. In order to achieve an adequate signal-to-noise ratio, the VLF band (DC-0.03 Hz) must be filtered by algorithms for

baseline or trend removal of the DC band frequency power. As a result, potentially influential physiological rhythms within the VLF band are not taken into account. Different techniques and methodologies must be applied for an understanding and quantification of the underlying physiological mechanisms existing within the VLF band (Task Force, 1996; Cerutti et al., 1995; Kamath and Fallen, 1993).

By providing us with a noninvasive look at ANS function, frequency domain power spectral measures allow cardiologists to determine the risk of mortality in post-MI patients (Singh et al., 1996; Vaishnav et al., 1994; Bigger et al., 1993a & b). As well, these measures can distinguish patients prone to cardiac arrest among a group of patients with heart disease (Myers et al., 1986), and post-MI patients from normals (Voss et al., 1996). Further benefits include the assessment of various pharmacological therapies in patients with heart disease (Burger et al., 1996; Brouwer et al., 1995; Cowan et al., 1993; Cook et al., 1991), age (Ryan et al., 1994; Ziegler et al., 1992; Pagani et al., 1986) and the influence of gender (Ryan et al., 1994) on sympathovagal balance, specifically LF:HF area ratio.

1.2.3 Time Domain Analysis of HRV

Time domain analysis is another method of HRV measurement. It may be assessed from both short-term (5-30 minutes), controlled recordings, and long-term, 24-hour ambulatory Holter monitoring (Task Force, 1996; Kleiger et

al., 1995). Time domain indices are derived from continuous ECG recordings, where each QRS complex is detected and the sinus conducted normal-to-normal (NN) intervals (in other words, all intervals between successive QRS complexes originating from sinus node depolarization), or instantaneous HR is determined (Task Force, 1996; Kleiger et al., 1995). Artifact and ectopic beats causing non-normal intervals are excluded from analysis, minimizing erroneous calculations of time domain indices (Kleiger et al., 1995). By correcting ectopic, often premature beats, the shortened beat-to-beat interval followed by a compensatory delay that is longer than normal interval length is eliminated, reducing the likelihood of signal contamination (Kamath and Fallen, 1995).

There are two classes of time domain measures: 1.) those directly derived from inter-beat intervals such as mean HR (RR-interval), SDNN, SDANN, and SDNN-index, and 2.) those derived from differences between the lengths of adjacent cycles, such as r-MSSD and pNN50 (Kleiger et al., 1995; Stein et al., 1994; van Ravenswaaij-Arts et al., 1993). The measures derived from cycle intervals are broad-based, suggesting that they are influenced by both short-term (i.e. respiration) and long-term (i.e. circadian and secular trends) factors. In contrast, differences between adjacent intervals represent short-term measures of HRV, mainly vagal activity and are independent of diurnal or secular trends (Kleiger et al., 1995 & 1992; Stein et al., 1994; van Ravenswaaij-Arts et al., 1993). For descriptive definitions of time domain indices, refer to Table 1.

Table 1: Time Domain Index Definitions

Time Domain Indices	Definitions
SDNN (ms)	Standard deviation (SD) of all normal RR-intervals for an entire 24-hour ECG recording
SDANN (ms)	Standard deviation of the mean of all 5-minute segments of normal RR-intervals for a 24-hour ECG recording
SDNN-index (ms)	Mean of the SD's of normal RR-intervals for all 5-minute segments over a 24-hour recording
pNN50 (%)	Percent of differences between adjacent normal RR-intervals that are greater than 50 ms computed over 24-hours.
r-MSSD (ms)	Root mean square successive differences, the square root of the mean of the sum of the squares of differences between adjacent normal RR-intervals over an entire 24-hour period

Additional measures, such as a 24-hour plot of mean hourly circadian HR and SD, as well as a 24-hour frequency distribution histogram of normal RR-intervals, provides researchers with important information (Task Force, 1996). From these measures, circadian rhythm and the effects of ambulation and normal daily activities on HR and HRV can be evaluated

Correlations between several time domain and frequency domain indices have been reported in normals. Kleiger and colleagues (1991) found HF power to correlate significantly with r-MSSD (r=0.98) and pNN50 (r=0.92). Likewise, r-MSSD and pNN50 were closely related (r=0.96), suggesting that these two time domain indices represent short-term vagal modulation (Kleiger et al., 1991). Similar investigations in heart diseased patients also support these findings (Reinhardt et al., 1996; Bigger et al., 1992a & 1989; Dougherty and Burr, 1992).

In addition, LF power has also been found to correlate with r-MSSD (r=0.91), pNN50 (r=0.81) and SDNN (0.85), reflecting the dependency of LF power on both vagal and sympathetic modulation (Kleiger et al., 1991). As expected, SDNN has been found to correlate with total area (Kleiger et al., 1995), but not HF power (Adamopoulos et al., 1992; Bigger et al., 1989).

The clinical importance of time domain measures is their ability to predict risk of mortality following a MI (Algra et al., 1993; Dougherty and Burr, 1992; Kleiger et al., 1987) and evaluation of pharmacological intervention (Burger et al., 1996; You-hua et al., 1995; Cowan et al., 1993; Flapan et al., 1992). As well, prognostic significance and clinical usage depends on the reproducibility of such measures. All time domain measures, with the exception of pNN50, have been consistently reported as being reproducible (Kautzner et al., 1995; Van Hoogenhuyze et al., 1991). In an attempt to provide standardized age references for normal healthy individuals, the time domain measures pNN50 and r-MSSD, revealed an inverse relationship with age similar to that reported for power spectral measures (Ziegler et al., 1992; Mølgaard et al., 1991).

Twenty-four hour time domain parameters are simple to calculate, clinically useful and prognostically significant, however these measures have been the subject of criticism. Ambulatory time domain statistics capture data from real life settings (free from laboratory setting biases), circadian variations and overall autonomic function over a given day (American College of

Cardiology/American Heart Association Task Force, 1989). However, ambulatory Holter monitoring does not control or account for a patient's dynamic state. In addition, recordings may have too many ectopic beats and artifacts, not permitting statistical computation. Further, time domain indices do not have the capability to separate ANS signals (SNS and PNS) acting on the SA node. Despite skepticism surrounding the use of 24-hour time domain statistics, clinicians and researchers continue to use 24-hour ambulatory Holter monitoring as a means of obtaining ECG recordings for the evaluation of autonomic function in a variety of pathologies (ACA/AHA Task Force, 1989).

1.2.4 HRV and RSA

In a study done in the 1960's, HR was observed to increase upon inspiration and decrease, or remain constant, upon expiration in healthy humans (Davies and Neilson, 1967). This phenomenon of beat-to-beat variation is known as respiratory sinus arrhythmia (RSA; beats/minute or ms).

In one of the first studies on RSA, changes in both heart period and parasympathetic control were reported to be proportional to changes in RSA (Katona and Jih, 1975). This finding was based on linear relationships found between heart period, cardiac vagal modulation (measured as a change in mean heart period following vagal blockade), and RSA (measured as the average difference between maximum and minimum heart periods over several respiratory cycles (Katona and Jih, 1975). The correlation coefficient between

PNS control and RSA was reported as (mean ± SD) 0.969 ± 0.024, while a correlation of 0.914 ± 0.044 was observed between heart period and RSA (Katona and Jih, 1975).

In a more recent study by Kollai and Mizsei (1990), only a moderate correlation ($r=0.61$; $p<0.001$) was found to exist between PNS control and RSA. In fact, multiple regression analysis revealed PNS control, respiratory cycle length and tidal volume to yield a higher correlation coefficient ($R=0.93$; $p<0.001$).

Pioneers of RSA, Angelone and Coulter (1964), attempted to demonstrate the effects of respiration rate on RSA. These investigators found heart rate fluctuations to be maximal at approximately 5 breaths/minute, decreasing in magnitude above or below this rate (Angelone and Coulter, 1964). Subsequent investigations have disagreed with the above findings, as an increase in RSA up to approximately 7 breaths/minute, at a constant tidal volume, has been reported by a number of researchers (Brown et al., 1993; Eckberg, 1983; Hirsch and Bishop, 1981). Furthermore, increasing tidal volume under controlled respiration, has been found to increase RSA (Brown et al., 1993; Eckberg, 1983; Hirsch and Bishop, 1981).

The above effects of respiration rate and tidal volume on RSA are reflected through spectral analysis of HRV in the frequency domain. Human subjects breathe, on average, 10-20 breaths/minute (Åstrand and Rodahl, 1986),

corresponding to a spectral frequency range of 0.17-0.33 Hz. Vagal nerve stimulation in the supine position appeared to facilitate coupling between respiration frequency and vagal efferent nerve activity, demonstrated by a large increase in HF component amplitude (0.18-0.30 Hz) (Kamath et al., 1992). An increase in respiratory rate between 10-15 breaths/minute, at a given tidal volume, revealed a marked reduction in power spectra respiratory frequency, as well as LF power (Brown et al., 1993; Novak et al., 1993). In contrast, breathing at a rate below 10 breaths/minute has been found to cause an increase in LF power (Brown et al., 1993; Novak et al., 1993). This phenomenon is called entrainment, and occurs when LF power overlaps with the respiratory band into one dominant oscillation. As a result of respiratory frequency impinging upon the LF band (0.1 Hz), it is very difficult to separate respiratory vagal modulation from SNS activity (Malliani et al., 1991). In reference to larger tidal volumes, respiratory spectral power was found to be significantly larger ($p<0.05$) at a tidal volume of 1500 ml, compared to 1000 ml at respiration rates between 5-25 breaths/minute (Brown et al., 1993).

The physiological inputs responsible for RSA include both central and peripheral influences. Respiratory sinus arrhythmia is generated by an interaction between respiratory and cardiac centres located in the medulla, in addition to reflexes originating from pulmonary and right atrium (Bainbridge reflex) stretch receptors and baroreceptors (both the carotid sinuses and aortic

arch) (Berne and Levy, 1997; Saul, 1990). Cardiac vagal nerve activity has been observed to cease firing during inspiration and diaphragmatic contraction, while phrenic nerve and cardiac sympathetic efferent activity is evident (Kollai and Koizumi, 1979; Katona et al., 1970). In contrast, vagal cardiac motoneuron discharges have been observed to occur during expiration (Eckberg et al., 1985; Eckberg, 1983; Kollai and Koizumi, 1979). In addition, increasing tidal volume has been found to stimulate pulmonary mechanoreceptors, causing an elevation in SNS activity through a reflex increase in afferent feedback activity to the respiratory centre located in the medulla (Seals et al., 1990).

Overall, higher frequency HR fluctuations specifically correlate with respiratory modulation of cardiac vagal activity (Saul, 1990; Eckberg, 1983; Kollai and Koizumi, 1979). The effects of respiration on SNS efferent activity at typical breathing frequencies (>0.15 Hz) are negligible, as the rate of response of the SA node to SNS activity is too slow to alter HR (Berne and Levy, 1997; Brown et al., 1993; Saul, 1990; Kollai and Koizumi, 1979). In fact, breathing rate has been suggested to influence RSA significantly more so than tidal volume. A dramatic decrease in HF power observed beyond a breathing rate of 7 breaths/minute for tidal volumes ranging between 500-3000 ml, supports the above statement (Brown et al., 1993; Hirsch and Bishop, 1981). Age has also been found to have a negative effect on the magnitude of RSA (Shannon et al., 1987; Smith and Smith, 1981).

In light of the above influences of respiration on frequency domain indices and increasing usage of power spectral analysis in the clinical setting, it is important to account for respiration and its influences on HRV power spectral measures for correct interpretation. However, under ambulatory conditions (i.e. 24-hour ambulatory Holter monitoring) it is difficult to record respiration rate.

1.3 Reproducibility of HRV Indices

Heart rate variability parameters have been shown to be important in both physiological and clinical investigations (Bigger et al., 1993a & 1992a; Cripps et al., 1991; Kleiger et al., 1987; Lombardi et al., 1987; Martin et al., 1987). The prognostic significance and clinical usage of HRV indices depends on the reproducibility of such measures over time. Under controlled conditions, for example at rest in a supine or standing position, and possibly under controlled respiration, both time and frequency domain measures have been found to be reproducible (Freed et al., 1994; Ziegler et al., 1992).

In addition, several recent studies conducted on normals have shown both 24-hour time domain and power spectral measures to be reproducible (Dekker et al., 1996; Kleiger et al., 1991; Huikuri et al., 1990). Huikuri and colleagues (1990) discovered that SDNN-index had a lower mean intra-individual coefficient of variation for two consecutive days of recording (mean ± SD; 4.2 ± 2.9%), compared to one week apart (7.3 ± 7.4%) (Kautzner, 1995). In another study, intraclass correlation coefficients, calculated from two 24-hour Holter

recordings 3-65 days apart, showed 24-hour average NN-interval, pNN50, r-MSSD and SDNN-index to have coefficients of 0.90. Log-transformed total power, LF power and HF power had intraclass coefficient correlations of 0.89, 0.91, and 0.84 respectively (Kleiger et al., 1991).

Despite the 24-hour reproducibility of HRV measures observed in normals, reproducibility of such measures in patients with heart disease is not firmly established. Several past investigations have reported reproducibility of time domain and power spectral measures over consecutive 24-hour periods in patients with CHF, CAD and/or MI (Kamalesh et al., 1995; Hohnloser et al., 1992; Van Hoogenhuyze et al., 1991). However, these studies consisted of a relatively small number of subjects that varied in age and gender. In addition, these studies also used correlation statistics (Hohnloser et al., 1992; Van Hoogenhuyze et al., 1991) and analysis of variance significant differences ($p<0.05$) (Kamalesh et al., 1995) to determine reproducibility.

In more recent studies, a better measure of reproducibility, termed intraclass correlation coefficient, has been employed. This measure of repeatability evaluates the strength of association between two measurement periods, reflecting intra-subject reproducibility. In other words, the amount of person-to-person variance of a particular parameter is due to the variance of steady state (Kautzner, 1995). Intraclass correlation coefficient of the time domain measure that is physiologically similar to pNN50, and consists of the

number of beat-to-beat increases in RR-interval length > 50 ms, has been reported to be 0.97 in normals and 0.94 in patients with ischemic heart disease, for two 24-hour recording periods 2-6 weeks apart (Nolan et al., 1996). Similarly, post-MI patients have been found to have an intraclass coefficient of 0.85 for HR, while frequency domain intraclass coefficients have been found to range between 0.79-0.96 (Bigger et al., 1992b). In particular, Ln HF power in post-MI patients with sustained ventricular arrhythmia was 0.92 (Bigger et al., 1992b). In contradiction to the above, Kautzner et al. (1995) found that pNN50 was not reproducible. They reported a relative error measure of (mean ± SD) 45 ± 45% for pNN50, while all other time domain measures (SDNN, SDANN, SDNN-index and r-MSSD) had relative errors ranging between 10-20%.

Heart rate variability reproducibility has been reported to be superior compared to other indices predicting mortality in survivors of MI, such as ventricular ectopy and silent ischemia episodes (Kautzner et al., 1995). However, reproducibility of the time domain measure pNN50 is questionable. Thus, further studies are required to resolve this issue. As well, no study has attempted to investigate the reproducibility of frequency domain measures at predetermined time intervals over consecutive 24-hour recording periods. Reproducibility of HRV parameters may differ at different times over a 24-hour day.

1.4 Circadian Variability of HRV Indices

Circadian rhythm may be defined as a time event series with a principal frequency of one cycle occurring every 24-26 hours (Fallen and Kamath, 1995). It has been found that sudden cardiac death occurs more often in the morning, corresponding with the circadian increase in blood catecholamine levels, platelet aggregability, HR, ventricular ectopic activity and myocardial ischemia during the morning hours (Hohnloser and Kingenheben, 1994; Rocco et al., 1987; Tofler et al., 1987).

Circadian rhythm of ambulatory HR and HRV parameters has been reported in normals. Heart rate has been found to significantly decrease at night during sleep hours (42-86 beats/minute) and subsequently increase upon awaking (52-100 beats/minute), remaining elevated throughout the day (Mølgaard et al., 1991; Huikuri et al., 1990). The time domain measure SDNN-index, taken over successive 1-hour segments for a total of 24-hours, has demonstrated greater values during sleep compared to wakefulness (Huikuri et al., 1990). In addition, pNN50 for successive 2-hour segments over a 24-hour period, has been shown to significantly increase at night. However, the normalized time domain measure indicative of PNS modulation, pNN6% (percentage of successive RR-intervals that differ > 6%), failed to show a similar night increase in normals (Mølgaard et al., 1991).

The day-night difference for the frequency domain parameter, LF:HF power ratio, has been found to increase significantly ($p<0.05$) from (mean ± SEM) 1.6 ± 0.2 during sleep hours to 4.6 ± 1.2 during awake hours (Furlan et al., 1990). As well, Di Rienzo et al. (1989) reported HF power to increase significantly at night. However, the reciprocal night decrease in LF power observed by the aforementioned study (Furlan et al., 1990) was not observed by this group of investigators. Di Rienzo and colleagues (1989) concluded that the failure of LF power to decrease at night was caused by the observed increase in vagal activity, thus counteracting the effect of diminished SNS activity known to occur at night on LF power.

Similar to normals, patients with CAD, CHF and/or post-MI have been reported to exhibit an identical, yet attenuated circadian HR and HRV pattern (Lombardi et al., 1992; Kamath and Fallen, 1991; Casolo et al., 1989; Bigger et al., 1988). A blunted decrease in HR from day to night hours has been observed in CAD and/or post-MI patients (Lombardi et al., 1992; Casolo et al., 1989; Bigger et al., 1988). In comparison to normals, normalized (corrected for HR) HF power and LF:HF power ratio have specifically demonstrated a blunted, yet comparable circadian pattern in patients with heart disease (Lombardi et al., 1992). In a study by Lombardi et al. (1992), 24-hour Holter data was collected in both normals and post-MI patients. These investigators found that normalized HF power in healthy controls significantly increased ($p<0.05$) from 1200-1800

hours (mean ± SEM; 17.5 ± 1.3 nu) and 1800-2400 hours (19.9 ± 1.1 nu) to 0-0600 hours (31.7 ± 2.3 nu), and decreased from 0-0600 hours to 0600-1200 hours (18.4 ± 1.1 nu). In contrast, only a significant increase ($p<0.05$) in HF power was observed between 1200-1800 hours (14.2 ± 1.5 nu) and 0-0600 hours (22.7 ± 2.1 nu) in post-MI patients. As well, the rate of change of LF:HF power ratio during early morning hours (5-9 am) was compared between groups. As predicted, Lombardi and colleagues (1992) found that the rate of LF:HF ratio change was significantly greater in control subjects (first order derivative; 3.34 ± 0.83) than in patients (0.96 ± 0.66; $p<0.05$). Similarly, in a more recent study by Huikuri et al. (1994), significant day-night differences for both absolute and normalized HF power and LF power, and LF:HF ratio were found in normals, but not in CAD patients.

Circadian variability of HRV has also been compared among post-MI patients with varying disease severity. In agreement with the above, the circadian rhythm in healthier post-MI patients reflects that of normals more so than post-MI patients with complications (Malik et al., 1990).

Although the majority of studies suggest a blunted circadian rhythm of HRV measures in heart disease patients, some studies suggests a total lack of circadian fluctuation in both time and frequency domain parameters (Casolo et al., 1991 & 1989). Nevertheless, all findings regarding circadian rhythm of HRV suggest an altered diurnal and nocturnal fluctuation of both vagal and

sympathetic activity in patients with heart disease. Specifically, a consistently large LF:HF power ratio and LF power elevation over 24-hours, accompanied by a blunted circadian HF power, LF power and LF:HF ratio variability, suggests SNS modulation predominance in post-MI patients and/or those with CAD and CHF (Lombardi et al., 1992; Casolo et al., 1991; Bigger et al., 1988).

The importance of the physiological implications of the above studies must be viewed in light of study limitations. These limitations include sample size (Casolo et al., 1989), failure to examine a broad range of low-to-high risk patients (Malik et al., 1990; Casolo et al., 1989), as well as control for several inherent factors which are known to alter HRV, such as age, gender, physical activity level and smoking habits (Mølgaard et al., 1991).

1.5 The Effects of CAD on HRV Indices

1.5.1 HRV in Patients with CAD

One of the first studies to determine the degree of sympathetic modulation elicited by coronary occlusion, was done by Malliani et al. (1969). Simultaneous recording of SNS preganglionic fibres in cats (isolated from the left third thoracic ramus communicans, T_3), while artificially occluding the coronary left anterior descending, circumflex or left main artery, revealed an increase in preganglionic sympathetic neuron discharge.

Studies assessing HRV measures in patients with CAD and/or CHF, have also suggested SNS predominance. Enhanced sympathetic activity has been

reflected through diminished RSA (Airaksinen et al., 1987), depressed HF power (>0.1 Hz) and elevated LF:HF area ratio (Binkley et al., 1991), as well as lower than normal SDNN and SDANN values (Casolo et al., 1995).

The knowledge that CAD diminishes HRV led researchers to focus on how HRV measures reflect disease severity. In two successive studies, Hayano et al. (1991 & 1990) found that angiographic severity, defined as the number of major coronary vessels (including right coronary artery, circumflex branch, left anterior descending and left main coronary artery) demonstrating 50% or more intra-luminal narrowing, was negatively related to RSA. Additional studies on patients with CHF, secondary to CAD, have also reported inverse relationships between SDNN, SDANN, LF area, and HF area and New York Heart Association (NYHA) functional class (Casolo et al., 1995; Szabó et al., 1995). However, LF:HF area ratio failed to change with functional severity (Casolo et al., 1995). These studies suggest a progressive decrease in neural activity to the heart with increasing disease severity, affecting both branches of the ANS without prevalence of one component over the other (Casolo et al., 1995).

On the contrary, several studies have failed to observe a significant relationship between extent of CAD and HRV (Huikuri et al., 1994; Nolan et al., 1994; Rich et al., 1988). As well, no relationship between stenosis location and time domain indices, as well as frequency domain measures has been reported (Airaksinen et al., 1996, 1994a, 1993, 1991 & 1990). Angiographically

determined stenosis location and degree of RSA modulation failed to reveal a significant relationship, even when stenosis was located proximal to the origin of or within the SA node or AV node artery (Hayano et al., 1991 & 1990). In two investigations conducted by Airaksinen and others (1994a & 1993), patients referred for coronary angioplasty underwent artificial coronary occlusion for a short time period. Changes in HF and r-MSSD measures were observed. However, these changes could not be predicted by site of occlusion. In fact, balloon occlusion of the left anterior descending artery resulted in an abnormal increase in HRV indices reflective of vagal modulation, as opposed to the expected increase in SNS activity (Airaksinen et al., 1994a & 1993).

In general, HRV in patients with CAD has been shown to be diminished. Findings suggest an overall decrease in neural activity to the heart (Casolo et al., 1995), and in some cases elevated SNS modulation (Binkley et al., 1991). The relationship reported between disease severity and HRV indices is equivocal. In addition, location of coronary occlusion has failed to demonstrate a relationship with HRV indices in patients with CAD.

1.5.2 HRV in Post-MI Patients

A number of HRV studies on post-MI patients have shown sympathovagal balance to differ from healthy individuals. The majority of studies have found post-MI patients to have a lower SDNN (Casolo et al., 1989), SDANN and SDNN-index (Van Hoogenhuyze et al., 1991), along with a smaller HF

power, and a larger LF power and LF:HF power ratio (Lombardi et al., 1992; Casolo et al., 1991; Pagani et al., 1991). In fact, SDNN has been found to be less in post-MI patients compared to normals and patients with unstable angina (Casolo et al., 1992). As well, frequency domain indices have been found to be significantly higher ($p<0.001$) in post-MI patients with infarct-related artery patency, as opposed to those with blockage (Hermosillo et al., 1993). Similarly, post-MI patients with high HRV (SDNN $\geq$ 100 ms) had a larger pNN50 and r-MSSD compared to those with low HRV (SDNN < 50 ms) (Bigger et al., 1988). However, in a study by Huang et al. (1995), SDNN, SDANN, SDNN-index, r-MSSD and pNN50, as well as both LF (0.04-0.15 Hz) and HF power (>0.15 Hz), were found to be reduced similarly in both patients with unstable angina and those with MI's compared to healthy controls. Unlike previous studies (Casolo et al., 1991; Pagani et al., 1991), this study failed to show a significant increase in LF:HF area ratio in patients with heart disease compared to controls (Huang et al., 1995).

The time course for recovery of HRV was first reported by Lombardi and colleagues (1987). In patients two weeks post-MI, compared to 26 age-matched controls, resting LF power (mean ± SEM; 69 ± 2 versus 53 ± 3 nu) and LF:HF area ratio (8 ± 1.1 versus 2 ± 0.3) were significantly greater ($p<0.05$), while HF power was significantly smaller (17 ± 1 versus 35 ± 3 nu; $p<0.05$). At six and twelve months, a progressive decrease in the LF area (62 ± 2 and 54 ± 3 nu) and

LF:HF ratio (4 ± 0.6 and 3 ± 0.7), and an increase in HF area (23 ± 2 and 30 ± 2 nu) was observed. Also, by measuring autonomic response to tilt, these investigators concluded that by twelve months post-MI, sympathovagal balance had recovered during resting conditions and in response to sympathetic stimulation such as tilt (Lombardi et al., 1987). Other studies have suggested that recovery of SDANN, as well as its circadian rhythm, occur as early as three weeks (Kümmell et al., 1993), while power spectral measures have been found to recover within three months (Bigger et al., 1991). It should be noted that HRV indices never return completely to normal values (Lombardi et al., 1987; Bigger et al., 1991).

It is well known that MI alters ANS function. However, MI location has been suggested to have differing effects on ANS function. In a study by Webb et al. in 1972, patients with posterior MI's were found to have PNS overreactivity; defined as sinus bradycardia (HR < 60 beats/minute), atrioventricular block (second degree or complete), or transient hypotension (systolic BP ≤ 100 mmHg) in the absence of bradycardia, within 30-minutes of the onset of MI. As well, degree of SNS activity (measured by epinephrine and norepinephrine blood concentrations) has been found to relate to the extent and location of myocardial damage (Karlsberg et al., 1981).

Studies using the noninvasive tool of HRV to gain insight into ANS function, have also found HRV indices to be related to MI size and location. In a

study by Casolo et al. (1992), SDNN was found to inversely relate to degree of infarct size measured by CK-MB concentration. Additional studies have shown patients with one week old anterior wall MI's to have lower pNN50, SDANN, and HF power (Lombardi et al., 1996a; Singh et al., 1996), and higher LF power values compared to those patients with inferior wall MI's (Lombardi et al., 1996a). In agreement, patients with inferior wall infarctions generated a greater number of RR-intervals exceeding the preceding RR-interval by > 50 ms, or 6.25% of the previous RR-interval (Flapan et al., 1993). The above research data suggest that patients with inferior MI's have enhanced PNS modulation, while those with anterior wall MI's have enhanced SNS activity, compared to one another. However, some studies dispute the finding that LF power is higher in patients with an anterior MI compared to those with an inferior infarction (Singh et al., 1996; Valkama et al., 1994). These studies would argue that all power spectral measures are significantly reduced more in patients with anterior wall infarctions. In fact, some research investigations have altogether failed to find significant differences in various HRV indices for MI location (Vaishnav et al., 1994; Farrell et al., 1991; Hayano et al., 1991).

A number of physiological theories have been developed in an attempt to explain the observed sympathovagal imbalance towards SNS predominance in post-MI patients. The central nervous system receives tonic sensory input from both vagal and sympathetic afferent fibres originating from the heart's atria and

ventricles. Myocardial infarction may cause derangements in neural activity of cardiac origin, altering ANS function (Schwartz et al., 1988). Direct recordings of afferent fibres originating from the heart's atria and ventricles, as well as efferent SNS fibre activity in animals, demonstrated an increase in sympathetic reflex activity in response to experimentally induced myocardial ischemia (Malliani et al., 1973; Brown and Malliani, 1971). Conversely, PNS activity has been found to be reduced (Higgins et al., 1972; Cerati and Schwartz, 1991). Due to geometrical alterations resulting from a MI, cardiac mechanoreceptors are subjected to abnormal stretch, increasing cardiac sympathetic afferent activity which in turn exerts a tonic restraint on vagal outflow (Cerati and Schwartz, 1991).

Necrotic regions in the myocardium have also been found to interrupt SNS efferent fibres (Stanton et al., 1989), as well as sympathetic and vagal afferent fibres passing through the infarct zone (Barber et al., 1985), resulting in denervation of the viable, non-infarcted myocardial region apical to the infarcted area. This may in turn cause the apical site to be supersensitive to catecholamine levels (Inoue and Zipes, 1987).

In summary, changes in the geometry of the beating heart in response to the formation of necrotic and non-contracting myocardial segment(s), results in an increase in SNS afferent fibre activity due to the mechanical distortion and alteration of SNS cardiac receptors. An increase in SNS afferent reflex activity

interferes with vagal modulation, reducing its influence on the SA node (Schwartz et al., 1992). As well, a reduction in ACh cardiac neuronal stores may contribute to the reduced PNS modulation reported in post-MI patients (Eckberg et al., 1971). The SA node itself may also be less responsive to neural modulation as a result of geometric alteration of the heart (Malliani et al., 1994; Eckberg et al., 1971).

Central factors influencing HRV may also be altered following a MI (Kienzle et al., 1992). For example, an increase in muscle sympathetic nerve activity, measured from direct microneurographic recordings of the peroneal nerve, has been observed in moderate-to-severe heart failure patients with infarctions (Leimbach et al., 1986). In addition, a reduction in cardiac acceleration has been reported in patients with heart disease following adrenergic and subsequent pharmacologic blockade of the PNS, suggesting a diminished outflow of parasympathetic nerve activity from the central nervous system (Eckberg et al., 1971). These findings provide direct evidence of enhanced central SNS neural outflow along with diminished PNS modulation.

Myocardial infarction induces changes in ANS status through both central and peripheral mechanisms. An increase in sympathetic modulation has been suggested to result from a MI. However, conflicting results regarding the frequency domain measure LF:HF area ratio, a measure of sympathovagal balance, have failed to answer whether post-MI patients are subject to SNS

predominance. Sympathovagal balance has been observed to recover by one year post-MI in patients with elevated LF:HF area ratios, however never quite returning to normal values. As well, size and location of MI and its effects on HRV indices is a new topic for investigation.

1.5.3 The Effects of Left Ventricular Function on HRV

Over the years, a number of studies have focused on the effects of left ventricular function (LVF) on HRV indices. In a earlier study by Jose (1966), LVF in patients with heart disease was determined by increasing ventricular load (via raising arterial pressure), during simultaneous vagal and sympathetic blockade. The subsequent changes in stroke volume, stroke work, and end-diastolic pressure, provided an appropriate marker for altered contractile response in the presence of myocardial disease. This measure of contractile function in a group of patients with heart disease was found to correlate significantly with intrinsic heart rate (IHR; HR after isolation from both sympathetic and parasympathetic influence), suggesting that depression of contractile function was accompanied by depressed intrinsic rhythmicity (Jose, 1966). As well, Jose (1966) found that the observed change in HR from before, to 5-minutes after the injection of atropine and propranolol, was increasingly depressed according to severity of LVF.

In more recent studies, HRV measures have been reported to correlate with LVF. Several investigations have reported weak correlations, while others

have reported moderate to strong correlations in patients with heart disease (Singh et al., 1996; Casolo et al., 1995; Odemuyiwa et al., 1994; Kleiger et al., 1987). For example, Saul et al. (1988) found that absolute power within the 0.04-0.07 Hz power spectral band was directly related to cardiac index ($r=0.47$; $p<0.05$), and inversely with pulmonary capillary wedge pressure ($r=-0.55$; $p<0.01$). In two recent studies using left ventricular ejection fraction (LVEF) as a measure of LVF, Nolan and colleagues (1992) observed a significant linear correlation ($r=0.49$; $p<0.05$) between LVEF and the number of times each RR-interval exceeded the preceding RR-interval by > 50 ms, while Lombardi et al. (1996b) reported RR-variance to weakly, yet significantly correlate with LVEF ($r=0.40$; $p<0.01$). As well, upon dividing the post-MI subject group up into those with normal LVEF (≥40%) and those with reduced LVEF (<40%), Lombardi and colleagues (1996b) found that those patients with reduced LVEF had a non-significant increase in HR and a significant ($p<0.05$) decrease in spectral components including normalized LF power and LF:HF area ratio. However, normalized HF power was observed to be significantly higher in reduced LVEF post-MI patients. Circadian pattern was also attenuated in these patients compared to those with normal LVEF.

Strong correlations between LVF, HR and HRV indices have been reported by Casolo et al. (1995). In subjects with CAD, LVEF was found to significantly relate to HR with an r value ranging from 0.55 ($p<0.001$) during the

day and 0.65 ($p<0.001$) at night. Left ventricular ejection fraction was also found to be directly related to SDNN ($r=0.77$; $p<0.0001$) and SDANN ($r=0.80$; $p<0.0001$), while a logarithmic relationship was found between LF power ($r=0.79$; $p<0.001$), as well as HF power ($r=0.76$; $p<0.01$) and LVEF (Casolo et al., 1995).

Despite the aforementioned findings, a number of studies have rejected the possibility of any existing relationship between time, or frequency domain measures and severity of LVF (Szabó et al., 1995; Hayano et al., 1990; Rich et al., 1988). Bigger and colleagues (1992a) failed to demonstrate correlations between LVEF in post-MI patients and various time domain indices (including SDNN, SDANN, SDNN-index, Ln r-MSSD, and Ln pNN50), as well as power spectral components (Ln total power, Ln LF power, Ln HF power and Ln LF:HF power ratio) above 0.30. Supporting the findings of Bigger and colleagues (1992a), Spearman correlation tests performed by Vaishnav et al. (1994) in 266 post-MI patients, failed to demonstrate significant correlations between LVEF and SDNN, SDANN, SDNN-index, r-MSSD, pNN50, HF and LF power.

In general, the aforementioned studies suggest that a progressive decrease in neural activity to the heart occurs with advancing severity of heart disease, particularly LVF. Advancing disease severity affects both branches of the autonomic system, the SNS and PNS, reflected through depressed spectral measures including LF power, HF power, and LF:HF power ratio, as well as the

time domain measures pNN50 and r-MSSD (Lombardi et al., 1996b; Casolo et al., 1995).

1.5.4 HRV as a Predictor of Mortality

A pioneer study by Wolf et al. in 1978 was the first study to show that post-MI patients with sinus arrhythmia (defined as RR-interval variance of greater than 1000 ms over thirty consecutive intervals) had a lower in-hospital mortality rate of 4.1%, compared to 15.5% among those with no sinus arrhythmia ($p<0.05$).

In the early 1980's, studies showed elevated HR in healthy patients to be directly related to all-cause mortality, especially from coronary heart disease and CAD death (Kannel et al., 1987; Dyer et al., 1980). With the introduction of time domain HRV measures, studies began to investigate the capability of such measures to predict mortality (Singer et al., 1988; Martin et al., 1987). In the classic study by Kleiger et al. (1987), 24-hour Holter data obtained approximately (mean ± SD) 11 ± 3 days post-MI, revealed diminished SDNN to be a predictor of mortality for a 31 month follow-up period. Mortality rate for those with HRV < 50 ms was 33%, while for those patients with a SDNN > 50 ms, yet < 100 ms, mortality rate was 16%. The lowest mortality rate, 9%, was found for those patients with SDNN > 100 ms (Kleiger et al., 1987). In addition, a year later Rich and colleagues (1988) revealed SDANN to be an independent predictor of mortality in post-MI patients, by using techniques of multiple regression analysis

and adjusting for ventricular function, extent of CAD, digoxin, diabetes mellitus and smoking.

Further studies using time domain measures, as well as newly developed power spectral measures, continued to show that HRV was an independent predictor of mortality in post-MI patients (Copie et al., 1996; Odemuyiwa et al., 1994; Algra et al., 1993; Dougherty and Burr, 1992; Huikuri et al., 1992; Cripps et al., 1991; Odemuyiwa et al., 1991). In a comprehensive study by Farrell et al. (1991) 416 survivors of acute MI underwent 24-hour ambulatory Holter recording 6-7 days post-MI. These investigators followed these subjects for an average time period of 612 days. Heart rate variability was measured using triangular interpolation of the RR-interval frequency distribution. Because Farrell and colleagues (1991) had previously experienced the time domain measure, SDNN, to be affected by recording noise and artifact misrecognition, they chose to use the above geometrical HRV measure. In summary, these investigators found that post-MI patients with a greater incidence of late potentials, arrhythmic events and all-cause cardiac mortality, had a lower HRV. In addition, multivariate analysis revealed HRV < 20 ms to be the number one predictor of arrhythmic events and all-cause cardiac mortality compared to late potentials, repetitive ventricular forms and Killip class (Farrell et al., 1991).

A series of studies conducted by Bigger et al. (1992a & c and 1993a & b) provided further information regarding HRV as a predictor of cardiac death.

Multivariate Cox regression analysis, using the step-up approach and adjusting for covariates (age, NYHA functional class, rales in the coronary care unit, LVEF, and frequency of ventricular arrhythmias) to evaluate the independent association of time domain HRV measures with all-cause mortality, revealed significant moderate associations for SDANN and SDNN-index, but only weak associations for r-MSSD and pNN50 (Bigger et al., 1992a). Frequency domain parameters from 24-hour Holter data showed that ultra-LF (<0.0033 Hz), VLF (0.0033-0.04 Hz) and LF power (0.04-0.15 Hz) predicted mortality in post-MI patients, even after adjusting for predetermined covariates (Bigger et al., 1992c & 1993a). In fact, Bigger and colleagues (1993b) found that short day recording segments (i.e. 2-15 minutes) were excellent predictors of all-cause, cardiac and arrhythmic mortality and sudden death. Patients with low power spectral component values (including VLF, LF and HF power) had 2-4 times greater risk of death over a follow-up period of 31 months (Bigger et al., 1993b).

Additional research by Vaishnav and others (1994) supports the findings of Bigger et al. (1992a & c and 1993a & b) and also suggests that low LF:HF area ratio is an independent predictor of mortality (Singh et al., 1996; Vaishnav et al., 1994). As well, SDNN has been reported to be able to predict subsequent clinical heart failure (measured by coronary rales, pulmonary congestion and gallop rhythm) (Pipilis et al., 1991) and r-MSSD (<36 ms) the ability to predict subsequent life-threatening arrhythmic events in post-MI patients (Reinhardt et

al., 1996). Frequency and time domain measures have also been reported to have the ability to discriminate normals from post-MI patients (Voss et al., 1996).

The clinical prognostic significance of HRV indices stems from its ability to predict mortality in post-MI patients. Diminished HRV suggests autonomic disturbance and reduced neural modulation of heart rhythm. However, several factors must be viewed while interpreting the prognostic significance of HRV. Some studies consist of a limited sample size, a modest number of deaths, and a patient sample limited in risk stratification (Bigger et al., 1993a). As well, some studies must be questioned regarding their sampling rate and stationarity of HRV signal (Reinhardt et al., 1996). Caution must also be employed when comparing studies, due to differing patient populations, recording methodologies (ambulatory versus controlled conditions) and HRV analysis techniques (FFT versus AR modeling). Nevertheless, HRV is a noninvasive procedure providing information regarding ANS function. Heart rate variability parameters help clinicians assess a patient's prognosis, as well as aid in the prescription of therapeutic intervention to prevent subsequent cardiac events.

1.5.5 The Effects of Beta-Blocker Therapy on HRV

Multicentre trials assessing beta-adrenoreceptor blocker therapy have reported beneficial effects. Short-term effects following intravenous administration include a reduction in cardiac index, HR and BP, and thus a reduced myocardial oxygen consumption. In addition, beta-blockade reduces

circulating free fatty acid concentrations by antagonizing the lipolytic effects of catecholamines. The clinically favorable effects resulting from acute intravenous administration of beta-blockers includes a reduction in chest pain, infarct size, ischemia, and ventricular arrhythmias (Braunwald, 1997). As for long-term effects, beta-adrenoreceptor treatment has been found to reduce the number and duration of ischemic episodes (Brouwer et al., 1995; Portegies et al., 1994; Bigger and Coromilas, 1984), prevent the onset of arrhythmic events, and decrease the risk of mortality post-MI (Pitt, 1992; Bigger and Coromilas, 1984).

Easy access to HRV techniques has permitted the incorporation of this measurement tool into studies investigating the effects of beta-blocker therapy on ANS status (Müller et al., 1996; Schweizer et al., 1993; Guidera et al., 1990). A conglomerate of studies have reported beta-adrenoreceptor blocker therapy to increase pNN50, r-MSSD, SDNN, LF and HF power, while decreasing LF:HF power ratio (Keeley et al., 1996; Cowan et al., 1993; Hohnloser et al., 1993; Kamath and Fallen, 1991; Guidera et al., 1990). Cook and colleagues (1991) conducted a randomized placebo-controlled crossover study investigating the effects of five day atenolol treatment on 24-hour Holter HRV indices in normal volunteers. They observed a 24% increase in RR-interval length ($p<0.01$). As well, pNN50 increased 69% and r-MSSD increased 61% from baseline values ($p<0.01$ for both). Frequency domain measures also showed significant ($p<0.01$) increases in Ln LF power (45%), Ln HF power (84%), and Ln total power (68%),

while LF:HF power ratio decreased from a placebo value of (mean ± SD) 2.5 ± 1.0 to 1.6 ± 0.6 with atenolol, a 36% decrease (Cook et al., 1991). However, despite the significant changes in total power, LF power and average RR-interval, Cook et al. (1991) failed to observe an increase in SDNN, which has been found to correlate with total power, and LF power (Kleiger et al., 1995; Bigger et al., 1992a; Kleiger et al., 1991).

In a subsequent study using stable CAD males, the effects of both atenolol (a non-lipophilic beta-blocker) and metoprolol (a lipophilic beta-blocker) on HRV measures were investigated (Niemelä et al., 1994). It was found that both beta-blockers affected time and frequency domain measures similarly. Atenolol increased HF power by 64%, while metoprolol increased HF power 62% over placebo values ($p<0.001$ for both). As well, SDNN ($p<0.01$) and r-MSSD ($p<0.001$) increased similarly from placebo measures for both types of beta-blockers. This study supports the findings of Cook and colleagues (1991) and it also suggests that beta-blocker type (non-lipophilic versus lipophilic) has no effect on the degree of ANS modulation and therefore is not necessarily of central origin (Airaksinen et al., 1994b; Niemelä et al., 1994).

Despite agreement among the above studies, the findings of Burger and colleagues (1996) are discordant. As in the other two studies, the results of this investigation showed an increase in RR-interval length, as well as pNN50 from baseline (mean ± SD; 4.9 ± 3.9%) to beta-blockade (10.5 ± 8.7%; $p<0.003$).

However, the subject sample consisting of nineteen symptomatic stable angina patients (some with MI's) on atenolol or betaxolol, demonstrated a decrease in both total power (21.4 ± 10.3 to 14.0 ± 7.3 [(beats/minute)^2/Hz]; $p<0.0001$) and LF power (3.2 ± 1.5 to 1.8 ± 1.4 [(beats/minute)^2/Hz]; $p<0.0001$), rather than an increase. Nevertheless, these findings coincide with a previous study by Bekheit et al. (1990), who also failed to find an increase in LF power in post-MI patients on metoprolol.

The apparent discrepancies in the above results can be explained by a number of differences between the studies. First, the patient populations differed; second, nitrate therapy was withdrawn in Burger et al.'s (1996) study, while maintained in the other two investigations; third, both the duration of therapy, as well as the dosages were different; last, Burger et al. (1996) used AR analysis, while Cook et al. (1991) and Niemelä et al. (1994) used FFT modeling.

Beta-adrenoreceptor blockade has been found to affect circadian rhythm in post-MI patients. A reduction in day-night difference of mean RR-interval length has been observed in patients participating in beta-blocker therapy (Sandrone et al., 1994; Mølgaard et al., 1993). As well, attenuated diurnal fluctuations of power spectral measures has been reported (Sandrone et al., 1994; Kamath and Fallen, 1991). In a study by Kamath and Fallen (1991), HF peak power increased significantly from 3 pm to 11 pm ($p<0.05$), while LF:HF peak and LF:HF area ratios showed a significant decrease ($p<0.05$) in post-MI

patients not on beta-blockers. In contrast, no significant diurnal fluctuations were observed among those on beta-blockers. Beta-adrenoreceptor blockers have also been shown to diminish the well documented morning increase in LF power (Sandrone et al., 1994). However, a study by Niemelä and colleagues failed to show a change in circadian pattern during beta-blocker therapy. When on beta-blockers, patients were observed to have elevated HF, LF, VLF power and r-MSSD values over the entire 24-hours. Nevertheless, circadian pattern was similar to that observed during the placebo period (Niemelä et al., 1994).

As assessed by time and frequency domain measures of HRV, beta-adrenoreceptor blockade appears to enhance vagal activity in patients with CAD and/or who have survived a MI. Several physiological mechanisms have been proposed in an attempt to explain this observation. As early as 1976, it was suggested that propranolol administration augmented baroreflex sensitivity, measured by a change in pulse interval during graded neck suction (Eckberg et al., 1976). The authors concluded that enhanced baroreflex responsiveness, following propranolol administration, was due to the simple removal of opposing tonic adrenergic stimulation.

In subsequent studies, SNS afferent and efferent fibre activity has been found to decrease with beta-blockade. The combination of vagi cooling (of the vagal fibres located in the neck) along with atenolol administration in anaesthetized cats, demonstrated a decrease in SNS efferent nerve discharge

(from SNS nerve fibre recordings in the lumbar trunk, splanchnic or renal nerves) (Scott, 1983). The act of vagi cooling removed any inhibitory influences that may be exerted by vagal afferent fibres on sympathetic nerve activity. Therefore, the observed decrease in spontaneous SNS efferent discharge must have resulted from peripheral beta-blockade, which caused a decrease in SNS afferent activity (Coker et al., 1984; Scott, 1983). Under the influence of hyoscine butylbromide, a parallel decrease in RR-interval length and variation was observed in twelve healthy volunteers (Coker et al., 1984). In contrast, an increase in RR-interval length and variation was found following atenolol administration. These findings suggest that HRV is abolished by vagal blockade, while a decrease in SNS afferent reflex activity results in reduced central sympathetic outflow and in turn a reciprocal excitation of vagal motor nuclei to the heart (Coker et al., 1984; Scott et al., 1983). In addition, beta-adrenoreceptor blockade has been reported to decrease the mechanosensitivity of SNS afferent fibres, which are responsible for mediating excitatory reflexes (Lombardi et al., 1986).

All of the above studies suggest that beta-blocker therapy influences ANS balance through peripheral mechanisms. However, one central mechanism has been suggested. Beta-adrenoreceptor blockers are thought to increase central neural outflow of vagal activity, and in turn RR-interval variance. Lipophilic beta-blockers have the ability to cross the blood-brain barrier, thus accumulating in the central nervous system (Sandrone et al., 1994; Pitt, 1992).

However, HRV studies have failed to show a difference between lipophilic and hydrophilic (non-lipophilic) beta-blocker effects on HRV (Tuininga et al., 1995; Airaksinen et al., 1994b; Niemelä et al., 1994; Sandrone et al., 1994).

In summary, beta-blocker therapy enhances PNS activity, yet suppresses circadian sympathovagal modulation. A decrease in sympathetic afferent fibre activity has been postulated as the main mechanism by which beta-blockers alter HR and HRV measures. Clinical benefits of beta-blocker therapy include a decrease in the number and duration of ischemic episodes among patients with low HRV (Brouwer et al., 1995), the facilitation of HRV recovery in post-MI patients (Kontopoulos et al., 1996), as well as prevention of the early morning increase in LF power, suggesting efficacy of this drug in the prevention of sudden cardiac death and MI in the early morning (Sandrone et al., 1994). Finally, a study by Tuininga et al. (1995) revealed the ability of beta-blocker therapy to increase HF power, decrease LF power and attenuate circadian rhythm of HRV. In addition to the above commonly reported findings, these researchers observed the ability of beta-blockers to maintain SDNN, total, LF and HF power during a stressful mental performance task. Therefore, under mentally stressful situations, beta-blockade can preserve normal autonomic balance in post-MI patients, perhaps preventing ventricular fibrillation (Tuininga et al., 1995).

1.6 The Effects of Stress on HRV Indices

Activation of the SNS during stress is often termed the "*fight-or-flight response*" (Vander et al., 1990; Eliot et al., 1977). Upon the onset of physical activity, an increase in general sympathetic activity occurs in order to meet bodily demands. The actions of the SNS includes: 1.) an increase in hepatic and muscle glycogenolysis; 2.) an increase in the breakdown of adipose tissue triacylglycerol; 3.) a decrease in skeletal muscle fatigue; 4.) an increase in cardiac output secondary to an increase in cardiac contractility and HR; 5.) shunting of blood from the viscera to the skeletal muscles by means of vasoconstriction in the former beds and vasodilation in the latter; 6.) an increase in ventilation and 7.) an increase in blood coagulability (Vander et al., 1990). However, whether these same adaptations occur, and the degree to which they occur during psychological and emotional stress is questionable.

In 1948, Hickam and colleagues assessed the effects of mental stress on cardiovascular function. Twenty-three healthy male medical students were subjected to SNS measures both before and after a scheduled exam. These investigators found that test anxiety caused an increase in HR, cardiac output, BP and rate of oxygen consumption, and a decrease in peripheral resistance (Hickam et al., 1948).

Additional studies have focused on the application of mental stressors in the laboratory. In normals, as well as patients with CAD, arithmetic tests, video

games, reaction time tests, psychological interviews, as well as task oriented tests, have all supported the findings of Hickam et al. (1948) (Lane et al., 1992; L'Abbate et al., 1991; Follick et al., 1990; Norvell et al., 1989; Specchia et al., 1984; Bassan et al., 1980). Mental arithmetic testing resulted in a similar rate-pressure product as observed during a multistage cycle exercise test, as well as myocardial ischemia (ST-segment alteration) in patients with CAD (Specchia et al., 1984). In addition, ventricular premature complexes in CAD patients were found to increase three-fold while playing a video game (Follick et al., 1990). In order to counteract the onset of myocardial ischemia during mental stress, beta-blocker therapy has proven to be effective (Jennings and Follansbee, 1985).

The above findings suggest that mental stress stimulates SNS activity modulation. Studies using HRV analysis have provided a noninvasive look at ANS function during mental stress. Mental stress tests have been found to cause a decrease in RSA (Sloan et al., 1991) and HF power (Jiang et al., 1993; Langewitz et al., 1991). As for LF power, a lack of change has been observed (Langewitz and Rüddel, 1989). In a study by Pagani and others (1991), a significant ($p<0.05$) decrease in normalized HF power from (mean ± SEM) 28 ± 3 nu at rest, to 16 ± 2 nu, while an increase in normalized LF power from 58 ± 5 nu to 76 ± 3 nu, was observed in normals during a 10-minute semi-structured interview performed by a psychologist. Similar trends were observed in CAD patients one month post-MI, however, the observed changes in power spectral

HRV indices failed to reach significance. This suggests that the physiological response to mental stress was blunted in post-MI patients (Pagani et al., 1991). A further supportive finding is the observation that the greater the RSA in normals, the more rapidly HR adapted to stress (Lane et al., 1992).

Although many studies have looked at mental stressors in the laboratory setting and how they affect the ANS function, few have looked specifically at real life stressful events. In 1971, Engel conducted a retrospective study, which consisted of gathering newspaper clippings making reference to precipitating life situations and cause of death. Engel (1971) found eight categories for which sudden death was found to occur; for example, death of a loved one, acute grief etc. Subsequent studies found that real life psychologically stressful events increased HR, BP, cortisol, adrenaline and noradrenaline levels (Dobkin and Pihl, 1992; Van Doornen and Van Blokland, 1989; Freeman et al., 1987; Levine et al., 1982). Real life stressful situations have also been found to precipitate myocardial ischemia (Sharkey et al., 1995) and ventricular arrhythmia (Reich et al., 1981) in heart disease patients. As well, sudden cardiac death was found to be more common in those individuals with underlying atherosclerotic heart disease during the earthquakes of 1978 in the city of Thessaloniki (Greece) (Katsouyanni et al., 1986).

In a classic study by Freeman et al. (1987), thirty patients with angina undergoing coronary angiography, underwent two 48-hour Holter monitoring

periods. Time one followed coronary angiography and represented a time of uncertainty as results and the need for surgery were discussed. Time two was scheduled an average of nine weeks later, allowing patients to adjust to the decision-making process. What Freeman and colleagues found was that a clinically stressful event, such as a coronary angiogram, increased the number and length of ischemic episodes experienced by patients with angina. As well, noradrenaline and cortisol levels were found to be elevated during the stressful period compared to control levels (Freeman et al., 1987).

As for assessing HRV during real life stress, a study done by Myrtek et al. (1996) monitored fifty university females for 23-hours. As expected, the more stressed an individual perceived themselves to be, and the larger an individual's mental load (defined as study time), the higher the HR and the lower the HRV (measured as mean squared successive difference of heart periods, MSSD) for a given person (Myrtek et al., 1996). In a study evaluating the ability of HRV to predict one year mortality in patients receiving thrombolytic therapy, Singh et al. (1996) obtained 48-hour Holter data from 204 patients (participating in the GUSTO-1 study) on days one and two post-MI. On day one, all patients underwent coronary angiography, so the investigators were able to observe the effects of a clinically stressful event on HRV. There was a significant ($p=0.001$) decrease in SDANN, pNN50, LF area, and HF area from day one to two, but no meaningful change in LF:HF area ratio.

More studies are needed to assess the effects of real life stressful situations on ANS function through both time and frequency domain measures. The only limitations to using real life psychologically stressful situations are the lack of standardization of the event and homogeneity of the subject sample. Each person reacts to psychological stimuli differently, and the extent to which each individual's electrophysiological mechanisms are sensitive to a given stimulus also differs (Coumel and Leenhardt, 1991). The aforementioned limitation follows the widely recognized *"stress theory"* described by Lazarus and Folkman (Myrtek et al., 1996). Stress describes the relationship between a person and the environment, whereby the meaning of the event to an individual determines the emotional and behavioural response of that individual. This response is dependent on coping resources (including both cognitive and behavioural efforts) towards the management of both external and internal demands. Strong emotions result from inadequate coping resources and result in drastic physiological adaptations (Myrtek et al., 1996).

1.7 Summary and Statement of Purpose

Heart rate variability has become a widely accepted, and an objective noninvasive tool for the evaluation of ANS function. Heart rate variability is attributed to cyclical fluctuations in autonomic input, from both the sympathetic and parasympathetic nervous systems on the SA node. Two methods of HRV analysis include time domain and power spectral analysis, in the frequency

domain. Time domain measures appropriately reflect overall autonomic activity, while frequency domain indices are capable of distinguishing between the two ANS branches, hence providing information regarding sympathovagal balance.

The clinical significance of HRV lies in its ability to predict the risk of mortality in post-MI patients. Patients with CAD, CHF and/or a MI have been found to have lower HRV compared to normals. The lower the HRV, the greater the risk of mortality for a particular patient. With this knowledge, cardiologists have the ability to assess a patient's health status (specifically autonomic function) and determine therapeutic intervention. As well, through subsequent HRV measures during patient follow-up, the cardiologist can monitor a patient's recovery and response to a number of therapeutic interventions.

The clinical importance and incorporation of HRV into daily practice depends on its reproducibility. A majority of studies have reported both time domain and 24-hour frequency domain indices to be reproducible. However, controversy exist over whether the time domain measure, pNN50, is reproducible or too variable to be clinically beneficial. As well, nothing is known about the reproducibility of frequency domain indices at different time intervals over a 24-hour period.

Circadian rhythm of HRV measures in normals has been compared to patients with CAD. Findings suggest that circadian variability of both time and frequency domain measures in CAD patients is blunted. Dispute over the extent

to which this pattern is altered is under debate. Nevertheless, all findings suggest that both diurnal and nocturnal ANS function in patients with CAD has been altered.

A majority of patients with CAD have LV dysfunction. The degree of LV dysfunction has been found to influence HRV measures. The more severe the dysfunction, the less neural modulation of the heart and this is reflected through reduced time and frequency domain indices, as well as the circadian pattern of HRV.

An increasing number of pharmacological therapies are being prescribed to patients with CAD. Of the many types of drugs, beta-adrenoreceptor blockers have proven to be clinically beneficial by reducing mortality and morbidity. In an attempt to explain this observation, the effects of beta-blockers on HRV have been explored. Findings suggest that beta-blockade enhances PNS activity and overall HRV, while suppressing circadian sympathovagal modulation. However, some studies have failed to report an increase in HRV, and blunted circadian variation.

Although the effects of a number of laboratory physiological stimuli (i.e. exercise, orthostatic stress, controlled respiration), as well as mental stressors (i.e. arithmetic tests, task oriented tests, oral speaking) on HRV have been investigated, real life psychologically and emotionally stressful events have not been included. Questions regarding ANS response to a real life emotionally and

psychologically stressful event include: 1.) how is HRV altered as assessed through time domain analysis; 2.) how does the sympathetic and parasympathetic systems respond and 3.) what does the LF:HF area ratio reveal about sympathovagal modulation?

1.8 Objectives

The primary purpose of this thesis was threefold: 1.) to investigate the reproducibility of 24-hour time domain indices, as well as frequency domain measures of HRV at specific time intervals, over two consecutive recording periods in CAD patients; 2.) to determine the circadian pattern of frequency domain indices in patients with CAD and 3.) to assess the effects of a real life, psychologically and emotionally stressful event (coronary angiogram), on HRV measures including time and frequency domain measures, as well as circadian variability in patients with CAD. The secondary purpose of this study was to investigate the effects of MI status, beta-blocker therapy and LVF on both time and frequency domain indices, circadian pattern and the influence of stress.

1.9 Hypotheses

The primary hypotheses are as follows: 1.) HRV indices will be reproducible over the recording period; 2.) circadian pattern of HRV measures will exist in patients with CAD, demonstrating greater HRV during the day compared to at night and 3.) in response to a real life stressful event, HRV will decrease below normal values and blunt circadian variability, reflecting altered

ANS status. Secondary hypotheses include: 1.) CAD patients with MI's will have lower HRV compared to those CAD patients with no MI; 2.) left ventricular dysfunction will result in a decrease in HRV; 3.) CAD patients participating in beta-adrenoreceptor blocker therapy will have a greater HRV compared to those not on beta-blockers; 4.) beta-blockade, MI status and LV dysfunction will attenuate circadian variability in patients with CAD and 5.) HRV in CAD patients with altered LVF, previous MI and/or on beta-blockers, will be influenced less by stress compared to those CAD patients with normal LVF, not participating in beta-blocker therapy and/or have not had a previous MI.

2.0 METHODS

2.1 Subjects

2.1.1 Patient Demographics

Ambulatory ECG data used in this study were previously recorded between June 1992 to September 1993 (Runions, 1995). The sample population was from the Hamilton Wentworth Niagara Region, which includes both urban and rural communities. This geographical area is bounded by Welland on the South, Rockwood on the North, as well as Oakville and Burford on the East and West respectively. Patients who were consecutively referred to The Hamilton General Division of The Hamilton Civic Hospitals (a university teaching institution) for a coronary angiogram, were screened for the study prior to heart catheterization. Upon admission to the hospital or short stay unit, the patients were contacted and the purpose, procedures and time commitment required for the study were explained. Informed consent was obtained from each patient. Patient demographics are described in Table 3 under the Results section.

2.1.2 Inclusion Criteria

The patient population consisted of males and females that had angina for a duration of at least six months. Patients were required to have had a positive exercise ECG stress test (usually within two to three months prior to

coronary angiogram) established by the presence of ST segment depression of 1-mm or more occurring 0.08-seconds beyond the J point. In addition, subjects had to have established coronary artery disease demonstrated by intra-luminal narrowing of at least 50-70% in one or more coronary arteries detected during angiography.

2.1.3 Exclusion Criteria

Patients were excluded if they qualified for an emergency revascularization (i.e. CABG or PTCA). They were also excluded if they had valvular disease (i.e. mitral valve prolapse, mitral valve stenosis, aortic stenosis), or left ventricular hypertrophy with ST segment abnormality. Patients with myocardial autonomic abnormalities such as Left Bundle Branch Block, Wolff-Parkinson-White Syndrome, or a Pacemaker were excluded. Lastly, those with unstable angina requiring hospitalization, or who had an acute MI within four weeks of the angiogram were omitted.

2.2 Design and Intervention

2.2.1 Design

The design of this study was retrospective, in that the data were collected between June 1992 to September 1993 and were analyzed for the present study. The investigator was blinded to all patient characteristics throughout HRV analysis. Once the analysis was completed, health information was gathered on

each individual subject from the Health Records division of The Hamilton General Hospital.

2.2.2 Intervention

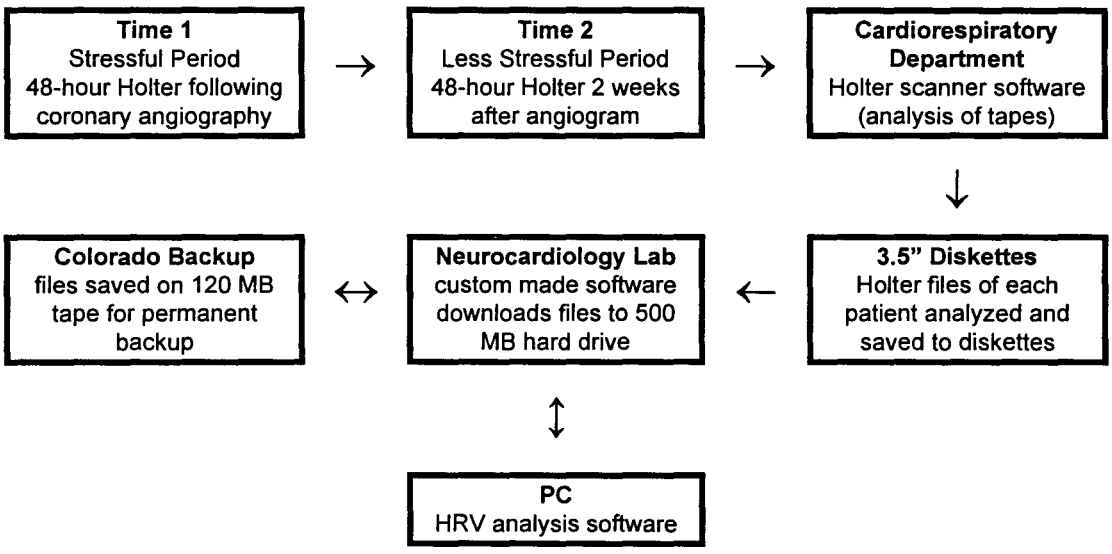
A descriptive flow chart of the study protocol is provided in Table 2. A clinically *'stressful'* event was selected for this study. This event incorporated the concept of receiving *'potentially threatening news'* from a cardiologist following coronary angiography. Throughout this experience each subject was quite uncertain about their current health status. Thus, even the possibility of good news was in the context of a bad situation.

The stressful interval began following each subject's scheduled coronary angiography. Initially, 4-hours post-angiography was allotted to allow for patient management and the withdrawal of various acute effects of medication given before or during the procedure (specifically that of 5 mg po of Valium as premedication administered approximately 1-hour before the procedure, or 15 mg iv provided during the procedure). Following this time period, continuous ECG was recorded by a Holter monitor for 48-hours. In addition, anti-anginal medication that might have been withheld was administered during the recovery period in the Heart Investigation Unit. Patients were sent home with the Holter monitor within approximately 8-hours of the angiography. Thus, Day 1 and Day 2 of recording, or the first 48-hours, represents TIME ONE, the *'stressful'* period. In fact, each subject received information regarding the results of the coronary

angiography near the end of the initial 24-hour period of Holter recording. In light of this, the first day of Holter monitoring was judged to be the most stressful. Two days later, a home visit was made to remove the electrodes and collect the monitor.

As for TIME TWO, the *'less stressful'* event, or control condition followed two weeks later. The Holter monitor was again hooked up to the patient on the same two days of the week to provide 48-hour ambulatory ECG data (Days 3 and 4). Patients maintained the same drug regimen over the two week period. Thus, both recording periods occurred when subjects were taking their usual anti-anginal medications. In addition, no attempt was made to control for the occurrence of additional life events and difficulties at TIME ONE or TWO. This was due to the low probability of major life events occurring within the two week time interval between recording periods for a large number of subjects.

Table 2: Study Protocol Flow Chart



2.3 Testing Protocol

2.3.1 Subject Preparation

In this study, the Holter monitor was a two channel frequency modulated Oxford Medilog 4500, MR 45 recorder. This particular model records ECG continuously for 24-hours at a sampling rate of 125/second. At the start of each recording period, operation of the equipment was demonstrated to each patient. In order to obtain 48-hours of recording, the subjects were instructed on how to change the tape and batteries, as well as confirm the date and time and patient status on the Holter. Once confirmation was given, the Holter recorder began an ECG signal test prior to calibrating the instrument. Following calibration, the Holter began recording for 24-hours. The importance of electrode attachment was explained to each subject along with the importance of testing the quality of the ECG signal when restarting the recorder after the initial 24-hour period. If the subjects had any difficulty, they were instructed to phone the investigator for in-home assistance.

2.3.2 Skin Preparation and Electrode Application

After skin abrasion, two exploring electrodes were applied to the chest wall in the Cm-V3 (left nipple line between the sixth and seventh rib) and Cm-V5 (left anterior axillary line at the fifth intercostal space). Two negative electrodes were positioned at the manubrium and right manubrial border of the sternum for Cm-V3 and Cm-V5 respectively. Finally, the ground electrode was placed on the

lower part of the chest wall. To reduce artifact in the recording, all electrodes were placed on bony prominences. In addition, electrodes were taped carefully at each attachment and the cables were taped to the chest for the purpose of reducing cable movement, disconnection, and minimization of artifact formation and isoelectric line drift. For both recording periods, TIME ONE and TWO, leads were placed in the same location.

2.4 HRV Techniques

2.4.1 Time Domain Analysis of HRV

The 24-h Holter tapes were collected for each subject and analyzed using Holter scanner commercial software (Medilog Excel, Oxford Medical Ltd., Oxon, UK) located in the Cardiorespiratory Department of the McMaster University Medical Centre (MUMC) (Kamath et al., 1992). Holter tapes were analyzed by technicians on automatic mode following tape calibration and confirmation of recording date and time. The Holter scanner software conducted arrhythmic analysis and ectopic elimination following digitization and recorrelation of the raw ECG signal. Holter reports were provided and beat data was exported to a 3½" diskette. From here, a custom designed software, located in the Neurocardiology Laboratory at MUMC, was used to download all patient files from the 3½" diskettes to the hard drive of an IBM computer and then onto a digital tape (DC 2120 Mini Data Cartridge, 120 Mbytes, 3M Data Storage Markets Division, St. Paul, MN) which was used as backup (Kamath et

al., 1992). Time domain measurements derived directly from intervals themselves over 24-hours included mean heart rate (HR) and RR-interval, SDNN, SDANN and SDNN-index, while those obtained from the difference between adjacent cycles over a 24-hour period included r-MSSD and pNN50. As well, a circadian plot of mean hourly HR and corresponding SD was provided. Refer to Table 2 for an outline regarding the procedure for HRV analysis.

2.4.2 Frequency Domain Analysis of HRV

Following time domain analysis, subsequent power spectral analysis was performed on four 45-minute time periods over the entire 24-hours for each day recorded during both the stressful and non-stressful periods. The times included 0300 (3 am), 0900 (9 am), 1500 (3 pm) and 2100-hours (9 pm). Initially, the RR-interval tachogram for the specified 45-minute time period was inspected for ectopic beats. If in fact ectopic beats were discovered, they were immediately corrected using a linear interpolation algorithm capable of accounting for the delays and artifacts produced by such beats. Correction of ectopic beats decreases contamination of the power spectra due to spurious energy generated from ectopic waveforms (Kamath and Fallen, 1995). If there were more than five consecutive ectopic beats, that segment of HRV was deleted.

In instances where the data were contaminated with too many ectopics and could not be corrected, the hour prior to or immediately following that sample period was investigated. Particular patient files that were of very poor quality at

any of the four times, over any of the four days, were eliminated from further computation. Following ectopic correction, RR-interval tachograms were resampled at 2 Hz using linear interpolation in order to obtain an equally sampled time series. Of this 45-minute long RR-interval signal, 128-seconds (256-points) underwent power spectral analysis. Power spectral computation was performed as follows: mean signal value was subtracted from each RR-interval, providing an equally sampled HRV signal. The signal was then filtered through a second order high-pass Butterworth filter having a cut-off of 0.02 Hz. An autoregressive (AR) model of the ninth order was applied (Kay and Marple, 1981). The mathematical expression of the AR model is as follows:

$$x[n] = -\sum_{k=1}^{p} a[k]\, x\,[n-k] + u[n]$$

where x[n] represents the output signal at any time point 'n' obtained from the input signal of white noise u[n], while k = {1,2... p} represents the parameters used to describe the signal. From these parameters, it is possible to calculate the AR power spectrum as follows:

$$P_{AR}(f) = \frac{\sigma^2 \Delta t}{\left[1 + \sum_{k=1}^{p} a[k] \exp(-j2\pi f k \Delta t)\right]^2}$$

in which σ^2 represents the variance of the white noise input signal and Δt the sampling interval. Additional information about the algorithm used to estimate AR parameters is available in the literature (Kay et al., 1981). This entire

process was repeated for consecutive 128-second samples, until the overall power spectrum consisted of at least twenty individually stacked power spectrums reflecting the desired 45-minute time period. Reliable estimators of power spectral indices were derived from averaging these twenty power spectra.

From the above procedure, a number of power spectral measures were calculated for each 45-minute time period including: mean HR; maximum value of peak power for both low frequency (LF; 0.02-0.15 Hz) and high frequency components (HF; 0.15-0.5 Hz); the central frequency (cf) of peak power of both components; total area of each component (LF and HF area) obtained through the integration of the power under each frequency band; a percentage measure of the area under each frequency component (derived by dividing each component power by total spectral power); and finally, two ratio measures consisting of component areas and peaks, LF:HF area ratio and LF:HF peak ratio respectively. In addition, total area (TA) of each 45-minute power spectrum was computed by adding the LF and HF area, and a compressed spectral array for each 24-hour recording period was obtained for each subject. Refer to Table 2 for the step-by-step breakdown of the study protocol.

2.5 Patient Health Information

From the Health Records division of The Hamilton General Hospital, personal health information was obtained for those subjects meeting the inclusion/exclusion criteria back in June 1992 to September 1993, and whose

Holter data were still available for analysis. Information regarding the subject's full name, age, gender, height, weight and prescribed drug medication, particularly those affecting sinus rhythm, was collected. Confirmation of CAD, requiring intra-luminal narrowing of at least 50-70% in one or more coronary vessels, along with MI status and information regarding PTCA and CABG was obtained. Degree of CAD was reflected by a single score. This score was derived from adding together each stenosed major artery, as well as its collaterals, for which each were given a value of 2 if the vessel was blocked 70% or more, or a value of 1 if the vessel was 50-70% blocked. In addition, degree of LVF was determined using estimates of wall motion function obtained from the angiogram. Any subject with reported wall motion abnormalities, including hypokinesis, akinesis or dyskinesis of a single or multiple segments were categorized as having LV dysfunction. These individuals were further ranked according to the degree of dysfunction. Function for each wall of the LV was classified as hypokinesis, akinesis or dyskinesis, and subsequently assigned a score reflecting the severity of dysfunction of 1, 2, or 3 respectively. In contrast, the absence of reported motion abnormalities indicated that a subject had normal LVF. A summary of patient information may be found in the Results section under Table 3.

2.6 Statistical Analysis

Statistical analysis of time domain indices included SDNN, SDANN, and pNN50. As for power spectral measures, LF area, HF area, LF:HF area ratio, TA, and LFcf were investigated. As well, HR was included in statistical analysis.

The overall effect of stress (DAY) on each of the above time domain variables was determined with a one-way analysis of variance (ANOVA). The effects of splitting the patient population up according to MI status (non-MI/MI), LVF (non-dysfunction/dysfunction), or beta-blocker therapy (non-beta-blockers/beta-blockers) was assessed by two-way ANOVA's (GROUP X DAY).

Circadian rhythm of the above listed frequency domain indices at 0300, 0900, 1500 and 2100-hours, was determined with a one-way ANOVA (TIME). The effect of MI, LVF and beta-blocker therapy on circadian pattern was analyzed with two-way ANOVA's (GROUP X TIME). As well, two-way ANOVA'S were used to determine the effects of stress (DAY) on frequency domain variables (DAY X TIME). Division of subjects according to the above categories (MI, LVF, beta-blocker therapy) was investigated using a three-way ANOVA (GROUP X DAY X TIME). Post hoc analysis of main effects or interactions were performed by Tukey HSD test. All data are presented as means and standard errors (mean ± SEM), and statistical significance was fixed at $p \leq 0.05$.

Intraclass correlation coefficients were computed for time domain indices, as well as frequency domain indices (at the four specified time periods).

Intraclass correlations reflect intra-individual variability over two or more recordings periods. The closer the correlation coefficient is to 1.00 (a perfect correlation), the less variable and in turn the more reproducible the measure. Intraclass correlation coefficients are an appropriate measure of reproducibility for HRV indices (Kautzner et al., 1995). For information regarding this computation, refer to Appendix B.

3.0 RESULTS

3.1 Subject Characteristics

Of the initial 1601 consecutively screened patients referred for coronary angiography between June 1992 to September 1993, 139 patients met the cardiac inclusion and exclusion criteria. From the 139 possible subjects, 83 provided informed consent to participate. Subsequent time domain and frequency domain HRV analysis was completed on 61 patient subjects, whose ambulatory Holter data and personal health information were available for current analysis. The average age of the subject sample was 58.4 ± 0.15 years, ranging between 40-75 years. Of the 61 subjects, 59 were male and 2 female. Additional data regarding weight, height, degree of CAD, LVF, MI, PTCA and CABG status, as well as medications are reported in Table 3.

It should be noted that a variable number of patients did not complete four days of Holter monitoring due to personal choice, cardiovascular status (refer to exclusion criteria), or technical difficulties. As well, ambulatory ECG data that was of poor quality due to excessive ectopics, artifacts, or technical difficulties with the Holter monitor, were excluded from further analysis. As a result, subjects with incomplete data sets were excluded from statistical analysis (refer to Appendix A).

Table 3: Patient Demographics

DEMOGRAPHICS	SUBJECT GROUP (n=61)
Age (years)	58.4 ± 0.15
Gender	
males	59
females	2
Height (cm)	171 98 ± 1 07
Weight (kg)	83.83 ± 1.63
Degree of CAD (combined stenosis and number of vessels)	
1-3	n=21 (34%)
4-6	n=21 (34%)
7-9	n=14 (23%)
10-12	n=5 (8%)
LVF	
normal	n=26 (43%)
1-3	n=28 (46%)
4-6	n=7 (11%)
MI	n=39 (64%)
PTCA	n=4 (7%)
CABG	n=1 (2%)
Medications	
None	n=3 (5%)
Beta Blockers	n=33 (54%)
ACE Inhibitors	n=8 (13%)
Calcium Antagonists	n=39 (64%)
Nitrates	n=29 (48%)
Digoxin	n=2 (3%)
Amiodarone	n=1 (2%)

3.2 Reproducibility of HR and HRV Indices (Days 3 and 4)

3.2.1 HR

All intraclass correlation coefficients were determined for Days 3 and 4. Days 3 and 4 were during the less stressful period and occurred at home during a patients' normal daily activities, free from any major events that could have possibly influenced the reproducibility of HR and HRV indices. The HR intraclass

correlation coefficients calculated for four 45-minute time periods, including 0300, 0900, 1500 and 2100-hours were 0.89, 0.78, 0.80, and 0.91 respectively.

3.2.2 Time Domain Indices

Intraclass correlation coefficients for Day 3 and Day 4 time domain indices SDNN, SDANN and pNN50 ranged between 0.85-0.95. The reproducibility coefficient for SDNN was 0.91, while SDANN had a coefficient of 0.85. The highest intraclass correlation coefficient for the time domain indices was pNN50 at 0.95.

3.2.3 Frequency Domain Indices

On average, all frequency domain intraclass correlation coefficients were the highest at 0300-hours, during which time subjects were sleeping. At this time the coefficients ranged between 0.81-0.88. The highest intraclass coefficient for LF area, HF area and TA all occurred at 0300-hours and were 0.86, 0.88 and 0.81 respectively. As for LF:HF area ratio, a maximum intraclass coefficient of 0.88 was observed at 0900-hours, while LFcf reproducibility (0.84) was the best at 2100-hours. Nevertheless, LF:HF area ratio and LFcf intraclass correlation coefficients at 0300-hours were not very different from the above maximum values.

On the contrary, the worst reproducibility was observed at 1500-hours for all frequency domain variables. The correlations for this time period ranged between 0.50-0.77. Reproducibility for LF area, HF area, and TA was 0.71, 0.76,

0 50 respectively LF·HF area ratio had a calculated coefficient of 0 77, while LFcf was 0 63. For all intraclass correlation coefficients refer to Table 4.

Table 4: Time and Frequency Domain Intraclass Correlation Coefficients for Days 3 and 4

DEPENDENT VARIABLES	INTRACLASS CORRELATION COEFFICIENTS
Time Domain	
SDNN	0.91
SDANN	0.85
pNN50	0.95
Heart Rate	
0300-h	0.89
0900-h	0.78
1500-h	0.80
2100-h	0.91
Frequency Domain	
LF Area	
0300-h	0.86
0900-h	0.82
1500-h	0.71
2100-h	0.85
HF Area	
0300-h	0.88
0900-h	0.88
1500-h	0.76
2100-h	0.88
LF:HF Area	
0300-h	0.86
0900-h	0 88
1500-h	0.77
2100-h	0.79
Total Area	
0300-h	0 81
0900-h	0 79
1500-h	0 50
2100-h	0 65

Table 4: Continued

DEPENDENT VARIABLES	INTRACLASS CORRELATION COEFFICIENTS
LFcf	
0300-h	0.83
0900-h	0.79
1500-h	0.63
2100-h	0.84

3.3 Circadian Variability of HR and HRV Indices (Day 4)

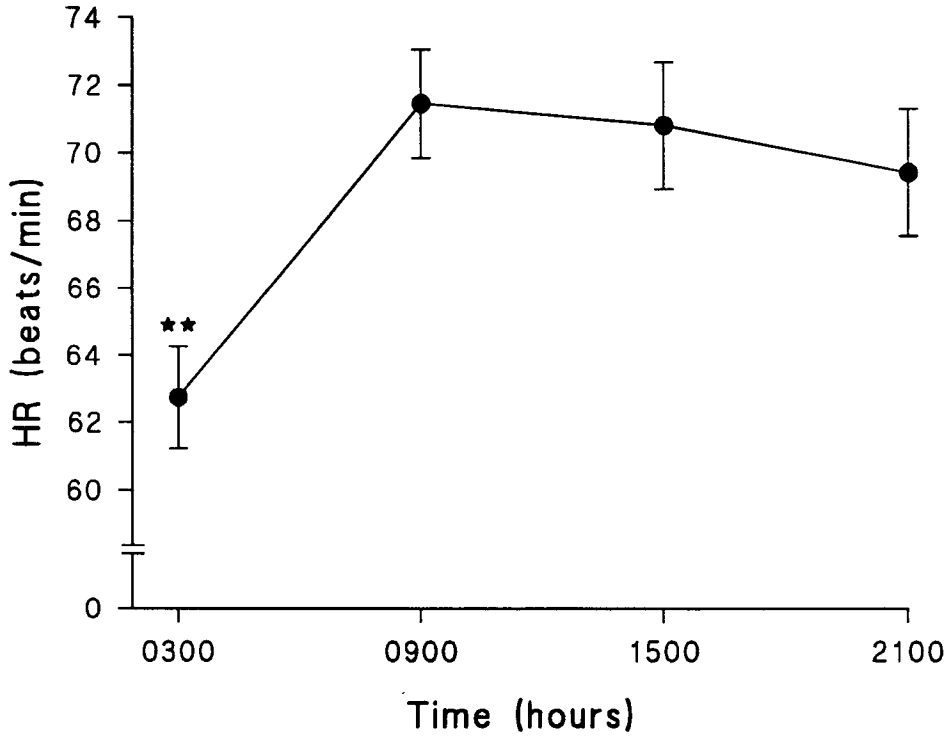
3.3.1 HR

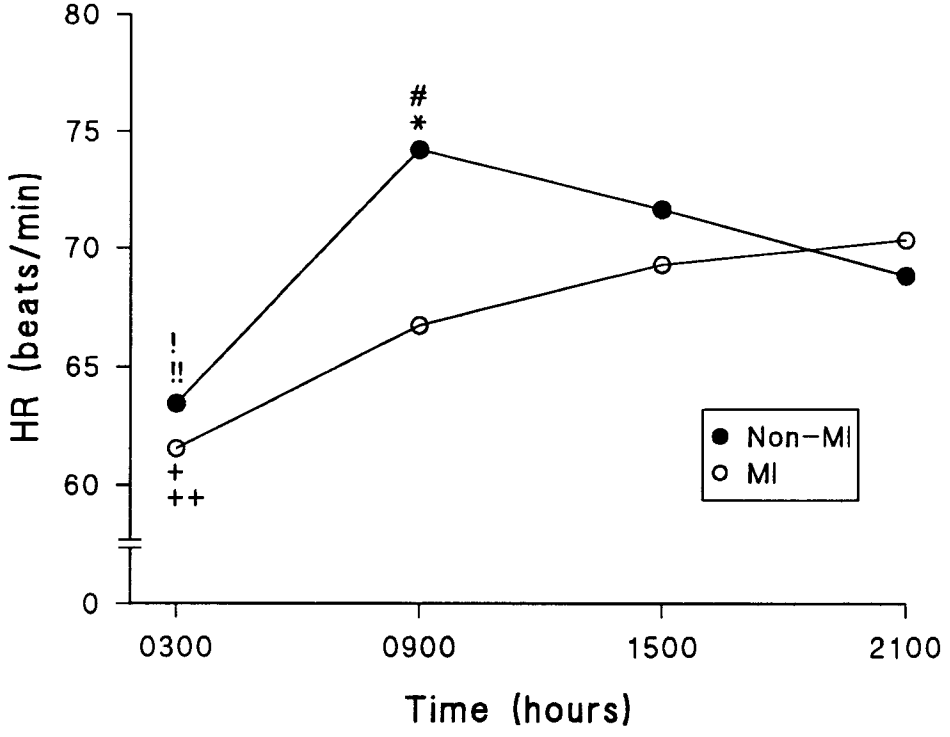
The 24-hour recording period on Day 4 was used to evaluate circadian rhythm. The reasoning behind this choice of day stems from the idea that this day represents the patients' least stressful period First, it is the time period furthest away from Day 1 (the most stressful interval), and second, it follows Day 3, allowing for a reduction in patient anxiety commonly felt as a reaction to wearing the Holter monitor Therefore, we believe Day 4 would reflect a 'true' circadian rhythm in the absence of extreme extraneous influences.

Statistical analysis of HR demonstrated a significant circadian variation ($p<0.01$) Post hoc analysis revealed a significant increase in HR from 0300-hours (62.74 ± 1.52 beats/minute) to 0900-hours (71.44 ± 1.60 beats/minute; $p<0.01$). Heart rate at 0300-hours also remained significantly less compared to HR observed at 1500-hours (70.77 ± 1.86 beats/minute) and 2100-hours (69.37 ± 1.86 beats/minute) ($p<0.01$ for both) (see Figure 2). Separating subjects according to beta-blocker therapy did not result in any additional findings.

Figure 2: The circadian pattern of HR (top); ★★ denotes that HR was lower at 0300-hours than at any other time over 24-hours ($p<0.01$).

The effect of MI on the circadian pattern of HR (bottom). In patients with a MI: + denotes an increase from 0300-hours to 1500-hours ($p<0.05$) and ++ an increase from 0300-hours to 2100-hours ($p<0.01$). In non-MI patients: !! denotes a significant increase in HR from 0300-hours to 0900-hours and 1500-hours ($p<0.01$) and ! indicates an increase from 0300-hours to 2100-hours ($p<0.05$). # indicates a decrease in HR between 0900-hours and 2100-hours ($p<0.05$). Comparison between patients: ✳ denotes that patients without a MI had a significantly greater HR at 0900-hours compared to those patients with a MI ($p<0.05$).


74
72
70
68
66
64
62
60
0
HR (beats/min)
**
0300
0900
1500
2100
Time (hours)


80
75
70
65
60
0
HR (beats/min)
#
*
!
!!
+
++
Non-MI
MI
0300
0900
1500
2100
Time (hours)

However, a main effect for LVF was close to significance ($p=0.064$), whereas a GROUP X TIME interaction was found for MI ($p<0.05$). Post hoc analysis revealed that HR in patients with a previous MI was significantly less at 0900-hours (66.75 ± 1.88 beats/minute) compared to those patients with no previous MI (74.22 ± 2.15 beats/minute; $p<0.05$). As well, patients with no MI demonstrated a significant increase in HR from 0300-hours (63.45 ± 2.16 beats/minute) to 0900-hours ($p<0.01$), 1500-hours (71.64 ± 2.50 beats/minute; $p<0.01$) and 2100-hours (68.81 ± 2.46; $p<0.05$), along with a subsequent decrease from 0900-hours to 2100-hours ($p<0.05$). In comparison, those with a MI only experienced a significant increase in HR between 0300-hours (61.54 ± 1.92 beats/minute) to 1500-hours (69.29 ± 2.73 beats/minute; $p<0.05$) and 2100-hours (70.33 ± 2.89 beats/minute; $p<0.01$) (see Figure 2).

3.3.2 Frequency Domain Indices

For an example of the typical circadian pattern of power spectral indices, a compressed spectral array is provided in Figure 3. As well, examples depicting typical power spectrums obtained at the four specified time periods (0300, 0900, 1500, and 2100-hours) over 24-hours is provided in Figure 4.

A one-way ANOVA revealed a main effect for TIME on LF area ($p<0.01$). LF area appeared to progressively increase with time of day. Post hoc analysis revealed that LF area at 0300-hours (6067.65 ± 140.54 $(beats/minute)^2/Hz$) was significantly less than at 1500-hours (6365.81 ± 131.42 $(beats/minute)^2/Hz$;

Figure 3: A compressed spectral array providing a typical example of the circadian pattern of power spectral indices obtained on Day 4.

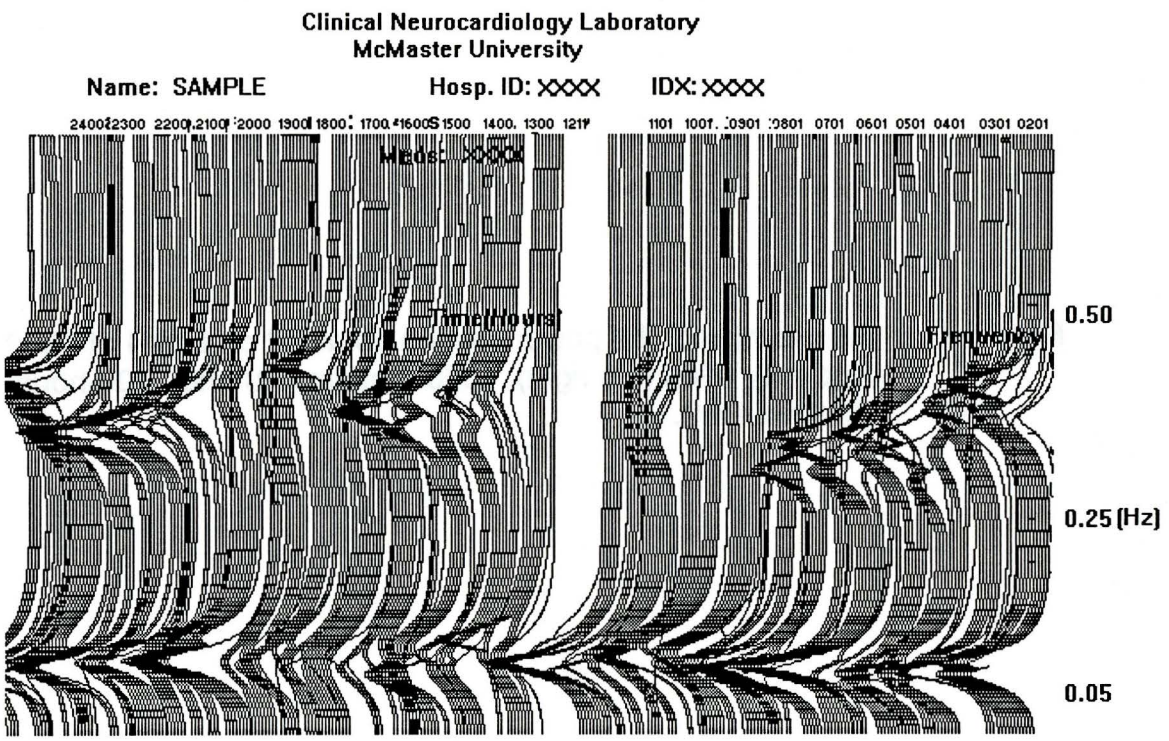
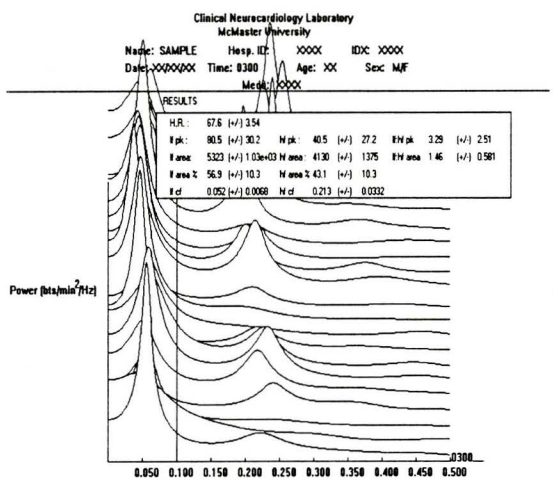
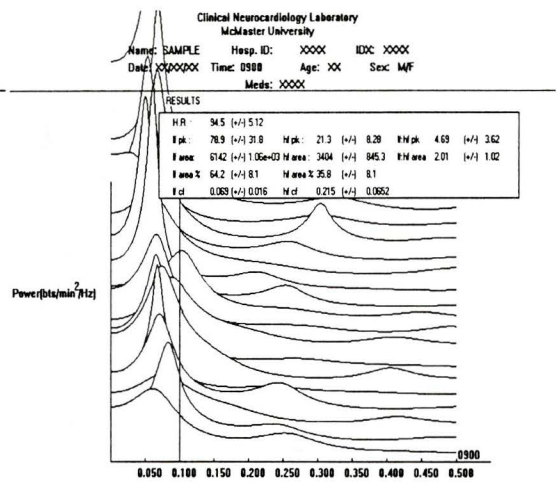
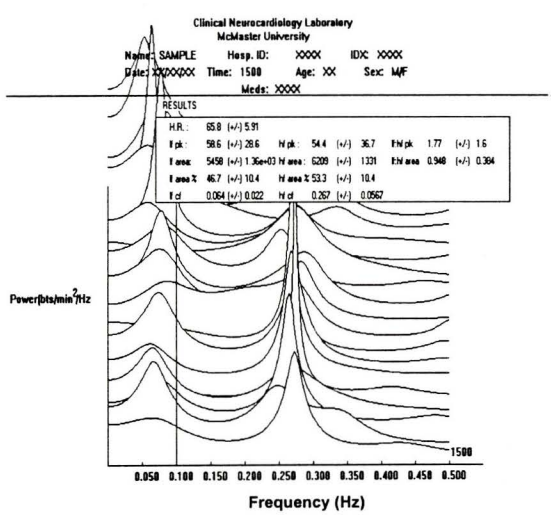
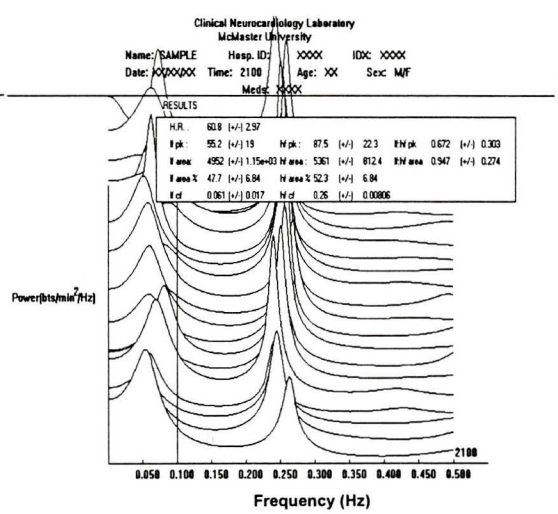

Clinical Neurocardiology Laboratory
McMaster University
Name: SAMPLE
Hosp. ID: XXXX
IDX: XXXX
2400 2300 2200 2100 2000 1900 1800 1700 1600 1500 1400 1300 1211
1101 1001 0901 0801 0701 0601 0501 0401 0301 0201
Meds: XXXX
Time (hours)
Frequency
0.50
0.25 (Hz)
0.05

Figure 4: An example of the power spectra obtained on Day 4 at 0300 (top left), 0900 (top right), 1500 (bottom left) and 2100-hours (bottom right).


Clinical Neurocardiology Laboratory
McMaster University
Name: SAMPLE Hosp. ID: XXXX IDX: XXXX
Date: XX/XX/XX Time: 0300 Age: XX Sex: M/F
Meds: XXXX
RESULTS
H.R.: 67.6 (+/-) 3.54
lf pk: 80.5 (+/-) 30.2 hf pk: 40.5 (+/-) 27.2 lf/hf pk 3.29 (+/-) 2.51
lf area: 5323 (+/-) 1.03e+03 hf area: 4130 (+/-) 1375 lf/hf area 1.46 (+/-) 0.581
lf area %: 56.9 (+/-) 10.3 hf area %: 43.1 (+/-) 10.3
lf cf: 0.052 (+/-) 0.0068 hf cf: 0.213 (+/-) 0.0332
Power (bts/min²/Hz)
0300
0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400 0.450 0.500


Clinical Neurocardiology Laboratory
McMaster University
Name: SAMPLE Hosp. ID: XXXX IDX: XXXX
Date: XX/XX/XX Time: 0900 Age: XX Sex: M/F
Meds: XXXX
RESULTS
H.R.: 94.5 (+/-) 5.12
lf pk: 78.9 (+/-) 31.8 hf pk: 21.3 (+/-) 8.28 lf/hf pk 4.69 (+/-) 3.62
lf area: 6142 (+/-) 1.05e+03 hf area: 3404 (+/-) 845.3 lf/hf area 2.01 (+/-) 1.02
lf area %: 64.2 (+/-) 8.1 hf area %: 35.8 (+/-) 8.1
lf cf: 0.069 (+/-) 0.016 hf cf: 0.215 (+/-) 0.0652
Power (bts/min²/Hz)
0900
0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400 0.450 0.500


Clinical Neurocardiology Laboratory
McMaster University
Name: SAMPLE Hosp. ID: XXXX IDX: XXXX
Date: XX/XX/XX Time: 1500 Age: XX Sex: M/F
Meds: XXXX
RESULTS
H.R.: 65.8 (+/-) 5.91
lf pk: 58.6 (+/-) 28.6 hf pk: 54.4 (+/-) 36.7 lf/hf pk 1.77 (+/-) 1.6
lf area: 5458 (+/-) 1.36e+03 hf area: 6209 (+/-) 1331 lf/hf area 0.948 (+/-) 0.364
lf area %: 46.7 (+/-) 10.4 hf area %: 53.3 (+/-) 10.4
lf cf: 0.064 (+/-) 0.022 hf cf: 0.257 (+/-) 0.0567
Power (bts/min²/Hz)
1500
0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400 0.450 0.500
Frequency (Hz)


Clinical Neurocardiology Laboratory
McMaster University
Name: SAMPLE Hosp. ID: XXXX IDX: XXXX
Date: XX/XX/XX Time: 2100 Age: XX Sex: M/F
Meds: XXXX
RESULTS
H.R.: 60.8 (+/-) 2.97
lf pk: 55.2 (+/-) 19 hf pk: 87.5 (+/-) 22.3 lf/hf pk 0.672 (+/-) 0.303
lf area: 4952 (+/-) 1.15e+03 hf area: 5361 (+/-) 812.4 lf/hf area 0.947 (+/-) 0.274
lf area %: 47.7 (+/-) 6.84 hf area %: 52.3 (+/-) 6.84
lf cf: 0.061 (+/-) 0.017 hf cf: 0.26 (+/-) 0.00806
Power (bts/min²/Hz)
2100
0.050 0.100 0.150 0.200 0.250 0.300 0.350 0.400 0.450 0.500
Frequency (Hz)

$p<0.05$) and 2100-hours (6517.56 ± 114.89 $(beats/minute)^2/Hz$; $p<0.01$) (see Figure 5). No new main effects or interactions were found following the separation of groups based on LVF or beta-blocker therapy. However, a main effect for MI status was found ($p<0.05$). Patients with a prior MI had a significantly larger LF area (6588.25 ± 156.39 $(beats/minute)^2/Hz$) compared to those with no prior MI history (6124.84 ± 173.30 $(beats/minute)^2/Hz$) (see Figure 6).

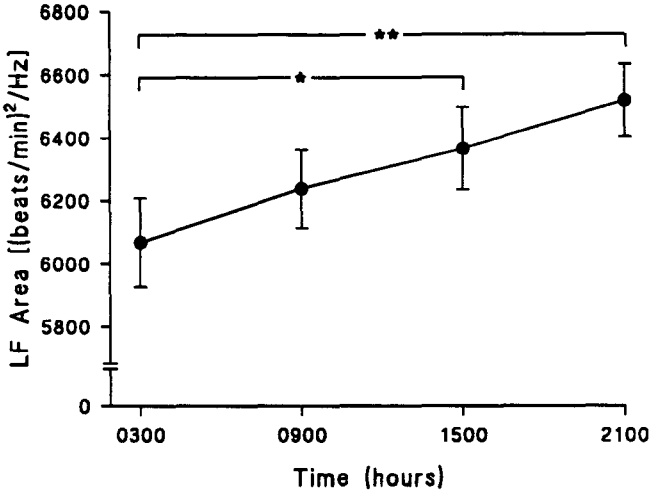
High frequency area demonstrated a significant circadian pattern ($p<0.01$), as this dependent measure increased from 0300 to 0900-hours, and then returned approximately to its 0300-hours value by 2100-hours. Post hoc analysis revealed a significant increase in HF area between 0300-hours (4432.21 ± 198.85 $(beats/minute)^2/Hz$) and 0900-hours (4873.07 ± 162.29 $(beats/minute)^2/Hz$; $p<0.05$), as well as a significant decrease between 0900-hours and 2100-hours (4465.14 ± 174.30 $(beats/minute)^2/Hz$; $p<0.05$) (see Figure 5). Following the division of subjects no additional findings were observed.

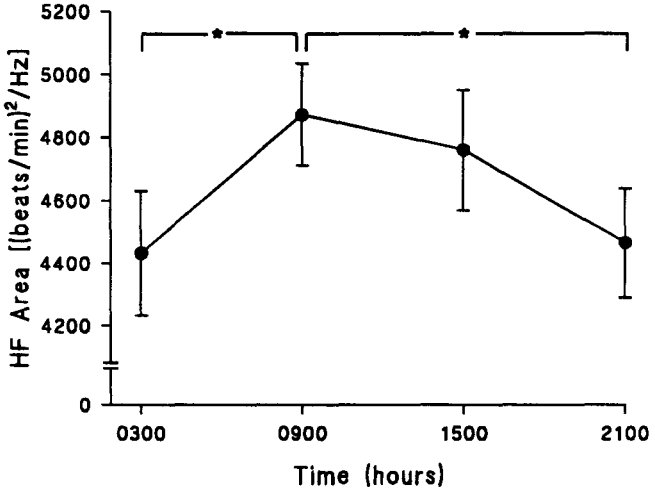
A main effect for TIME was not found for LF:HF area ratio ($p=0.140$). The only significant finding was a main effect for MI on LF:HF area ratio ($p<0.05$). Those with a prior MI had a larger LF:HF ratio (1.86 ± 0.11) than those with no history of a MI (1.50 ± 0.10) (see Figure 6).

Figure 5: The circadian pattern of LF area (top); ★ demonstrates that LF area was significantly less at 0300-hours compared to 1500-hours ($p<0.05$) and ★★ compared to 2100-hours ($p<0.01$).

The circadian pattern of HF area (middle); ★ denotes a significant increase in HF area from 0300-hours to 0900-hours and a significant decrease from 0900-hours to 2100-hours ($p<0.05$).

The circadian pattern of TA (bottom); ★★ demonstrates TA to be significantly lower at 0300-hours compared to all other times over 24-hours ($p<0.01$).


6800
6600
6400
6200
6000
5800
0
LF Area [(beats/min)²/Hz]
**
*
0300
0900
1500
2100
Time (hours)


5200
5000
4800
4600
4400
4200
0
HF Area [(beats/min)²/Hz]
*
*
0300
0900
1500
2100
Time (hours)

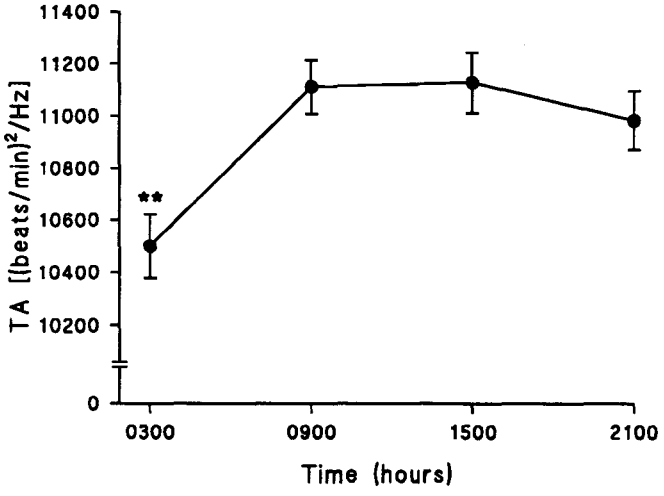
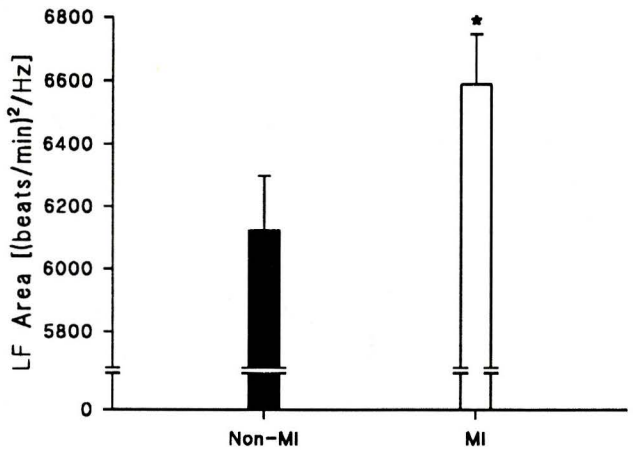
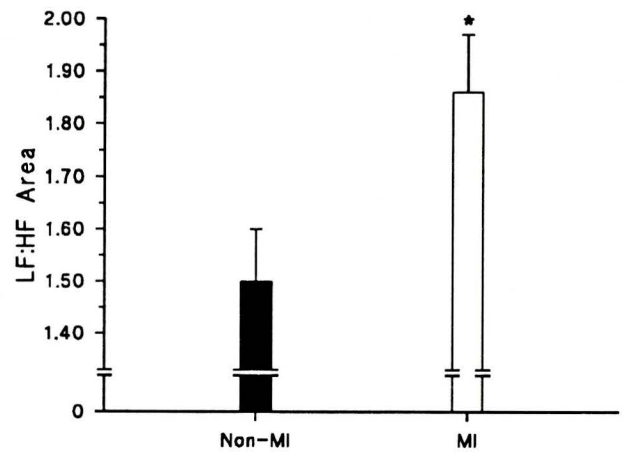

11400
11200
11000
10800
10600
10400
10200
0
TA [(beats/min)²/Hz]
**
0300
0900
1500
2100
Time (hours)

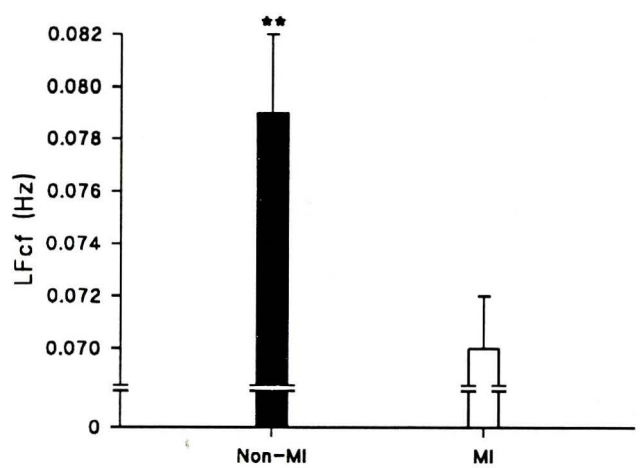
Figure 6: The effect of MI on LF area (top); ★ denotes that CAD patients with a MI had a greater LF area compared to those with no MI ($p<0.05$).

The effect of MI on LF:HF area ratio (middle); ★ reveals a significantly greater LF:HF area ratio for those CAD patients with a MI compared to those without ($p<0.05$).

The effect of MI on LFcf (bottom); ★★ demonstrates LFcf to be greater in those CAD patients with no MI compared to those with a MI ($p<0.01$).


6800
6600
6400
6200
6000
5800
0
LF Area [(beats/min)²/Hz]
*
Non-MI
MI


2.00
1.90
1.80
1.70
1.60
1.50
1.40
0
LF:HF Area
*
Non-MI
MI


0.082
0.080
0.078
0.076
0.074
0.072
0.070
0
LFcf (Hz)
**
Non-MI
MI

Total area demonstrated a main effect for TIME ($p<0.01$). This frequency domain measure increased dramatically from 0300 to 0900-hours. It continued to increase at a slower rate from 0900 to 1500-hours, then decreased somewhat between 1500 to 2100-hours. Total area was significantly less at 0300-hours compared to all other times ($p<0.01$) according to post hoc analysis (see Figure 5). No additional findings were found following subject division according to LVF, MI status or beta-blocker therapy.

Low frequency cf failed to demonstrate a significant effect for TIME ($p=0.065$). However, a main effect for MI status was found ($p<0.01$). Those patients with a MI had a lower LFcf (0.070 ± 0.002 Hz) than those with no prior MI (0.079 ± 0.003 Hz) (see Figure 6). Beta-blocker therapy and LVF failed to yield additional findings.

3.4 The Effects of Stress on HR and HRV Indices (Day 1 versus Day 4)

3.4.1 HR

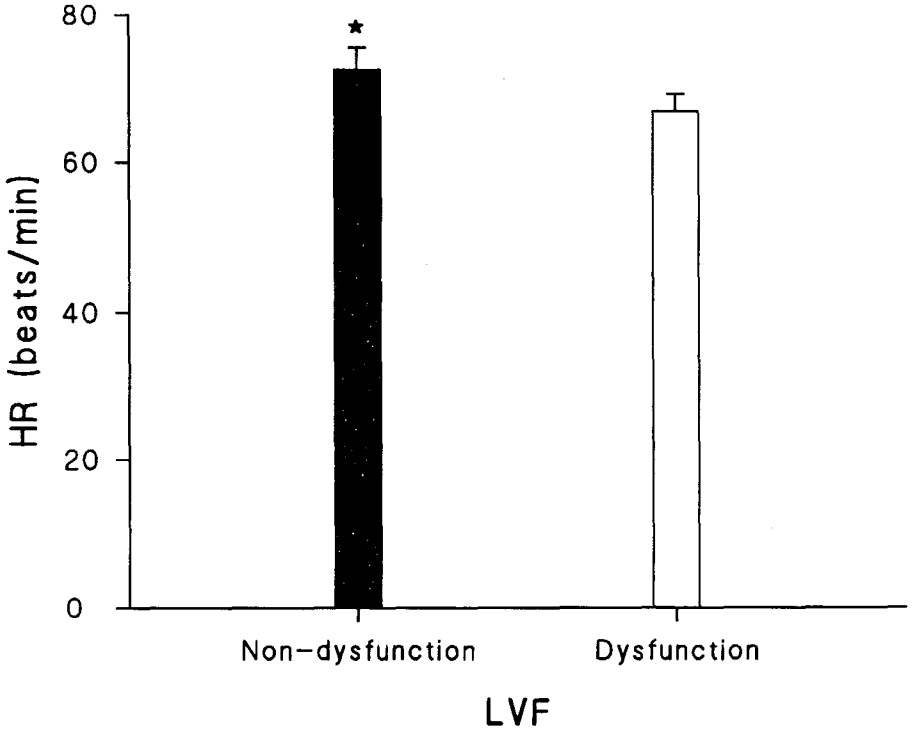
The overall effects of stress (DAY) were evaluated by comparing Day 1 to Day 4. Day 1 was hypothesized as the most stressful day, as patients had not yet received the results of their angiogram and were quite uncertain about their current health status. The least stressful day was judged to be Day 4, as it represented the farthest 24-hour period from the initial stressful period (two weeks earlier), and followed Day 3, allowing for a reduction in anxiety commonly felt by patients as a reaction to wearing the Holter monitor.

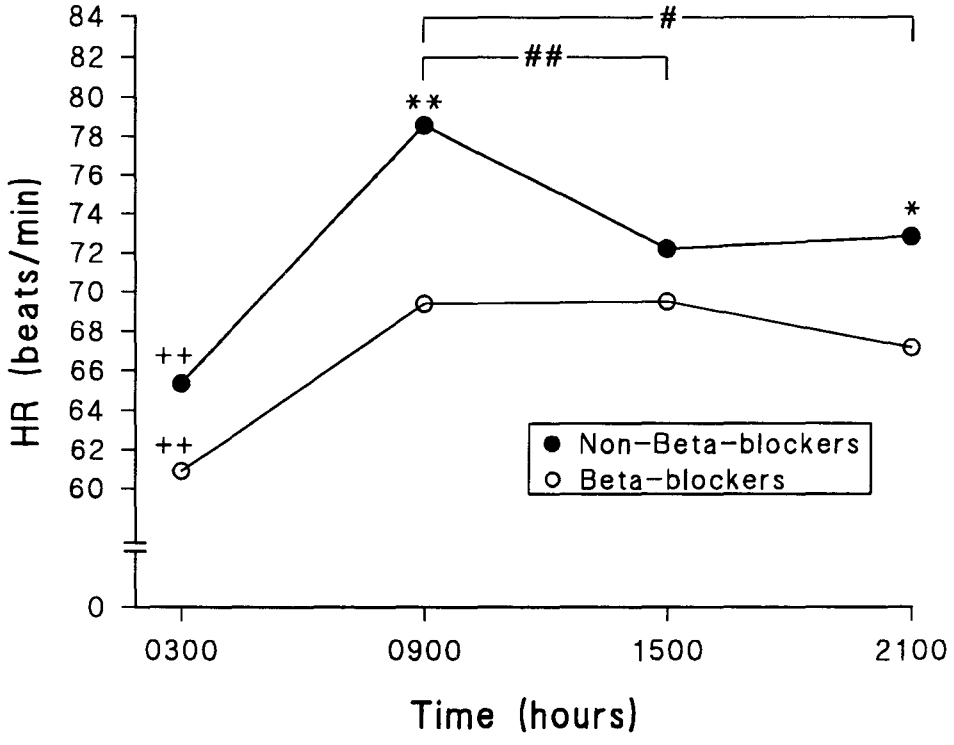
Heart rate did not demonstrate a significant effect for stress ($p=0.283$). As well, the DAY X TIME interaction for stress and time of day (circadian) was not significant ($p=0.071$).

Subsequent analysis following group division into those with LV dysfunction versus those with normal function, demonstrated a significant main effect for LVF ($p<0.05$). Patients with normal LVF were found to have a higher HR (72.54 ± 2.90 beats/minute) compared to those patients with dysfunction (66.68 ± 2.36 beats/minute) (see Figure 7). As for beta-blocker therapy, the average HR of those patients not on beta-blockers (72.21 ± 2.71 beats/minute) did not differ significantly from those patients on beta-blockers (66.70 ± 2.42 beats/minute; $p=0.062$). However, a significant GROUP X TIME interaction ($p<0.05$) for beta-blocker therapy was found. Post hoc analysis revealed that those patients not on beta-blockers had a significantly greater HR at both 0900-hours (78.55 ± 2.68 beats/minute; $p<0.01$) and 2100-hours (72.79 ± 2.65 beats/minute; $p<0.05$), compared to those patients on beta-blockers (69.36 ± 2.35 and 67.10 ± 2.65 beats/minute respectively). In addition, unlike those on beta-blockers, patients not taking beta-blockers demonstrated a significant decrease in HR from 0900-hours to 1500-hours (72.18 ± 2.70; $p<0.01$) and 2100-hours ($p<0.05$) (see Figure 7). Lastly, when dividing the patient group into those who have experienced a MI and those who have not, no main effects or significantly important interactions were found.

Figure 7: The effect of LVF on HR (top); ★ denotes that CAD patients with normal LVF had a higher HR compared to those with dysfunction ($p<0.05$).

The effect of beta-blocker therapy on the circadian pattern of HR (bottom); **++** denotes that within each group of patients the HR at 0300-hours was significantly lower than at any other time ($p<0.01$), while ✳✳ denotes a greater HR at 0900-hours ($p<0.01$) and ✳ at 2100-hours ($p<0.05$) for CAD patients not on beta-blockers compared to those on beta-blockers. In addition, **##** and **#** demonstrates a significant decrease in HR in those patients not on beta-blockers from 0900-hours to 1500-hours ($p<0.01$), and 2100-hours ($p<0.05$) respectively.


80
60
40
20
0
HR (beats/min)
*
Non-dysfunction
Dysfunction
LVF


84
82
80
78
76
74
72
70
68
66
64
62
60
0
HR (beats/min)
#
##
**
*
++
++
Non-Beta-blockers
Beta-blockers
0300
0900
1500
2100
Time (hours)

3.4.2 Time Domain Indices

For the time domain measure SDNN, no significant effect for stress was found, but there was a trend towards an increase from Day 1 to Day 4 ($p=0.072$). Upon classifying the group according to LVF, there was no main effect for function ($p=0.661$). However, there was a main effect for DAY as SDNN increased from 111.67 ± 6.13 ms on Day 1, to 121.54 ± 6.94 ms on Day 4 ($p<0.05$) (see Figure 8). In addition, there was a significant GROUP X DAY interaction between LVF and stress ($p<0.01$). According to post hoc analysis, the subjects with normal function demonstrated a significant increase in SDNN from Day 1 (101.27 ± 8.69 ms) to Day 4 (125.97 ± 12.33 ms; $p<0.01$), while those with dysfunction failed to show a significant change from Day 1 (120.13 ± 8.20 ms) to Day 4 (117.93 ± 7.88 ms) (see Figure 8). Similarly, upon dividing the group according to beta-blocker therapy, a significant GROUP X DAY interaction occurred ($p<0.05$). Post hoc analysis showed that SDNN increased significantly from Day 1 (107.76 ± 7.15 ms) to Day 4 (127.01 ± 8.87 ms) in those on beta-blockers ($p<0.05$), with no significant change in those patients not on beta-blockers (117.22 ± 10.99 ms on Day 1 versus 113.78 ± 11.17 ms on Day 4) was found (see Figure 8). As for MI status, no main effects or statistically significant interactions were observed.

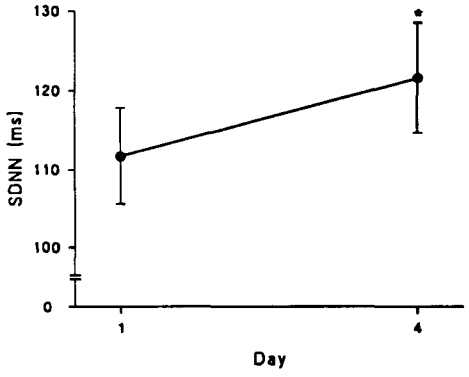
The overall effect of stress on SDANN was not significant ($p=0.182$). Similar to SDNN, SDANN showed a GROUP (LVF) X DAY (stress) interaction

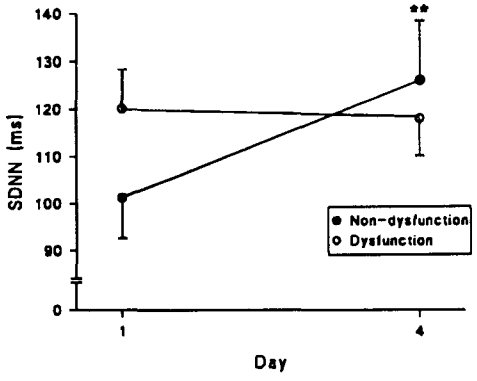
Figure 8: The effect of stress on SDNN (top left); ★ demonstrates a significant increase from Day 1 to 4 ($p<0.05$).

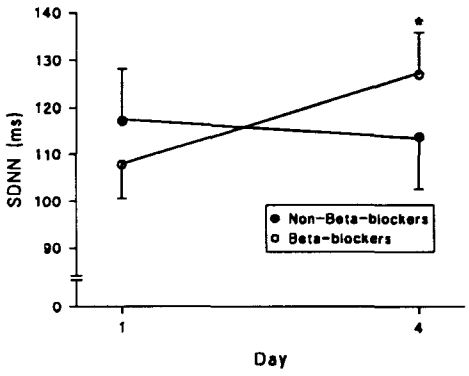
The combined effects of stress and LVF on SDNN (top right); ★★ denotes a significant increase in SDNN from Day 1 to 4 for those CAD patients with normal LVF ($p<0.01$).

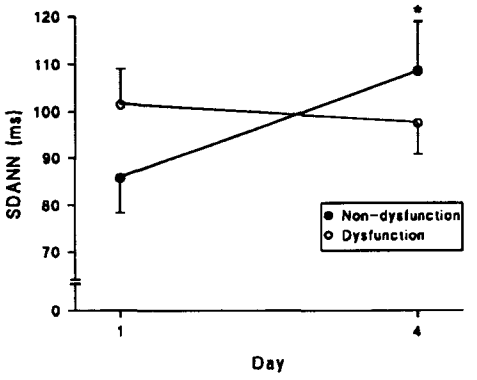
The combined effects of stress and beta-blocker therapy on SDNN (bottom left); ★ reveals a significant increase in SDNN from Day 1 to 4 for those CAD patients on beta-blockers ($p<0.05$).

The combined effects of stress and LVF on SDANN (bottom right); ★ denotes an increase in SDANN from Day 1 to 4 for those CAD patients with normal LVF ($p<0.05$).


130
120
110
100
0
SDNN (ms)
*
1
4
Day


140
130
120
110
100
90
0
SDNN (ms)
**
Non-dysfunction
Dysfunction
1
4
Day


140
130
120
110
100
90
0
SDNN (ms)
*
Non-Beta-blockers
Beta-blockers
1
4
Day


120
110
100
90
80
70
0
SDANN (ms)
*
Non-dysfunction
Dysfunction
1
4
Day

($p<0.05$). Once again those with normal LVF demonstrated a significant increase in SDANN from Day 1 (85.78 ± 7.37 ms) to Day 4 (108.65 ± 10.42 ms; $p<0.05$). In contrast, those with LV dysfunction demonstrated no significant change following post hoc analysis (see Figure 8). No other significant effects for MI or beta-blocker therapy were noted.

From the stressful period on Day 1 to the less stressful period on Day 4, pNN50 increased only slightly from 11.01 ± 2.95% to 12.82 ± 2.23% ($p=0.196$). Likewise, the measure pNN50 failed to show any significant effects after dividing the patient group according to LVF, MI status or beta-blocker therapy.

3.4.3 Frequency Domain Indices

An overall decrease in LF area from Day 1 (6343.63 ± 119.68 $(beats/minute)^2/Hz$) to Day 4 (6288.31 ± 132.77 $(beats/minute)^2/Hz$) was found to be non-significant ($p=0.389$). Division of groups by LVF and MI status did not reveal any significant main effects or interactions. Low frequency area did show a significant GROUP X DAY X TIME interaction between beta-blocker therapy, day and time of day ($p<0.01$). However, post hoc analysis failed to show anything of importance.

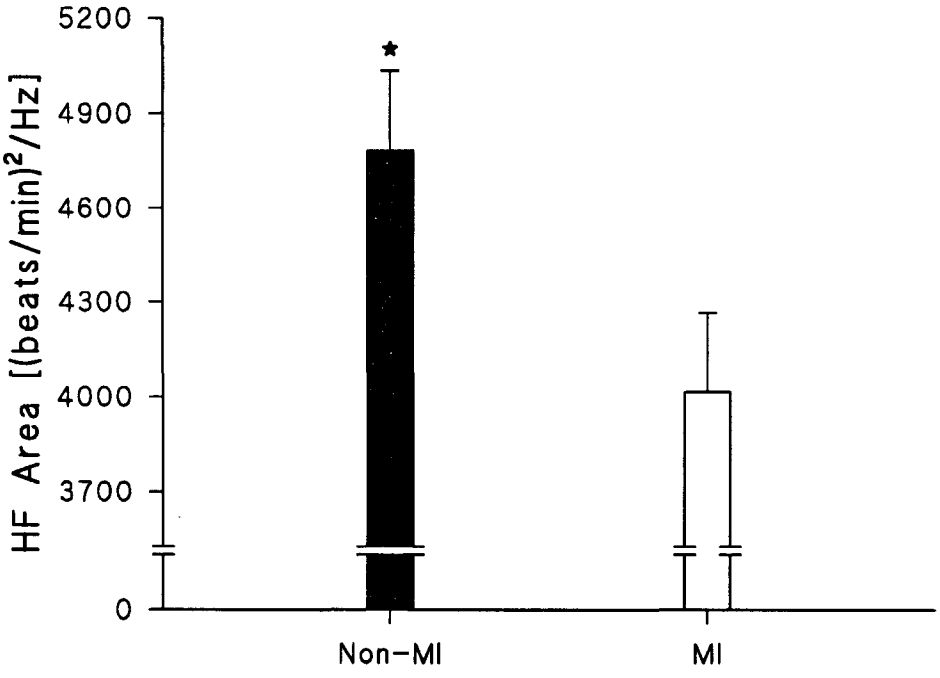
The overall effect of stress on HF area was not significant. Nevertheless, a trend towards an increase in HF area was observed from Day 1 (4456.93 ± 196.63 $(beats/minute)^2/Hz$) to Day 4 (4598.81 ± 190.43 $(beats/minute)^2/Hz$; $p=0.095$). Likewise, statistical analysis following the division of patients

according to LVF and beta-blocker therapy did not yield any significant associations. However, splitting patients according to MI status demonstrated that those patients with a prior MI had significantly lower HF area (4051.17 ± 249.10 (beats/minute)^2/Hz) compared to those with no MI history (4784.55 ± 250.33 (beats/minute)^2/Hz; $p<0.05$) (see Figure 9).

The frequency domain measure LF:HF area ratio, demonstrated a main effect for DAY ($p<0.05$) (see Figure 10). A significant decrease was observed from Day 1 (1.74 ± 0.09) to Day 4 (1.64 ± 0.09). Dividing the group into those with LV dysfunction, versus those patients with normal function, failed to show any significantly new findings. However, a significant GROUP X DAY X TIME interaction for beta-blocker therapy was found for LF:HF area ratio ($p<0.01$). Post hoc analysis revealed that patients not on beta-blockers had a significant decrease in LF:HF area at 0900-hours from the stressful period on Day 1 (1.89 ± 0.16) to the less stressful time period on Day 4 (1.44 ± 0.11; $p<0.01$). In contrast, those on beta-blockers failed to show a significant change from Day 1 to Day 4 at any of the four specified time periods (see Figure 10). In addition, a three-way ANOVA looking at the effects of stress (DAY), time of day (TIME), and MI status (GROUP) on LF:HF area, revealed a significant main effect for MI status ($p<0.05$). Patients with a history of MI had a higher LF:HF area value of 1.93 ± 0.14, as opposed to 1.56 ± 0.11 in those without a prior MI (see Figure 9). There were no other significant findings for LF:HF area.

Figure 9: The effect of MI on HF area (top); ★ denotes that CAD patients with no MI had a significantly greater HF area compared to those with a MI ($p<0.05$).

The effect of MI on LF:HF area ratio (bottom); ★ denotes LF:HF area ratio to be significantly larger in those CAD patients with a MI compared to those with no MI ($p<0.05$).


5200
4900
4600
4300
4000
3700
0
HF Area [(beats/min)²/Hz]
*
Non-MI
MI

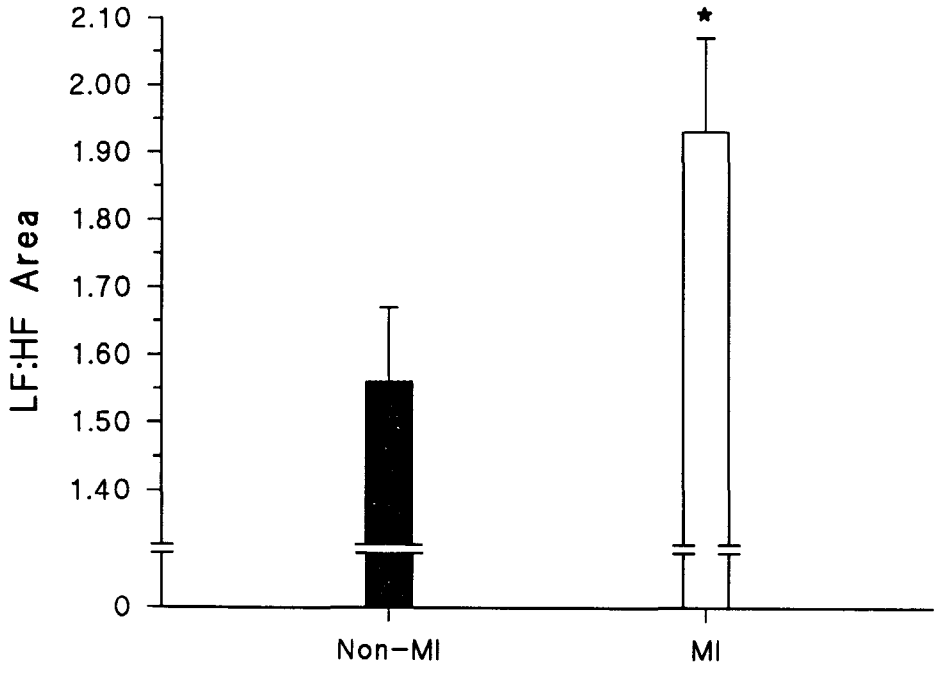
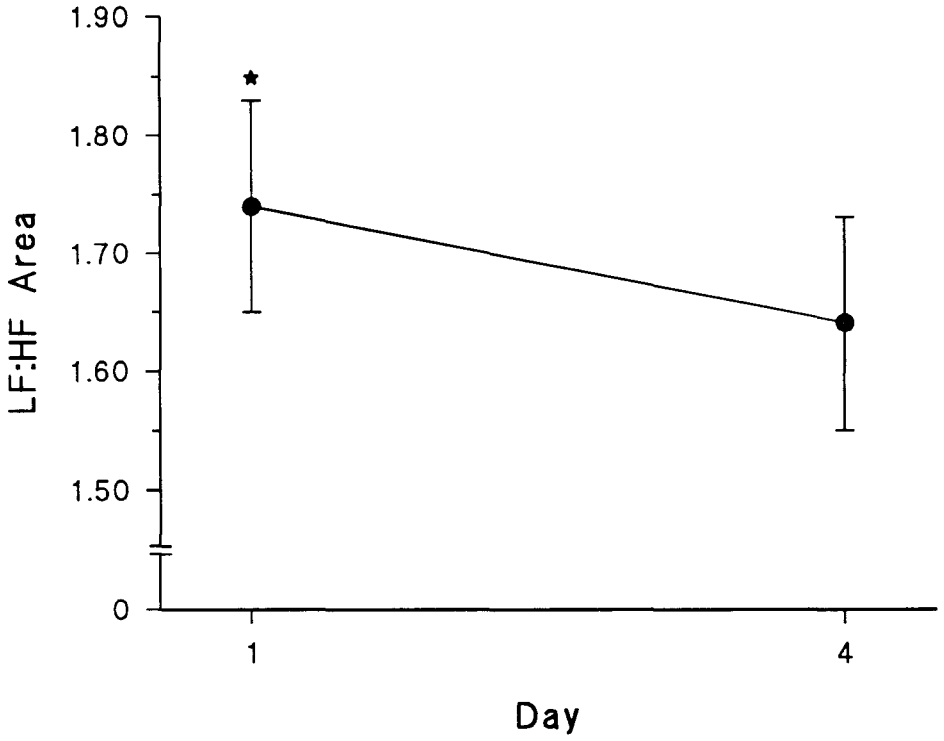
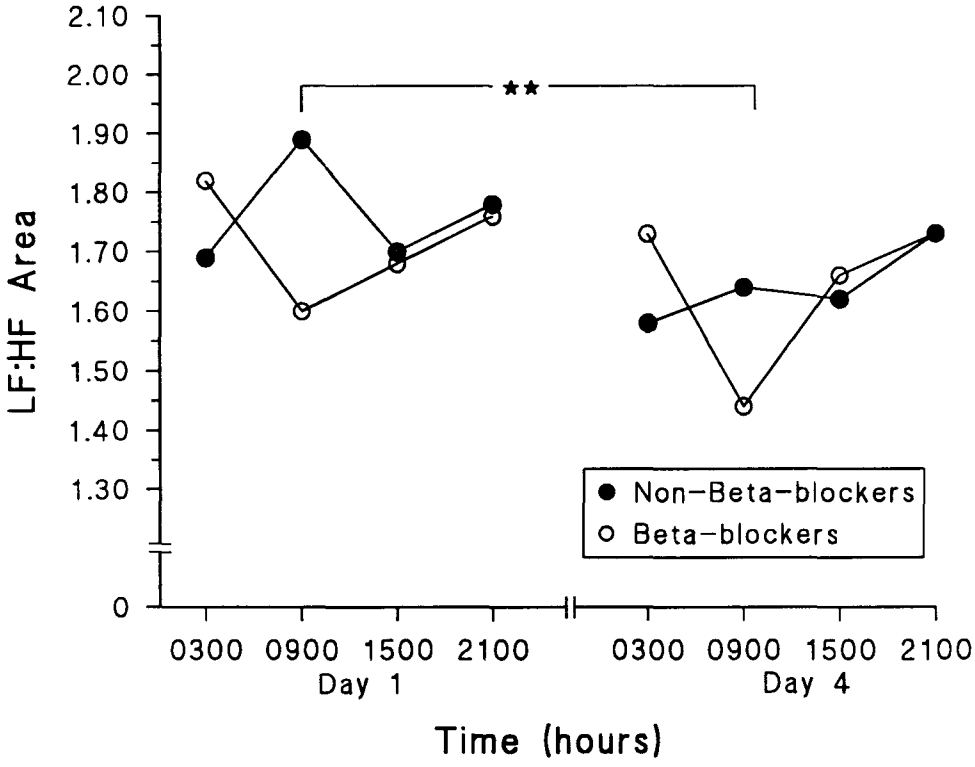

2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
0
LF:HF Area
*
Non-MI
MI

Figure 10: The effect of stress on LF:HF area ratio (top); ★ denotes a significant decrease in LF:HF area ratio from Day 1 to 4 ($p<0.05$).

The combined effects of stress and beta-blocker therapy on circadian LF:HF area ratio (bottom); ★★ reveals a significant decrease in LF:HF area ratio at 0900-hours from Day 1 to 4 in those CAD patients not on beta-blockers ($p<0.01$).


1.90
1.80
1.70
1.60
1.50
0
LF:HF Area
*
1
4
Day


2.10
2.00
1.90
1.80
1.70
1.60
1.50
1.40
1.30
0
LF:HF Area
**
Non-Beta-blockers
Beta-blockers
0300 0900 1500 2100
Day 1
0300 0900 1500 2100
Day 4
Time (hours)

Total area failed to demonstrate a significant effect for stress (Day 1 versus Day 4). On Day 1 TA was 10801.06 ± 137.53 $(beats/minute)^2/Hz$ and increased to 10887.13 ± 114.14 $(beats/minute)^2/Hz$ on Day 4 ($p=0.263$). Subsequent division of the subject group according to beta-blocker therapy, MI status and LVF also yielded no significant findings.

Low frequency cf failed to demonstrate an overall effect for stress ($p=0.298$) and there were no independent effects of beta-blocker therapy, MI status or LVF.

4.0 DISCUSSION

4.1 Purpose

The primary objective(s) of this investigation was to determine whether: 1.) HRV indices are reproducible; 2.) HRV indices in CAD patients follow a circadian pattern; and 3.) a real life, psychologically and emotionally stressful event (coronary angiogram) affects overall HRV (both time and frequency domain indices) in patients with CAD. In addition, a further purpose was to determine how MI status, beta-blocker therapy and LVF affects overall HRV in CAD patients, the circadian pattern of HRV, as well as the influence of stress on HRV.

4.2 Reproducibility of HR and HRV Indices

Reproducibility of 24-hour time domain and frequency domain indices has been reported in normals (Freed et al., 1994; Hohnloser et al., 1992; Kleiger et al., 1991; Huikuri et al., 1990) and in patients with heart disease (Nolan et al., 1996; Bigger et al., 1992b). However, these studies failed to determine when HRV is most reproducible over 24-hours. To answer this question, the present study looked at the reproducibility of 24-hour time domain indices, as well as HR and frequency domain indices for four 45-minute time periods starting at 0300, 0900, 1500, and 2100-hours.

In this study, the intraclass correlation coefficients for the time domain indices SDNN, SDANN and pNN50, were similar to those reported for normals (Kleiger et al., 1991) and patients with various types and degrees of heart disease (Nolan et al., 1996; Kautzner et al., 1995; Bigger et al., 1992b). However, the high reproducibility coefficient observed in this study for pNN50, does not agree with the findings of Kautzner et al. (1995). These investigators reported on the reproducibility of two consecutive 24-hour ambulatory Holter monitoring periods on days four and five post-MI. Autonomic nervous system function is altered following a MI; the process of returning towards a normal healthy state may explain the lack of reproducibility of pNN50 reported by Kautzner et al. (1995), as HRV has been known to change within one week post-MI (Lombardi et al., 1996a). In addition, MI location has been reported to affect ANS activity and in turn HRV. The inferior LV wall is richly innervated by the PNS. As the result of an inferior MI, vagal modulation increases, resulting in bradycardia and sudden beat-to-beat NN-interval length changes and corresponding pNN50 variability. (Lombardi et al., 1996a; Singh et al., 1996; Flapan et al., 1993; Webb et al., 1972).

Heart rate and frequency domain intraclass correlation coefficients for LF area, HF area, LF:HF area ratio, TA and LFcf, coincide with intraclass correlation coefficients of 24-hour average HR and frequency domain indices reported in both normals (Kleiger et al., 1991) and heart diseased patients (Bigger et al.,

1992b). Adding to the findings of past studies, this study found both HR and frequency domain indices to be more reproducible at 0300-hours compared to any other time over 24-hours. In contrast, the time which demonstrated the least reproducibility was 1500-hours. At 0300-hours (3 am), patients were most likely asleep, as this activity rarely varies from one day to the next. However, during the day at 1500-hours (3 pm), patients were participating in a variety of different activities that could have differed from one recording period to the next. This may account for the frequency domain indices being less reproducible at this time. In fact, past studies have shown frequency domain indices, taken every hour for 24-hours, to be more variable during the day compared to at night due to the wide variety of activities an individual may participate in over a given day (Fallen and Kamath, 1995; Lombardi et al., 1992; Furlan et al., 1990).

4.3 Circadian Variability of HR and HRV Indices

In this study HR was observed to increase significantly from 0300-hours to 0900-hours and remain elevated at 1500 and 2100-hours. Circadian rhythm of ambulatory HR has been reported to be significantly higher during the day compared to at night in healthy individuals (Mølgaard et al., 1991; Huikuri et al., 1990). A similar, yet blunted circadian pattern has been reported in CAD, CHF and/or post-MI patients (Lombardi et al., 1992; Kamath and Fallen, 1991; Casolo et al., 1989; Bigger et al., 1988).

As with HR, LF area, HF area, and LF:HF area ratio circadian pattern in heart disease patients are reportedly blunted compared to healthy controls (Lombardi et al., 1992; Casolo et al., 1991). Our findings agree with those of others which described a greater LF area during the day compared to night in both normals (Furlan et al., 1990) and post-MI patients (Lombardi et al., 1992; Casolo et al., 1991). However, for post-MI patients this finding failed to reach significance, possibly due to the small sample sizes used in previous studies by other groups (Lombardi et al., 1992; Casolo et al., 1991 & 1989).

The observed increase in TA from 0300-hours to day hours (0900, 1500, and 2100-hours) is a novel finding. In normals, SDNN for one hour segments, has been reported to show a similar pattern over 24-hours (Mølgaard et al., 1991). This is to be expected as SDNN has been found to correlate with TA (Kleiger et al., 1995).

The observed increase in HF area from 0300 to 0900-hours contradicts past observations of a decrease in HF area from sleep to wakefulness in both normals (Lombardi et al., 1992; Casolo et al., 1991; Furlan et al., 1990) and patients with heart disease (Lombardi et al., 1992; Casolo et al., 1991). As well, the significant decrease in HF area from 0900 to 2100-hours in the current investigation has not been reported previously in patients with heart disease. However, a non-significant decrease in HF area from 7-12 am to 7-12 pm was found by Casolo et al. (1991). Further investigations are required to solve these

discrepancies, as the information obtained from the present study does not allow us to comment on the above observations.

The dramatic increase in HR, LF area and TA from night to day hours likely reflects SNS predominance during the day and vagal predominance at night (Murakawa et al., 1993; Lombardi et al., 1992; Casolo et al., 1991; Mølgaard et al., 1991; Furlan et al., 1990; Huikuri et al., 1990). Studies investigating circadian variability of NE and epinephrine (E) levels (Tofler et al., 1987), as well as cortisol secretion (Weitzman et al., 1971) and alpha adrenergic activity (Panza et al., 1991), support the observation that SNS is elevated during awake hours. Circadian pattern of ischemic episodes, ectopic activity and ventricular arrhythmias, have also been found to coincide with elevated SNS activity over the day, subsiding at night with heightened PNS activity and attenuated sympathetic modulation (Fallen and Kamath, 1995; Hohnloser and Kingenheben, 1994; Rocco et al., 1987).

Failure to find a significant circadian pattern for LF:HF area ratio coincides with past studies (Lombardi et al., 1992; Casolo et al., 1991), and may be the result of persistent sympathetic overreactivity throughout the 24-hour period in CAD patients (Lombardi et al., 1992; Mølgaard et al., 1991). As a result, fluctuations in sympathovagal balance are blunted as the ANS system is primarily saturated with sympathetic input.

4.4 The Effects of Stress on HR and HRV Indices

The stressful event used in this study, coronary angiography, failed to have a significant effect on HR, unlike previously reported findings using standardized mental stressors (arithmetic tests, video games, reaction time tests, psychological interviews and task oriented tests) conducted in a laboratory acute setting (Lane et al., 1992; L'Abbate et al., 1991; Sloan et al., 1991; Follick et al., 1990; Norvell et al., 1989; Specchia et al., 1984; Bassan et al., 1980). Moreover, studies employing real life stressful events have also reported a significant increase in HR during the event (Myrtek et al., 1996; Dobkin and Pihl, 1992). The lack of a significant increase in HR in this study could have been the result of the stressful event being too weak. In addition, inter-individual variability could have played a role, as each individual responds to stress differently depending on the meaning of the event to the individual, how sensitive their physiological mechanisms are to the event, and the type of coping strategies the individual relies on (Myrtek et al., 1996; Coumel and Leenhardt, 1991). Nevertheless, Tuininga and colleagues (1995) also failed to find a significant increase in heart rate during a mental performance task in thirty post-MI patients, thus concurring with the finding of this study.

To date, very few studies have examined the effects of stress on time domain indices (Myrtek et al., 1996; Singh et al., 1996). In this study, SDNN was found to increase significantly from Day 1 (24-hours immediately following

coronary angiography and representing the stressful period) to Day 4 (24-hour recording period two weeks following coronary angiogram and representing the less stressful period). This observation suggests that neural modulation of HR was primarily affected by sympathetic components of the ANS during stress and returned to normal levels after two weeks.

Studies assessing the effects of mental stress on frequency domain indices in normals have shown LF area to increase, while HF area and RSA to decrease (Jiang et al., 1993; Langewitz et al., 1991; Pagani et al., 1991; Sloan et al., 1991). In a study by Pagani et al. (1991), both healthy controls and post-MI patients participated in a personal interview. The results revealed an increased LF area and a decreased HF area for both groups, but the changes in post-MI patients did not reach significance (Pagani et al., 1991).

In a similar study to the current one, Singh et al. (1996) reported that coronary angiography in post-MI patients caused a significant increase ($p=0.001$) in both LF and HF area, but no change in LF:HF area ratio compared to baseline values. The observed decrease in LF:HF area ratio, and increase in HF area and TA from Day 1 to Day 4 in the present investigation, therefore contradicts the findings of Singh et al. (1996). Nevertheless, the increase in TA coincides with the aforementioned increase in SDNN from Day 1 to 4.

Disagreement between the findings of this investigation and those of Singh and colleagues (1996), can be explained by several differences in

methodological procedures. First, Singh et al. (1996) assessed patients within the first 48-hours following a MI, whereas this study assessed CAD patients who may or may not have had a MI occurring a minimum of four weeks prior to angiogram; as well, their subjects were on thrombolytic therapy, while the subjects of this study were not. Second, baseline values in the current investigation were taken two weeks following coronary angiography, whereas Singh et al. (1996) took the second day immediately following angiography to represent baseline. Third, each subject responds to a stressful situation differently. These differences may have contributed to the difference in results between the two studies. In any case, ANS function appears to be altered during stress towards SNS predominance.

Both physical and mental stress has been found to induce a burst of SNS activity known as the *"fight-or-flight response"* (Vander et al., 1990). Upon the onset of a stressful event, HR, E and NE, cortisol secretion, BP and oxygen consumption all increase (Lane et al., 1992; L'Abbate et al., 1991; Follick et al., 1990; Norvell et al., 1989; Freeman et al., 1987; Specchia et al., 1984; Bassan et al., 1980; Hickam et al., 1948).

In a previous study by Freeman and colleagues (1987), thirty patients with angina underwent coronary angiography. These investigators hypothesized the stressful period to be 48-hours immediately following angiography, as during this time period patients were uncertain about test results and future surgery

options; the non-stressful period followed approximately nine weeks later. Measurements of cortisol secretion and NE/E blood concentrations, as well as the occurrence of ischemic episodes, revealed SNS overreactivity during the stressful period, whereas ANS status returned to normal weeks later. Thus, the increase in SDNN, HF area and TA area, and the decrease in LF area and LF:HF area ratio from Day 1 to 4 in this study, reflects heightened SNS modulation 24-hours following angiography (Day 1) and the return of sympathovagal balance two weeks later (Day 4).

4.5 The Effects of a MI on HR and HRV Indices

Although groups were not randomly chosen, the significant effect of MI status on LF area, HF area, LF:HF area ratio and LFcf in this study coincides with previous investigations. Both LF area and LF:HF area ratio have been reported to be elevated, while HF area reduced in post-MI patients compared to normals (Lombardi et al., 1996a, 1992 & 1987; Casolo et al., 1991; Coumel et al., 1991; Pagani et al., 1991; Saul et al., 1988). However, in a study by Huang and colleagues (1995), a non-significant difference between those with unstable angina and those with a MI (age- and sex-matched) was found for LF area, HF area and LF:HF area ratio. Contradicting this study, the time domain measure SDNN, which has been reported to significantly correlate with both TA and LF area (Bigger et al., 1992a; Dougherty and Burr, 1992), was found to be greater in patients with unstable angina compared to post-MI patients (Casolo et al., 1992).

The lack of a significant finding by Huang et al. (1995), as opposed to the present results, could be the result of the patient populations compared. This study included only patients with stable angina, thus reflecting a 'healthier' patient population and explaining the significant findings of this study, as opposed to the lack of findings previously reported (Huang et al., 1995).

The results of the present and past studies suggest a heightened sympathovagal balance in post-MI patients, compared to patients with heart disease without a previous MI. The leftward shift in LFcf in post-MI patients observed in this investigation supports the concept of SNS predominance, and is supported by Fallen and colleagues (1988) who reported a leftward shift in LFcf in healthy male volunteers upon standing erect from a supine position. As well, a case study by Kamath et al. (1992) found that by removing direct vagal stimulation LF area increased, HF area decreased, LF:HF area ratio increased and LFcf shifted leftward, all reflecting SNS predominance.

Myocardial infarction induces geometrical alterations of the heart, subjecting cardiac afferent mechanoreceptors (located in the atria and ventricles) to abnormal stretch (Cerati and Schwartz, 1991). As a result, the discharge of afferent SNS fibres increases, increasing sympathetic reflex activity and SNS efferent activity (Cerati and Schwartz, 1991; Malliani et al., 1973; Brown and Malliani, 1971). This heightened SNS activity in turn restrains vagal outflow, thereby adding to SNS predominance (Cerati and Schwartz, 1991). In addition,

necrotic regions have been found to interrupt both sympathetic and parasympathetic neural flow to and from the apical segment of the heart. This has been suggested to cause the apical area to be supersensitive to catecholamine levels, contributing to the SNS predominance reported in post-MI individuals (Inoue and Zipes, 1987). Finally, the observed increase in muscle SNS activity (obtained from direct peroneal nerve recordings) (Kienzle et al., 1992), as well as the reported decrease in cardiac acceleration upon muscarinic blockade, following initial adrenergic blockade in heart failure patients with previous infarctions (Eckberg et al., 1971), suggests increased sympathetic and decreased parasympathetic neural outflow from higher centres.

The finding that post-MI patients failed to exhibit a significant circadian pattern for HR compared to patients with no evidence of a MI, simply supports the finding of heightened SNS activity in post-MI patients. Under SNS predominance, an increase in HR will be minimal as the ANS is already saturated (primarily) with sympathetic input concurrent with reduced parasympathetic input (Lombardi et al. 1992; Malik et al., 1990; Casolo et al., 1989; Bigger et al., 1988). This concept is further supported by a previous study done by Malik et al. (1990), who reported the circadian rhythm of HR in post-MI patients without complications to resemble that observed in normals, compared to post-MI patients with complications. In addition, splitting post-MI patients into those with low HRV (SDNN < 50 ms) and high HRV (SDNN > 100 ms) (matched

for age, LVEF and coronary rales) revealed that those with high HRV demonstrated a greater increase in HR from 0-0500 hours to 0730-1430 hours compared to those with low HRV (Bigger et al., 1988).

4.6 The Effects of LVF on HR and HRV Indices

Stratifying patients according to LVF revealed that those CAD patients with LF dysfunction had a slower HR compared to those patients with normal LVF. This finding contradicts the observations of Lombardi and colleagues (1996b), where RR-interval length was less in those patients with reduced LVEF (<40%) compared to those with normal LVEF (≥40%), but this latter finding failed to reach significance. Nevertheless, patients with advancing CHF (based on NYHA functional class) and reduced LVF have been reported to have a faster HR over the entire 24-hour period (Casolo et al., 1995). The elevated HR demonstrated by patients with normal LV function in this investigation, could be the result of these patients being more active compared to those with LV dysfunction.

A significant interaction between LVF and stress was also found for the time domain indices SDNN and SDANN. This interaction revealed that subjects with normal LVF increased significantly from Day 1 to 4, while those with dysfunction failed to demonstrate a similar change. Due to the lack of research regarding the effects of real life stressful events on HRV, this observation is an interesting and novel finding, despite the lack of subject randomization.

Power spectral analysis studies suggest that autonomic nervous system function is reduced in both post-MI patients, as well as patients with CHF and LV dysfunction, secondary to CAD (Lombardi et al., 1996b; Casolo et al., 1995). This would explain the inability of patients with LV dysfunction to adapt to various physiological and mental stimuli. In fact, power spectral activity in patients with advancing heart disease is similar to that observed in heart transplant patients (Sands et al., 1989) and those with diabetic autonomic neuropathy (Lishner et al., 1987). These observations suggest cardiac denervation (Casolo et al., 1995 & 1991) and the possibility of a diminished responsiveness of the SA node (Lombardi et al., 1996b). Additional studies focusing on patients with CHF and reduced LVF have shown heightened catecholamine levels and plasma renin activity (Casolo et al., 1995; Himura et al., 1993; Francis et al., 1984). Reduced beta-adrenergic receptor density in the heart and impaired response to beta-adrenergic stimulation has also been observed in these patients (Bristow et al., 1982). The end result is heightened SNS activity and diminished vagal modulation (Francis et al., 1984), as well as defective reflex sympathetic activity in CHF patients with reduced LVF (Francis et al., 1984; Rutenberg and Spann, 1973).

4.7 The Effects of Beta-Blocker Therapy on HR and HRV Indices

Beta-blockers have been reported to decrease HR, as well as increase HRV (including both time and frequency domain indices) towards the restoration

of ANS function to normal (Keeley et al., 1996; Niemelä et al., 1994; Cowan et al., 1993; Hohnloser et al., 1993; Cook et al., 1991; Kamath and Fallen, 1991; Guidera et al., 1990). The apparent increase in cardiac neural activity in patients on beta-blockers stems from the ability of beta-blockers to block peripheral adrenergic receptors, as well as decrease SNS afferent fibre mechanosensitivity (Lombardi et al., 1986). The end result is a decrease in SNS afferent activity and in turn reflex efferent activity, as well as the removal of SNS inhibitory influences on PNS activity (Coker et al., 1984; Scott, 1983).

In this study, the higher HR found in patients not participating in beta-blocker therapy coincides with the above proposed mechanisms. This finding is also consistent with previous investigations. It has been consistently found that patients undergoing beta-blocker therapy have a lower diurnal HR (at all times of the day), compared to those not on beta-blockers (Tuininga et al., 1995; Sandrone et al., 1994; Mølgaard et al., 1993; Kamath and Fallen, 1991).

The increase in SDNN observed two weeks following coronary angiogram (from Day 1 to 4) in those on beta-blockers, suggests that patients taking beta-blockers are capable of adapting to external physiological stimuli. This finding contradicts the observation made by Tuininga et al. (1995), who found that the beta-blockers metoprolol and atenolol attenuate the reduction in SDNN during a mental performance task in post-MI patients. However, their subjects were stable post-infarction patients and the study was conducted in a

controlled laboratory setting, which may have limited the proportion of potential effects induced by beta-blockade (Tuininga et al., 1995). As stated above, the ANS status in heart disease patients taking beta-blockers shifts towards vagal modulation, and is therefore capable of reacting to a given stimulus. In contrast, patients not on beta-blockers have a predominance of SNS modulation and reduced parasympathetic input, resulting in a heightened sympathovagal balance less capable of adjusting to external stimuli, as found in this study.

This finding also coincides with the significant increase in SDNN from Day 1 to 4 in patients with normal LVF. Patients with LV dysfunction are not normally prescribed beta-blockers, as the therapeutic actions of beta-blockade would exacerbate the existing degree of heart failure by way of excessive bradycardia, heart block and negative inotropic effects.

Finally, post hoc analysis of the GROUP X DAY X TIME interaction for beta-blocker therapy revealed that the circadian pattern of LF:HF area ratio on Days 1 and 4 for patients not on beta-blockers was opposite to what might be expected. It appears that circadian pattern on Day 1 remained normal, but on Day 4 the pattern reflected that of patients on beta-blockers during the stressful period. Thus, instead of illustrating a return towards normalized sympathovagal balance and autonomic function on Day 4, those patients not taking beta-blockers demonstrated a normal ANS state on Day 1 and an altered state on Day 4. This finding requires further investigation for clarification.

4.8 Summary, Limitations and Future Research

4.8.1 Summary

This study found that both time domain, as well as HR and frequency domain indices taken at four equally spaced 45-minute time intervals, were reproducible in CAD patients. A circadian pattern of HR and frequency domain indices, especially LF area, HF area and TA, were found to reflect heightened ANS activity during the day. As well, a real life emotionally stressful event (coronary angiogram) was found to reduce HRV indices compared to normal values. The observed effects of MI status suggest sympathetic predominance in post-MI CAD patients. The blunted response of patients with LV dysfunction to stress also suggests SNS overreactivity and diminished HRV in these patients. Lastly, beta-blocker therapy was found to reduce HR and restore ANS function in heart disease patients.

4.8.2 Study Limitations

Twenty-four hour ambulatory Holter data were used to calculate all time domain indices. This method of HRV analysis does not account for, or control for a patient's dynamic state. The frequency domain indices were computed from four 45-minute time periods over 24-hours. The assumption of signal stationarity was met by relying on a number of consecutive short recording periods of 2.2-minutes in length. The sum of approximately twenty of these individual power spectra produced a larger power spectrum representing a

recording window of 45-minutes. From this technique valid and reliable power spectral indices were derived. For both time and frequency domain parameters, proper technical procedures for the elimination of ectopics and artifacts were used (refer to Methods).

As previously stated, ambulatory Holter data do not ensure steady state measures. However, it does allow researchers to look at circadian variability, overall ANS function for a 24-hour period, as well as the opportunity to assess real life stressors and how these events affect ANS function, and in turn HRV, free from laboratory setting biases (Parati et al., 1995; Kamath and Fallen, 1993; ACA/AHA Task Force, 1989). The two week interval between the initially stressful time period (24-hours post-angiography) and the less stressful period may have included additional, unknown major life events, which would in turn have influenced the results. However, for the majority of patients, the probability of a major life event occurring within two weeks time was very low. As well, because subjects did not have to complete a journal, the two 48-hour recording periods were done on the exact same two days of the week. This lessened the possibility of any extreme change in daily activities, for it was assumed that most of these patients were retired and had a weekly routine consisting of limited activity.

Another limitation of this study was that it was retrospective and the patient population was not randomly selected. Instead patients were selected

consecutively and had to meet a number of inclusion and exclusion criteria before they were stratified according to MI status, LVF and beta-blocker therapy. Thus, the results of this investigation can not be thought of as cause and effect, rather the relationship(s) is one of association.

The lack of findings regarding the overall influence of beta-blocker therapy on HRV was probably the result of patients taking additional drugs. Both calcium antagonists and angiotensin converting enzyme inhibitors have been reported to influence HRV (Müller et al., 1996; You-hua et al., 1995; Cowan et al., 1993; Flapan et al., 1992). A majority of the patients in this study were taking a combination of drugs, suggesting that most were under several HRV influencing medications.

It should also be noted that each person reacts to a stressful event differently, and the degree to which each individual's physiological mechanisms are sensitive to a particular external stimulus also differs (Coumel and Leenhardt, 1991). The above inter-individual variance originates from the different meanings each individual assigns to a particular event. As well, the reaction of an individual to a stressful event is different for each person depending on their coping resources (Myrtek et al., 1996).

Finally, several patients failed to complete the study. The loss of such data was random as some patients exercised their option to drop-out of the research study before completion, while some others experienced technical

difficulties with the Holter monitor. On one or more of the recording days, a number of patients had too many ectopics and artifacts for analysis, while others developed symptoms or a clinical condition which resulted in their exclusion from the study.

Despite these limitations, many of the present findings are novel and clinically useful. The importance of this study stems from the patient population it involved and the prognostic significance of the findings. Further, this study may act as a guideline for future studies, providing new research ideas and suggestions for improved study design.

4.8.3 Suggestions for Future Research

Additional investigations are required to determine HRV reproducibility for both time and frequency domain indices in diseased populations. The intraclass correlation coefficients reported in this study suggest that the most reproducible measures of HRV are obtained while a person is sleeping, but this is not clinically practical. Thus, future studies should examine various times during the day in order to determine which time period and HRV measure is most reproducible. The more reproducible the measure, the more prognostically significant and clinically useful it is.

Heart rate variability is a noninvasive tool for the assessment of ANS function and is a suitable method for the assessment of ANS adaptation to a stressful event. Despite a large number of studies using HRV techniques to

evaluate ANS reactivity to a variety of stressful situations conducted in a laboratory environment, few studies have focused on real life stressful events. In fact, this study was one of the first to investigate the effects of a real life stressful situation on HRV. Additional research studies incorporating common every day stressful situations should be conducted with HRV techniques. This would provide clinicians with the knowledge of the events that most likely influence HRV and which ones should be avoided.

Subsequent research studies assessing circadian pattern, the effects of stress, as well as the additional influences of MI status, LVF and beta-blocker therapy, should be conducted. As well, although only a few females participated in the present investigation, the effects of gender on HRV would be an interesting research topic. These future studies should incorporate a patient diary to control for varying intra-individual and inter-individual daily activities. These studies should also control for additional drug therapies, which could possibly influence HRV. Most importantly, future studies must be prospective, consisting of groups matched for possible factors that may influence HRV.

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SECTION 6.0:

APPENDICES

APPENDIX A:

RAW DATA

I) Patient Demographics

Subjects	Age	Sex	Wt (kg)	Ht (cm)	CAD	LVF	DRUGS	MI
Alger	74	1	83	169	4	3	14	1
Amos	66	1	75	170	9	6	2	2
Andoney	72	1	74.5	171	8	2	2	1
Arsenault	62	1	75.5	165	6	3	12	2
Baird	56	1	109.6	176.5	3	1	8	1
Barrett	51	1	81.6	167.6	2	1	12	2
Biggar	72	1	80	172	7	3	10	5
Bissessar	59	1	69.4	177.8	11	6	9	4
Borg	48	1	98	177	8	1	4	1
Brown	67	1	93	188	5	2	12	1
Cassar	62	1	113.5	164.5	3	1	10	1
Charest	52	1	85	164	2	1	10	1
Coons	46	1	103	184	2	3	6	3
Cosentino	54	1	73.5	168	8	1	11	3
Cove	74	1	88.8	182.5	7	2	10	1
Currie	47	1	94	165	7	3	7	1
Dawson	52	1	90	186	2	1	4	1
Day	71	1	71	172.5	8	1	7	1
Deboer	40	1	102	175.3	3	1	14	1
Elaco	55	1	72.3	151	6	3	12	1
Eramo	48	1	89.3	165	1	1	2	2
Fagan	64	2	62	165	2	1	10	1
Faiella	61	1	94.2	175	5	2	2	5
Farr	66	1	74.8	177.8	6	3	10	1
Galli	60	1	84	185	4	1	8	1
Goromaru	75	1	65	162	10	2	10	1
Guenther	74	1	81.6	180	6	2	8	5
Hawkins	65	1	84.5	168	4	2	10	5
Hill	71	1	87.2	163	12	3	12	2
Irani	46	1	65.9	167	4	3	4	3
Johnson	43	1	112	177	3	5	7	1
Kebic	65	1	62.7	165	8	1	11	5
Kennedy	56	2	71.6	160.2	3	1	9	1
Kergl	63	1	79.8	175	2	1	4	1
Koklis	56	1	77.8	165	2	1	1	1
Kostyk	70	1	90.2	181.5	8	6	8	2
Koutstaal	60	1	82	177	4	1	4	4
Loosemore	52	1	78.4	173.5	10	2	10	1
Losee	55	1	81 7	159	8	6	12	2
MacDonald	58	1	100.2	181.5	2	2	4	5
MacInnis	57	1	79	168	8	3	2	1
MacKenzie	52	1	77	175	9	1	4	1
Marks	53	1	90	179	4	1	2	1
Moore	69	1	83.5	171	3	1	8	1

Subjects	Age	Sex	Wt (kg)	Ht (cm)	CAD	LVF	Drugs	MI
Mueller	54	1	79.3	160	6	5	1	2
Oliver	55	1	70.8	167.5	4	3	12	2
Pegado	57	1	57.5	170	11	3	10	1
Posthuma	67	1	81.6	181.6	5	7	2	1
Poupore	70	1	74.5	165	5	1	10	1
Runggatsher	54	1	83	170.2	1	1	10	1
Scott	52	1	103	176	4	4	8	1
Seim	61	1	94.9	175.5	4	2	7	1
Senner	60	1	108.9	193	7	3	12	1
Sheppard	58	1	87.5	171	5	2	4	2
Slater	47	1	84	173	2	2	8	1
Slowey	49	1	81	177	2	2	1	1
Strecker	51	1	86	176	3	2	2	1
Walker	66	1	62.7	150	1	1	5	1
Wilson B	43	1	92	168	5	1	2	2
Wilson D	46	1	80	180	1	1	13	1
Woods	51	1	100	175	3	3	10	1

Sex: ♂=1 / ♀=2
CAD: increasing severity=1-12
LVF: normal=1 / dysfunction of increasing severity=2-7
No Drug Therapy=1
Single Drug Therapy: Beta-blockers=2 / Nitrates=3 / Calcium Antagonists=4 / Digoxin=5
Drug Therapy Combinations: 1+2=6 / 1+3=7 / 1+4=8 / 2+4=9 / 3+4=10 / 1+2+3=11 / 1+3+4=12
2+5+6=13 / 1+2+3+4=14
MI: Absent=1 / Inferior=2 / Anterior=3 / Inferior and Anterior=4 / Unspecified=5

II) Time Domain Data for Days 1 through to 4

Subjects	Day 1 HR	Day 1 NN	Day 1 SDNN	Day 1 SDNNi	Day 1 SDANN	Day 1 r-MSSD	Day 1 pNN50	Day 1 INT	Day 1 TIN	Day 1 AC
Alger	53.977	1111.6	99.763	40.23	85.903	20.119	1 75	47	47	99.5
Amos	55.356	1083.9	146.66	55.81	139.79	30.325	8.1	47	47	86
Andoney	50.724	1182.9	94.112	43.16	82.649	19.605	1.83	47	47	91.3
Arsenault										
Baird	59.257	1012.5	70.06	45.51	49.579	32.836	10.7	47	47	95.9
Barrett	78.661	762.76	80.574	40.83	70.504	26.659	5.89	47	47	87
Biggar	53.728	1116.7	134.85	86.19	89.878	153.58	74.5	47	47	69.6
Bissessar	74.107	809.64	69.052	39.98	63.475	28.042	3.77	14	14	94.5
Borg	95.91	625.58	52.593	18.67	47.544	9.7476	0.145	47	47	99.9
Brown	55.248	1086	147.04	68.49	132.77	73.319	27.5	45	45	75.8
Cassar	76.802	781.23	108.09	44.33	92.391	23.17	4.11	47	47	99.8
Charest										
Coons	72.061	832.63	171.56	64.94	156.03	35.629	12.9	47	47	98
Cosentino										
Cove	78.002	769.21	84.695	41.94	72.821	51.426	7.67	47	47	80.5
Currie	65.727	912.87	92.869	55.41	72.69	29.834	8.32	47	47	99.8
Dawson	54.675	1097.4	112.84	51.97	98.654	27.655	5.95	47	47	98.6
Day	63.101	950.86	116.63	39.75	105.17	19.227	2.48	47	47	99.2
Deboer	69.936	857.93	81.294	55.34	57.591	40.1	18.8	47	47	99.5
Elaco	60.272	995.49	64.662	44.22	43.389	27.426	5.63	47	47	99.5
Eramo										
Fagan	84.872	706.95	106.32	35.49	96.371	13.659	0.412	47	47	99.8
Faiella										
Farr	62.127	965.77	117.59	70.12	90.231	101.47	46.1	47	47	73.5
Galli	55.736	1076.5	102.21	43.8	89.176	20.449	1.67	47	47	99.3
Goromaru										
Guenther	60.537	991 13	94.667	52.16	73.988	29.569	4.6	47	47	98.4
Hawkins										
Hill	57.523	1043.1	80.078	52.88	54.784	30.337	7.4	47	47	98.9
Irani	73.037	821.5	122.75	39.55	118.27	16.638	1.24	47	47	100
Johnson										
Kebic	75.842	791 12	121.39	61.62	100.41	22.776	3.14	47	47	98.8
Kennedy										
Kergl	79.508	754.64	112.65	35.66	103.03	15.684	0.665	47	47	99.9
Koklis										
Kostyk	62.416	961.3	115.91	40.36	103.54	23.272	2.52	47	47	97.6
Koutstaal										
Loosemore										
Losee	64.856	925.13	93.075	27.25	82.13	19.645	0.743	47	47	99.1
MacDonald	67 783	885.18	133.66	48.19	120.02	20.184	2.15	45	45	98.7
MacInnis										
MacKenzie										
Marks	66.044	908.49	112.28	47.09	99.483	27 749	6.58	47	47	99.6
Moore	59.222	1013.1	172.47	80.36	140.24	73.376	28.5	47	47	98.4

Subjects	Day 1 HR	Day 1 NN	Day 1 SDNN	Day 1 SDNNi	Day 1 SDANN	Day 1 r-MSSD	Day 1 pNN50	Day 1 INT	Day 1 TIN	Day 1 AC
Mueller										
Oliver	60.188	996.88	108.11	46.69	95.651	26.582	5.47	47	47	99.5
Pegado	72.179	831.27	150.27	37.09	140.68	17 165	1.07	47	47	100
Posthuma										
Poupore										
Runggatsher	76.424	785.09	120.22	65.78	96.084	42.829	15.4	44	44	95.3
Scott	57.636	1041	101.56	51.87	86.022	35.874	13.1	48	48	98.1
Seim	61 15	981 19	110.16	65.25	83.798	26.537	5.39	47	47	99.5
Senner										
Sheppard										
Slater	69.355	865.11	126.56	62.47	104.68	62.559	20.5	47	47	98.6
Slowey	55.231	1086.4	195.99	120.2	134.52	73.988	43.4	48	48	66.7
Strecker	58.508	1025.5	112.47	56.5	94.556	36.895	10.5	47	47	95.7
Walker	74.337	807 14	65.988	13.18	63.934	21.369	4.53	47	47	98.9
Wilson B										
Wilson D										
Woods	71.591	838.09	124.91	37.6	118.75	14.5	0.439	47	47	99.8

Subjects	Day 2 HR	Day 2 NN	Day 2 SDNN	Day 2 SDNNi	Day 2 SDANN	Day 2 r-MSSD	Day 2 pNN50	Day 2 INT	Day 2 TIN	Day 2 AC
Alger	64.096	936.1	143.75	35.05	136.33	17.005	1.04	48	48	99.3
Amos	54.482	1101.3	132.7	62.82	118.24	36.218	13.1	47	47	91
Andoney	52.653	1139.5	87 116	46.61	68.913	20.605	2.02	47	47	98.3
Arsenault										
Baird	64.772	926.32	94.78	52.17	75.126	37.269	15.2	47	47	92.8
Barrett	74.232	808.27	84.428	48.33	72.968	31.311	9.51	48	48	88.8
Biggar	56.022	1071	140.96	96.96	101.18	158.58	74.1	47	47	67.8
Bissessar	86.641	692.51	87.833	33.13	79.303	24.213	2.78	47	47	95.9
Borg	97.256	616.93	73.65	20.52	71.391	11.048	0.335	47	47	99.9
Brown	59.646	1005.9	172.89	66.96	144.2	72.214	22.1	43	43	74.8
Cassar	76.616	783.13	124.46	47.89	115.15	26.315	6.12	47	47	99.6
Charest										
Coons	76.699	782.28	148.37	69.15	132.25	37.442	10.4	47	47	89.4
Cosentino										
Cove										
Currie	67.47	889.28	95.944	59.29	73.615	29.068	7 16	47	47	99.5
Dawson	55.133	1088.3	118.03	52.72	104.5	27.919	6.18	47	47	98.5
Day	65.542	915.45	116.35	39.94	106.09	22.817	4.31	47	47	99.5
Deboer	69.566	862.48	82.121	54.82	58.802	37.243	15.7	47	47	99.7
Elaco	61.574	974.43	73.636	45.25	55.212	28.953	6.98	47	47	99.1
Eramo	60.683	988.74	100.28	59.48	75.577	37.984	17.5	44	44	99.6
Fagan	84.749	707.98	103.42	37.69	94.161	13.196	0.339	48	48	99.6
Faiella										
Farr										
Galli	55.988	1071 7	137.51	54.41	131.57	24.165	3.47	47	47	88
Goromaru										
Guenther	61.696	972.5	83.066	52.42	60.62	31.366	4.75	47	47	94.1
Hawkins										
Hill	60.111	998.16	99.432	65.79	66.538	37.519	10.5	48	48	97.9
Irani	78.395	765.36	80.294	32.74	71.807	12.655	0.266	47	47	100
Johnson										
Kebic	69.227	866.72	146.04	83.91	113.07	33.593	11	47	47	99.3
Kennedy										
Kergl	76.419	785.15	111.46	40.07	106.22	16.517	0.826	47	47	99.8
Koklis										
Kostyk	69.524	863.01	81.209	33.26	71.326	27.872	1.29	47	47	97 1
Koutstaal										
Loosemore										
Losee	64.59	928.93	59.44	27.23	50.582	16.837	0.512	47	47	99.3
MacDonald	68.751	872.71	138.01	49.24	127.89	20.501	2.19	47	47	98.7
MacInnis										
MacKenzie										
Marks	66.585	901 1	131.89	55.74	118.77	29.914	7.83	47	47	99
Moore	65.915	910.27	228.39	76.37	194.37	61.057	19	47	47	96.7

Subjects	Day 2 HR	Day 2 NN	Day 2 SDNN	Day 2 SDNNi	Day 2 SDANN	Day 2 r-MSSD	Day 2 pNN50	Day 2 INT	Day 2 TIN	Day 2 AC
Mueller										
Oliver	64.527	929.84	71.281	41.92	55.147	23.954	3.79	47	47	99.7
Pegado	77.893	770.28	159.85	37 78	162.1	14.125	0.688	47	47	100
Posthuma										
Poupore										
Runggatsher	73.839	812.58	128.88	61 79	109.4	38.06	13.9	47	47	94.8
Scott										
Seim	62.93	953.44	156.71	71.56	138.74	26.468	5.35	48	48	99.2
Senner	63.549	944.15	96.492	76.05	72.303	40.252	11.6	42	42	60.4
Sheppard										
Slater	71 143	843.37	102.75	50.68	86.207	47 103	11 9	45	45	99.2
Slowey	61.354	977.93	212.95	118.2	171.24	65.954	34.5	46	47	71.4
Strecker	59.664	1005.6	110.64	67 77	89.046	43.277	13.2	47	47	65.7
Walker	69.214	866.88	64.082	16.55	61 189	19.248	1.32	47	47	96.4
Wilson B										
Wilson D										
Woods	69.989	857.28	110.23	45.02	97 748	17.866	1.26	47	47	99.9

Subjects	Day 3 HR	Day 3 NN	Day 3 SDNN	Day 3 SDNNi	Day 3 SDANN	Day 3 r-MSSD	Day 3 pNN50	Day 3 INT	Day 3 TIN	Day 3 AC
Alger										
Amos	56.323	1065.3	150.64	60.94	143.04	34.136	11	47	47	83.3
Andoney										
Arsenault										
Baird	79.727	752.56	95.171	37.41	83.554	25.508	4.4	47	47	97.3
Barrett	71 704	836.78	82.47	50.67	60.578	25.53	4.82	47	47	99.8
Biggar	65.703	913.2	194.11	83.78	162.8	102.94	41.6	47	47	78.5
Bissessar										
Borg	99.556	602.68	74.544	19.44	73.064	9.2082	0.166	48	48	99.9
Brown	55.485	1081.4	157.25	114	146.66	93.761	35.5	46	47	54.4
Cassar	76.651	782.77	119.06	43.47	110.53	27 133	6.88	47	47	99.6
Charest										
Coons	74.87	801.39	130.96	71.08	111.34	31 781	9.64	49	49	97.2
Cosentino										
Cove	73.381	817.66	112.93	46.23	100.15	54.466	10.2	47	47	80.8
Currie	71.805	835.6	109.56	48.41	93.321	23.683	4.25	48	48	99.8
Dawson										
Day	57.304	1047	157.96	54.38	139.06	28.649	7.36	47	47	97 7
Deboer	69.11	868.19	101.53	61.35	77.859	41.169	20.1	48	48	99.7
Elaco	60.532	991.22	115.52	66.13	98.867	42.647	14.8	47	47	80.5
Eramo										
Fagan										
Faiella										
Farr										
Galli	53.575	1119.9	134.9	64.66	116.46	25.973	4.78	47	47	89.9
Goromaru										
Guenther	57.33	1046.6	96.203	55.1	73.56	33.986	5.21	47	47	97.3
Hawkins										
Hill	69.516	863.11	74.996	43.08	57.881	25.465	4.83	47	47	98.4
Irani	79.966	750.31	80.882	36.1	71.258	14.887	0.641	47	47	99.9
Johnson										
Kebic	71.33	841 16	139.9	76.79	113.58	34.208	11.3	47	47	99.7
Kennedy										
Kergl	75.671	792.91	106.45	46.07	93.343	23.285	2.4	47	47	97.9
Koklis										
Kostyk	67.95	883	104.18	61.23	84.653	56.749	5.34	47	47	61.4
Koutstaal										
Loosemore										
Losee	71.329	841 17	102.36	25.57	98.341	12.579	0.234	47	47	99.6
MacDonald	68.27	878.86	141.05	58.87	133.68	30.146	5.73	47	47	98
MacInnis										
MacKenzie										
Marks	56.913	1054.2	151.62	78.12	125.61	42.175	18.4	47	47	98
Moore	56.991	1052.8	170.61	80.7	135.66	74.079	26.4	47	47	97.5

Subjects	Day 3 HR	Day 3 NN	Day 3 SDNN	Day 3 SDNNi	Day 3 SDANN	Day 3 r-MSSD	Day 3 pNN50	Day 3 INT	Day 3 TIN	Day 3 AC
Mueller										
Oliver	60.963	984.2	91 741	54.47	70.282	33.707	8.45	47	47	97.6
Pegado	73.11	820.69	120.23	48.18	105.5	21 796	2.78	47	47	99.9
Posthuma										
Poupore										
Runggatsher	82.144	730.42	110.97	55.32	92.584	37.649	12.8	46	46	92.6
Scott										
Seim										
Senner	72.024	833.05	93.476	58.55	71.857	41 79	15.5	46	46	87.3
Sheppard										
Slater	70.204	854.65	123.83	60.81	106.88	55.724	19.3	47	47	99.4
Slowey	55.75	1076.2	176.93	118.9	127.36	67.89	40.3	48	48	70.3
Strecker										
Walker	70.601	849.85	49.782	20.79	43.225	31.88	5.16	47	47	93.9
Wilson B										
Wilson D										
Woods	70.568	850.24	104	48.61	91.321	22.252	2.77	48	48	99.6

Subjects	Day 4 HR	Day 4 NN	Day 4 SDNN	Day 4 SDNNi	Day 4 SDANN	Day 4 r-MSSD	Day 4 pNN50	Day 4 INT	Day 4 TIN	Day 4 AC
Alger										
Amos	54.3	1105	136.91	56.03	125.74	31.999	9.27	47	47	90.6
Andoney										
Arsenault										
Baird	65.629	914.23	141.31	51	125.58	36.472	15.5	47	47	95.3
Barrett	74.174	808.91	83.505	49.08	63.171	23.445	3.46	47	47	99.8
Biggar	61.342	978.12	176.75	88.34	145.28	111.54	47.6	48	48	76.9
Bissessar										
Borg	100.62	596.3	61.449	18.53	58.451	9.7642	0.26	47	47	99.9
Brown	55.554	1080	132.8	86.65	104.34	79.795	29.2	47	47	64.9
Cassar	75.46	795.12	107 73	45.79	96.575	27.846	6.69	47	47	99.6
Charest										
Coons										
Cosentino										
Cove	73.4	817.44	98.507	45.03	83.796	54.754	9.66	47	47	80.8
Currie	65.195	920.32	107.61	64.96	82.613	36.537	14.3	47	47	99.9
Dawson										
Day	55.644	1078.3	132.78	52.85	122.63	28.358	7 17	47	47	94
Deboer	77.837	770.84	132.34	52.93	116.76	33.3	11.5	48	48	99.6
Elaco	68.591	874.75	92.87	52	74.008	41 708	14.3	47	47	95.7
Eramo	64.24	934	117.09	56.39	98.793	34.549	13	47	47	97.6
Fagan										
Faiella										
Farr										
Galli	54.272	1105.5	164.78	62.48	144.09	26.465	4.69	47	47	92.1
Goromaru										
Guenther										
Hawkins										
Hill	66.207	906.24	103.35	50.2	86.461	29.778	7 72	47	47	98.2
Irani	71.245	842.16	85.787	44.01	71.809	18.453	1.4	47	47	100
Johnson										
Kebic	75.291	796.91	161.94	69.54	141.42	29.258	7.94	47	47	99.6
Kennedy										
Kergl	73.94	811.47	109.05	48.12	97.949	21 745	2.97	47	47	99.8
Koklis										
Kostyk	77.082	778.39	93.031	35.59	68.834	113.44	23.5	47	47	41.5
Koutstaal										
Loosemore										
Losee	67.353	890.82	78.756	26.41	71.485	15.345	0.429	47	47	99.4
MacDonald	66.219	906.08	146.76	56.79	139.81	26.938	4.58	47	47	97.9
MacInnis										
MacKenzie										
Marks	61.925	968.91	147.26	76.73	120.63	38.584	14	47	47	98.8
Moore	58.392	1027.5	224.07	76.71	185.69	76.825	25.8	47	47	96.7

Subjects	Day 4 HR	Day 4 NN	Day 4 SDNN	Day 4 SDNNi	Day 4 SDANN	Day 4 r-MSSD	Day 4 pNN50	Day 4 INT	Day 4 TIN	Day 4 AC
Mueller										
Oliver	58.284	1029.4	94.995	61.53	65.752	35.791	14	48	48	98.6
Pegado	73.745	813.62	124.15	48.45	110.13	25.918	5.42	48	48	99.8
Posthuma										
Poupore										
Runggatsher	77.331	775.88	104.42	65.4	77 181	42.902	17	46	46	90.2
Scott										
Seim										
Senner	62.995	952.46	102.21	72.51	70.465	47.691	22.6	47	47	83.6
Sheppard										
Slater	68.38	877.46	130.91	64.82	112.35	57.923	20.1	47	47	99.5
Slowey	56.155	1068.5	184.61	139.1	135.13	80.94	45.6	46	47	59.4
Strecker										
Walker	71.871	834.83	66.991	20.36	62.328	28.33	4.35	47	47	91 7
Wilson B										
Wilson D										
Woods	72.91	822.94	99.139	45.45	85.124	22.555	3.25	47	47	99.2

III) Frequency Domain Data for Days 1 to 4 at the Recording Times: 0300, 0900, 1500, and 2100-hours.

Subjects	Day 1 Time 1 HR	Day 1 Time 1 LFpk	Day 1 Time 1 LFA	Day 1 Time 1 %LFA	Day 1 Time 1 LFcf	Day 1 Time 1 HFpk	Day 1 Time 1 HFA	Day 1 Time 1 %HFA	Day 1 Time 1 HFcf	Day 1 Time 1 LF:HFpk	Day 1 Time 1 LF:HFA	Day 1 Time 1 TA
Alger	51.2	56.7	5400	48.1	0.094	52.8	5851	51.9	0.183	1.21	0.994	11251
Amos	46.5	76.7	6111	57.9	0.05	40.8	4441	42.1	0.24	2.63	1.62	10552
Andoney	46.1	84	6179	61.3	0.048	20.3	3831	38.7	0.277	4.33	1.65	10010
Arsenault	56.6	70.1	7037	65.9	0.073	30.3	3634	34.1	0.261	2.49	2.04	10671
Baird	58.6	66.7	5940	53	0.13	60.8	5241	47	0.179	1 16	1 16	11181
Barrett	79	73.7	6239	61.3	0.068	26.5	3920	38.7	0.219	3.02	1.64	10159
Biggar												
Bissessar												
Borg	86	76.2	6936	64.1	0.055	19.4	3867	35.9	0.26	4.37	1.88	10803
Brown	62.9	44.7	5901	54.1	0.072	30	5154	45.9	0.272	1.6	1.3	11055
Cassar	75.8	71.6	5707	56	0.065	48.3	4467	44	0.264	2.69	1.46	10174
Charest	60.4	97.6	6741	71 7	0.065	17.8	2668	28.3	0.215	6.54	2.68	9409
Coons	56.7	65.2	5557	49.5	0.075	43.1	5720	50.5	0.24	1.63	1.01	11277
Cosentino	60.2	76.6	6500	66.1	0.068	24.7	3312	33.9	0.228	3.79	2.2	9821
Cove	73.3	26.8	4134	38.7	0.11	30.5	6742	61.3	0.296	0.944	0.708	10876
Currie	61.5	78.2	7397	71	0.07	21.4	3075	29	0.235	4.34	2.6	10472
Dawson	50.6	65.3	5703	50	0.07	50.3	5688	50	0.243	1.54	1.05	11391
Day	57 1	122	6314	68.7	0.06	17.3	2928	31.3	0.241	9.06	2.39	9242
Deboer	71.9	69	6200	58.6	0.062	32.3	4406	41.4	0.243	2.6	1.48	10606
Elaco	59.6	81.3	6161	57.2	0.059	53.1	4625	42.8	0.247	2.71	1.6	10786
Eramo												
Fagan	71.5	70.6	6382	61.4	0.063	43	4075	38.6	0.292	2.39	1.8	10457
Faiella	57.4	78	6558	62.9	0.064	21.5	3925	37 1	0.284	4.42	2.04	10483
Farr	65.3	25.3	3574	29.9	0.14	51 1	8263	70.1	0.303	0.531	0.464	11837
Galli	49.5	76.9	6322	58.2	0.066	32.4	4679	41.8	0.248	2.58	1.56	11001
Goromaru	81.3	70.1	6767	64.3	0.069	18.3	3917	35.7	0.225	4.46	2.32	10684
Guenther	58.6	84.5	6243	60.9	0.067	22.1	4131	39.1	0.287	5.07	1.89	10374
Hawkins	65.2	82.3	6811	63.5	0.073	21.9	4341	36.5	0.189	4.83	2.04	11152
Hill	58	71.3	6929	68.8	0.062	19.3	3235	31.2	0.258	4.2	2.53	10164
Irani	57.9	102	6933	72.5	0.063	22.1	2599	27.5	0.188	5.41	2.87	9532

Subjects	Day 1 Time 1 HR	Day 1 Time 1 LFpk	Day 1 Time 1 LFA	Day 1 Time 1 %LFA	Day 1 Time 1 LFcf	Day 1 Time 1 HFpk	Day 1 Time 1 HFA	Day 1 Time 1 %HFA	Day 1 Time 1 HFcf	Day 1 Time 1 LF:HFpk	Day 1 Time 1 LF:HFA	Day 1 Time 1 TA
Johnson	77.6	71.5	6820	57	0.071	37 1	5128	43	0.29	2.17	1.43	11948
Kebic	68.1	89.8	6841	68.3	0.061	25.4	3202	31 7	0.232	4.51	2.4	10043
Kennedy	68.5	70.8	5486	55.2	0.058	42	4391	44.8	0.275	3.24	1.44	9877
Kergl	70.3	93.2	6228	67.8	0.064	24.8	3081	32.2	0.255	6.3	2.54	9309
Koklis	70.6	76	6058	53.6	0.053	28.9	5465	46.4	0.273	3.17	1.39	11523
Kostyk	60.5	78.8	6447	62.4	0.071	21 1	4237	37.6	0.224	4.57	1.9	10684
Koutstaal	68	101	6382	63.2	0.056	29	3696	36.8	0.191	4.93	2.14	10078
Loosemore	51	65.3	5172	46.4	0.065	77.5	6061	53.6	0.223	0.878	0.895	11233
Losee	60.9	46.8	4676	46.4	0.094	25.4	5811	53.6	0.253	2.15	0.965	10487
MacDonald	60.4	99.7	6457	70.8	0.063	16.8	2650	29.2	0.216	6.47	2.57	9107
MacInnis	58.3	82.9	6488	67 7	0.056	27.9	3199	32.3	0.267	4.92	2.39	9687
MacKenzie	64.2	78	6511	67.9	0.072	32.3	3046	32.1	0.267	3.34	2.35	9557
Marks	60.2	72.5	6274	59.5	0.062	30.5	4362	40.5	0.296	3.05	1.62	10636
Moore	51.6	66.4	6224	60.6	0.071	22.1	4279	39.4	0.291	4.14	1.83	10503
Mueller	66.5	70.2	6447	60.4	0.063	47 7	4311	39.6	0.324	1.96	1.67	10758
Oliver	57.6	79.5	6450	62.9	0.064	42.8	3782	37 1	0.313	2.49	1.8	10232
Pegado	67.6	80.5	5370	57.5	0.052	40.3	4083	42.5	0.217	3.37	1.52	9453
Posthuma	58.2	99.9	6895	68.8	0.059	21.5	3106	31.2	0.267	6.27	2.55	10001
Poupore	65.9	46.6	4579	39.2	0.071	65	7114	60.8	0.267	0.8	0.661	11693
Runggatsher	71.8	69.3	7247	57.4	0.091	34.3	5413	42.6	0.23	2.19	1.42	12660
Scott	51.8	69.5	6648	63.8	0.067	45.4	3794	36.2	0.225	3.02	1.98	10442
Seim	53.7	87.6	6636	70.8	0.058	18.2	2747	29.2	0.239	6.13	2.58	9393
Senner												
Sheppard	65.9	78.3	7260	64.5	0.064	32.4	4149	35.5	0.346	2.86	2.03	11409
Slater	64.2	58.2	6497	55	0.086	34.7	5343	45	0.253	1.94	1.38	11840
Slowey	47.4	66	6147	57 1	0.08	44.4	4761	42.9	0.226	2.6	1.54	10980
Strecker	51.8	74.7	6536	60.8	0.07	22.8	4210	39.2	0.225	3.57	1 76	10746
Walker	69.8	29.4	4245	33.3	0.11	37 1	8372	66.7	0.298	0.824	0.557	12617
Wilson B	72.8	65	6621	62.1	0.076	43.3	4013	37.9	0.282	2.36	1.83	10634
Wilson D	75.5	61.8	5817	53.8	0.079	44.6	4884	46.2	0.207	1 77	1.29	10710
Woods	60.1	98.7	5996	64.3	0.059	30.1	3236	35.7	0.233	3.74	1.98	9232

Subjects	Day 1 Time 2 HR	Day 1 Time 2 LFpk	Day 1 Time 2 LFA	Day 1 Time 2 %LFA	Day 1 Time 2 LFcf	Day 1 Time 2 HFpk	Day 1 Time 2 HFA	Day 1 Time 2 %HFA	Day 1 Time 2 HFcf	Day 1 Time 2 LF:HFpk	Day 1 Time 2 LF:HFA	Day 1 Time 2 TA
Alger	55.1	66.9	5180	46.1	0.078	47	6066	53.9	0.227	2.2	0.949	11246
Amos	54.2	84.2	6961	64.9	0.063	24	3776	35.1	0.266	4.12	2.06	10737
Andoney	53.9	86.2	7217	68.2	0.055	19.2	3369	31.8	0.252	5.07	2.48	10586
Arsenault	77 7	81.3	6698	67 1	0.068	19.4	3459	32.9	0.209	4.91	2.3	10157
Baird	58.7	47.5	4833	39.2	0.08	48.5	7311	60.8	0.241	1 15	0.688	12144
Barrett	70.7	73.7	6471	57	0.072	39	4821	43	0.22	2.34	1.42	11292
Biggar												
Bissessar												
Borg	100	72.8	6719	62.4	0.068	22.2	4063	37.6	0.224	3.8	1 78	10782
Brown	55	49.2	5631	51 7	0.082	24.7	5521	48.3	0.235	2.28	1.2	11152
Cassar	95.6	84.9	6982	68.6	0.06	16.2	3227	31.4	0.232	5.82	2.27	10209
Charest	75.9	79.6	7194	69.8	0.069	20	3105	30.2	0.193	4.09	2.41	10299
Coons	93.8	77.6	7155	65.5	0.074	20.1	3759	34.5	0.235	4.04	1.99	10914
Cosentino	69.8	86.8	6982	69.4	0.064	18	3114	30.6	0.177	5.86	2.43	10096
Cove	89.5	26.5	4334	40.2	0.12	30.9	6411	59.8	0.373	0.902	0.84	10745
Currie	65.6	78.5	6684	64.4	0.072	23.9	3691	35.6	0.175	3.79	1.89	10375
Dawson	58	91.5	6839	62.7	0.077	24.1	4097	37.3	0.194	3.97	1 75	10936
Day	70.9	66.3	5846	52.3	0.065	27.8	5591	47 7	0.307	3.12	1.28	11437
Deboer	70.5	56.8	6816	54.1	0.091	33.6	5762	45.9	0.216	1 79	1.23	12578
Elaco	62.1	63	5962	55.6	0.053	26.5	4735	44.4	0.301	2.75	1.39	10697
Eramo												
Fagan	94.5	77.4	6992	67.3	0.07	20.5	3448	32.7	0.183	4.06	2.16	10440
Faiella	62.1	65.5	5818	53.6	0.055	23.5	5234	46.4	0.284	3.51	1.38	11052
Farr	67.9	33.9	5426	56.6	0.08	27.4	4332	43.4	0.431	1.28	1.56	9758
Galli	66.2	74.5	6530	66.3	0.065	17.2	3456	33.7	0.242	4.68	2.64	9986
Goromaru	74	68.2	6925	63.3	0.072	33.7	4028	36.7	0.266	2.46	1.92	10953
Guenther	59.5	58	6134	58.9	0.069	23.5	4474	41 1	0.276	2.78	1 77	10608
Hawkins	62.7	70.6	6489	62.7	0.074	21 7	4062	37.3	0.221	3.63	1.88	10551
Hill	57 1	65.5	6220	59.3	0.061	23.3	4369	40.7	0.21	3.19	1.56	10589
Irani	82.1	61 1	6364	63.4	0.078	25.2	3755	36.6	0.178	2.86	1.87	10119
Johnson	95.1	66.3	6283	60.1	0.09	29.4	4137	39.9	0.333	2.35	1.56	10420

Subjects	Day 1 Time 2 HR	Day 1 Time 2 LFpk	Day 1 Time 2 LFA	Day 1 Time 2 %LFA	Day 1 Time 2 LFcf	Day 1 Time 2 HFpk	Day 1 Time 2 HFA	Day 1 Time 2 %HFA	Day 1 Time 2 HFcf	Day 1 Time 2 LF:HFpk	Day 1 Time 2 LF:HFA	Day 1 Time 2 TA
Kebic	82	79.8	6248	67.9	0.077	17.2	2978	32.1	0.174	4.97	2.31	9226
Kennedy	77.3	86	6817	67 7	0.064	17.8	3297	32.3	0.24	5.57	2.24	10114
Kergl	93.2	76.8	6367	65	0.073	18.8	3397	35	0.279	4.38	2.2	9764
Koklis	85.4	55.5	6853	57 7	0.058	26	5074	42.3	0.305	2.3	2.06	11927
Kostyk	79	57.4	5733	63	0.067	17.3	3365	37	0.286	3.55	1.82	9098
Koutstaal	80.4	83.5	7201	70.9	0.075	19.1	2938	29.1	0.202	4.93	2.6	10139
Loosemore	63	61.6	6278	61 7	0.073	22.9	3889	38.3	0.215	2.83	1.65	10167
Losee	64.7	47.2	5601	50.1	0.054	30.3	5549	49.9	0.28	1 71	1.06	11150
MacDonald	83.1	78	6593	65	0.07	20.4	3634	35	0.298	4.28	1.97	10227
MacInnis	73.5	71.8	6592	68	0.072	24.5	3040	32	0.22	3.51	2.22	9632
MacKenzie	78.3	70.3	7123	71	0.078	20.7	3021	29	0.226	3.85	2.7	10144
Marks	72.7	59.2	6210	60.8	0.073	22.9	4149	39.2	0.233	2.88	1.65	10359
Moore	58.7	45	5462	46.9	0.11	31.8	6137	53.1	0.257	1.49	0.966	11599
Mueller	76.8	66	7081	64.5	0.063	24.4	3937	35.5	0.319	3.01	2.02	11018
Oliver	68.7	65.1	7169	60.9	0.075	26.3	4660	39.1	0.266	2.75	1 79	11829
Pegado	94.5	78.9	6337	66.4	0.069	19.8	3209	33.6	0.231	5	2.18	9546
Posthuma	86.6	60.5	6462	57.2	0.088	30.5	5045	42.8	0.342	2.68	1.67	11507
Poupore	80.8	39.7	6302	52.2	0.081	34.2	5606	47.8	0.337	1.27	1.21	11908
Runggatsher	93.1	59.6	6018	55.6	0.09	32.9	4836	44.4	0.284	2.19	1.47	10854
Scott	53.1	54.5	6302	57	0.073	52.9	4810	43	0.334	1.3	1.53	11112
Seim	68.8	84.1	6986	68	0.069	18.3	3308	32	0.197	4.95	2.26	10294
Senner												
Sheppard	72.3	60.1	7153	63.4	0.078	30.7	4224	36.6	0.302	2.19	1.87	11377
Slater	70.5	58.3	6619	55.7	0.077	39.2	5310	44.3	0.237	1.81	1.37	11929
Slowey	56.8	70.4	6600	59.5	0.097	35.6	4495	40.5	0.18	2.1	1.53	11095
Strecker	57.2	52.6	6315	49.1	0.079	29	6404	50.9	0.26	1.85	1.03	12719
Walker	83.1	34.6	4454	37.8	0.98	41.3	7266	62.2	0.28	0.982	0.64	11720
Wilson B	99.2	72.6	6998	67 7	0.08	19.3	3319	32.3	0.2	3.96	2.19	10317
Wilson D	77.4	76.1	6364	57.8	0.077	35.7	4631	42.2	0.246	3.04	1.5	10995
Woods	87.4	105	6761	77.2	0.066	11.5	2036	22.8	0.258	10.4	3.64	8797

Subjects	Day 1 Time 3 HR	Day 1 Time 3 LFpk	Day 1 Time 3 LFA	Day 1 Time 3 %LFA	Day 1 Time 3 LFcf	Day 1 Time 3 HFpk	Day 1 Time 3 HFA	Day 1 Time 3 %HFA	Day 1 Time 3 HFcf	Day 1 Time 3 LF:HFpk	Day 1 Time 3 LF:HFA	Day 1 Time 3 TA
Alger	57 1	80.3	5206	49.9	0.06	44.9	5222	50.1	0.241	2.03	1.03	10428
Amos	51.5	86.8	6818	66.1	0.066	24.1	3440	33.9	0.266	3.83	2.19	10258
Andoney	54.2	73.3	7593	67 1	0.063	22	3877	32.9	0.265	3.58	2.21	11470
Arsenault	72.5	69.4	6515	61 1	0.069	20.7	4475	38.9	0.348	3.75	1.85	10990
Baird	57.3	53.3	5841	47 1	0.063	41.2	6563	52.9	0.233	1.46	0.967	12404
Barrett	68.2	57.3	5081	42.4	0.069	56.8	6786	57.6	0.248	1.26	0.774	11867
Biggar												
Bissessar												
Borg	91.3	66.8	7709	69.4	0.055	26.9	3374	30.6	0.395	2.59	2.46	11083
Brown	53.2	55.4	6963	55.3	0.081	34.7	5892	44.7	0.296	1 78	1.39	12855
Cassar	64	62.6	5976	58.5	0.07	53.3	4407	41.5	0.286	1 76	1.52	10383
Charest	77 1	65.3	6758	60.8	0.078	36.5	4422	39.2	0.281	2.54	1 72	11180
Coons	84.8	84.5	7455	68.1	0.073	20	3536	31.9	0.197	4.63	2.26	10991
Cosentino	67.8	86.2	7080	73.1	0.071	15.9	2614	26.9	0.222	6.12	2.91	9694
Cove	69.9	47.4	5070	49.1	0.091	25.8	6118	50.9	0.251	2.27	1.05	11188
Currie	61.8	63	7332	67 1	0.067	34.5	3627	32.9	0.304	2.13	2.15	10959
Dawson	62	81.3	6756	67.8	0.068	19.4	3244	32.2	0.193	4.72	2.22	10000
Day	63.9	82.3	6256	63.1	0.06	21.9	3834	36.9	0.229	5.24	2.03	10090
Deboer	73.9	61.8	6886	60.4	0.08	29.6	4490	39.6	0.265	2.3	1.6	11376
Elaco	61.3	57.5	6587	52.4	0.047	31 1	6041	47.6	0.304	1.97	1.25	12628
Eramo												
Fagan	76.1	75.5	6652	61.6	0.068	27.5	4121	38.4	0.189	3.14	1.69	10773
Faiella	67 1	78.4	6514	64.7	0.062	22.1	3668	35.3	0.297	4.45	2	10182
Farr	56.6	21.6	3736	31.8	0.12	67.8	7763	68.2	0.389	0.341	0.547	11529
Galli	58.4	76.5	6847	62.8	0.06	21 7	4109	37.2	0.239	3.98	1.81	10956
Goromaru	66.8	73.7	6554	61 1	0.068	32.3	4192	38.9	0.231	2.94	1 71	10746
Guenther	68	71 7	7274	64.7	0.076	23.6	4357	35.3	0.261	3.4	2.08	11631
Hawkins	60.3	65.3	6263	56.7	0.076	32.5	4966	43.3	0.291	2.39	1.5	11229
Hill	62.8	69.3	6808	56.3	0.076	26.7	5389	43.7	0.202	2.88	1.4	12197
Irani	69	70.8	5849	63.9	0.071	23	3303	36.1	0.215	3.79	1.92	9152
Johnson	89.6	52.2	6452	57 7	0.085	37.8	4709	42.3	0.345	1.57	1.46	11161

Subjects	Day 1 Time 3 HR	Day 1 Time 3 LFpk	Day 1 Time 3 LFA	Day 1 Time 3 %LFA	Day 1 Time 3 LFcf	Day 1 Time 3 HFpk	Day 1 Time 3 HFA	Day 1 Time 3 %HFA	Day 1 Time 3 HFcf	Day 1 Time 3 LF:HFpk	Day 1 Time 3 LF:HFA	Day 1 Time 3 TA
Kebic	83.7	81.9	6690	71.2	0.076	18.6	2640	28.8	0.184	4.76	2.65	9330
Kennedy	77.9	88.3	6825	68.5	0.063	15.6	3174	31.5	0.215	6.51	2.31	9999
Kergl	96.7	68.5	6458	63.8	0.069	17 7	3666	36.2	0.249	4.21	1.87	10124
Koklis	92.4	53.7	6986	58.4	0.07	31.3	4998	41.6	0.338	1.83	1.45	11984
Kostyk	66.7	60.2	6534	61.5	0.059	20.2	4046	38.5	0.211	3.18	1.68	10580
Koutstaal	71.3	84.7	6939	64.5	0.062	27 1	3884	35.5	0.223	3.91	1.98	10823
Loosemore	53.7	69.9	6681	63.9	0.059	27 7	3696	36.1	0.229	3	1.92	10377
Losee	64.3	40.1	5371	45.6	0.067	51.4	6382	54.4	0.307	1 13	0.904	11753
MacDonald	88.2	84.2	6599	68.3	0.065	15.1	3032	31 7	0.243	6.05	2.33	9631
MacInnis	62.4	77.3	7495	69.9	0.069	21 1	3281	30.1	0.262	3.88	2.68	10776
MacKenzie	74.8	90.8	6813	67.6	0.073	18.4	3335	32.4	0.184	5.83	2.24	10148
Marks	73.6	60.4	6888	63.9	0.77	23.9	3892	36.1	0.278	2.83	2.11	10780
Moore	64.5	48.3	6018	53.5	0.081	28.7	5302	46.5	0.234	1.94	1.36	11320
Mueller	73.9	81 7	7159	71 1	0.062	20.8	2885	28.9	0.271	4.62	2.58	10044
Oliver	69.5	70	6987	64.2	0.055	23.9	3842	35.8	0.286	3.41	1.93	10829
Pegado	65.8	58.6	5519	47.2	0.064	54.1	6148	52.8	0.27	1.81	0.986	11667
Posthuma	101	54.2	5725	51.8	0.075	23.4	5319	48.2	0.326	2.9	1.42	11044
Poupore	74.3	48.9	6038	47.2	0.079	44.3	6743	52.8	0.285	1.25	1.03	12781
Runggatsher	73.5	84.8	6213	55.6	0.077	28.3	4979	44.4	0.247	3.16	1.32	11192
Scott	53.6	59	6166	53.3	0.061	54.1	5328	46.7	0.307	1.34	1.24	11494
Seim	57 7	75.8	6790	67.2	0.064	22	3333	32.8	0.226	3.73	2.3	10123
Senner												
Sheppard	81.5	48.5	5970	58.6	0.076	23.1	4375	41.4	0.284	2.21	1 76	10345
Slater	64.4	55.1	6051	49.7	0.08	41 1	6147	50.3	0.234	1.4	1.02	12198
Slowey	48.9	56.7	6416	60.7	0.09	28.9	4171	39.3	0.213	2.36	1.63	10587
Strecker	58.8	65.1	5755	51.4	0.073	29.4	5852	48.6	0.205	2.44	1 15	11607
Walker	73.6	29.3	4139	37 1	0.1	38.7	6804	62.9	0.297	0.856	0.672	10943
Wilson B	70.5	74.8	7131	68	0.075	21 1	3365	32	0.182	3.8	2.18	10496
Wilson D	71	69.8	6259	58.3	0.078	27.6	4474	41 7	0.244	2.91	1.52	10733
Woods	72.8	75.3	6796	64	0.076	31.2	4061	36	0.263	3.04	2.04	10857

Subjects	Day 1 Time 4 HR	Day 1 Time 4 LFpk	Day 1 Time 4 LFA	Day 1 Time 4 %LFA	Day 1 Time 4 LFcf	Day 1 Time 4 HFpk	Day 1 Time 4 HFA	Day 1 Time 4 %HFA	Day 1 Time 4 HFcf	Day 1 Time 4 LF:HFpk	Day 1 Time 4 LF:HFA	Day 1 Time 4 TA
Alger	53.6	72.5	5974	52.2	0.069	34.9	5466	47.8	0.232	2.51	1.22	11440
Amos	55.4	78.2	6950	66.2	0.062	19.4	3534	33.8	0.251	4.25	2.19	10484
Andoney	49.1	94.2	6486	61.8	0.054	22.8	3997	38.2	0.264	4.55	1 75	10483
Arsenault	75.5	82.9	6711	67.3	0.068	16.8	3493	32.7	0.268	5.83	2.4	10204
Baird	64.2	52.2	5421	48.5	0.064	41.6	5730	51.5	0.252	1.58	1.06	11151
Barrett	88.5	56.4	5660	47.9	0.076	31.9	6099	52.1	0.296	1.97	0.936	11759
Biggar												
Bissessar	71.2	78.3	6399	57 7	0.07	29	4848	42.3	0.23	3.66	1.61	11247
Borg	93.3	69.9	7560	63.7	0.068	32.2	4293	36.3	0.34	2.77	1.95	11853
Brown	66.6	52.1	6287	48.7	0.087	31.4	6717	51.3	0.258	1 75	1.01	13004
Cassar	73	78.1	6785	61.9	0.063	26.7	4173	38.1	0.248	3.24	1 71	10958
Charest	75.7	56	5529	47	0.078	52.8	6147	53	0.293	1.25	0.93	11676
Coons	59.5	43.7	5166	46.3	0.086	58.6	5929	53.7	0.287	0.872	0.886	11095
Cosentino	67.9	74.5	6476	60.7	0.073	39.1	4163	39.3	0.258	2.21	1.62	10639
Cove	79.1	34.4	4464	40.2	0.1	31.6	6858	59.8	0.26	1.3	0.732	11322
Currie	69.2	68.6	6589	65	0.079	23	3589	35	0.189	3.41	1.97	10178
Dawson	56.5	74.8	6593	66.4	0.073	19.4	3300	33.6	0.206	4.08	2.01	9893
Day	59.7	70.5	6402	52.6	0.063	37 7	5823	47.4	0.259	2.03	1 19	12225
Deboer	69.1	58.5	6048	51.4	0.071	49.9	5662	48.6	0.259	1.41	1 12	11710
Elaco	61.8	79.9	6874	64.1	0.061	23.8	3951	35.9	0.236	3.75	1.88	10825
Eramo												
Fagan	81.9	81.3	6932	66.9	0.071	28.5	3475	33.1	0.252	4.18	2.19	10407
Faiella	60.4	82.5	6568	62.6	0.062	21 7	3964	37.4	0.25	4.52	1.82	10532
Farr	58	32.5	4660	40.1	0.071	55.2	7102	59.9	0.367	0.889	0.888	11762
Galli	59.8	85	6967	70.8	0.071	17.4	2919	29.2	0.195	5.5	2.67	9886
Goromaru	70.1	71.5	6636	64.5	0.075	31.6	3582	35.5	0.298	2.58	2.04	10218
Guenther	60	70.9	6459	59.9	0.066	21 1	4457	40.1	0.222	3.81	1 72	10916
Hawkins	64	73.1	6356	63.8	0.065	18.8	3661	36.2	0.24	4.37	1.93	10017
Hill	54.7	77.9	6845	67.6	0.07	25	3273	32.4	0.276	3.39	2.21	10118
Irani	92.3	82.3	6612	71.2	0.081	18.5	2669	28.8	0.171	4.84	2.56	9281
Johnson	87	50.8	5677	49.5	0.086	60	5845	50.5	0.308	0.994	1.02	11522

Subjects	Day 1 Time 4 HR	Day 1 Time 4 LFpk	Day 1 Time 4 LFA	Day 1 Time 4 %LFA	Day 1 Time 4 LFcf	Day 1 Time 4 HFpk	Day 1 Time 4 HFA	Day 1 Time 4 %HFA	Day 1 Time 4 HFcf	Day 1 Time 4 LF:HFpk	Day 1 Time 4 LF:HFA	Day 1 Time 4 TA
Kebic	92.4	82.7	7099	72.9	0.065	15.3	2657	27 1	0.179	5.8	2.87	9756
Kennedy	68.5	75.9	6724	66	0.062	27 1	3603	34	0.293	3.59	2.2	10327
Kergl	69.9	74.4	7052	60.9	0.076	28.7	4573	39.1	0.262	2.86	1.61	11625
Koklis	67.6	84.5	6775	63.6	0.057	20.8	3891	36.4	0.293	4.39	2.03	10666
Kostyk	64.4	74.4	6890	64.3	0.069	21.4	3839	35.7	0.202	3.9	1.99	10729
Koutstaal	66	87 7	6181	65	0.064	19.4	3310	35	0.203	4.83	2.01	9491
Loosemore	53.4	58.8	6620	66.9	0.065	23.8	3229	33.1	0.247	2.63	2.16	9849
Losee	66.6	57.8	5666	51.8	0.069	34.8	5496	48.2	0.286	2.38	1.3	11162
MacDonald	74.9	97.5	6927	64.4	0.067	21.4	3845	35.6	0.289	5.25	1.97	10772
MacInnis	57.5	85.2	7085	68.8	0.06	35.9	3204	31.2	0.306	3.18	2.33	10289
MacKenzie	61.9	75.4	8112	68.8	0.076	40.4	3713	31.2	0.308	2.19	2.4	11825
Marks	73.6	58.7	6332	53.2	0.069	36.6	5588	46.8	0.356	1.82	1.28	11920
Moore	57.2	54.5	6748	54.7	0.067	30.9	5632	45.3	0.226	1.82	1.28	12380
Mueller	79.4	67 7	6712	66.4	0.062	33.2	3468	33.6	0.351	2.71	2.16	10180
Oliver	62.3	78.2	7641	72.2	0.06	25	2981	27.8	0.325	3.47	2.92	10622
Pegado	60.8	55.2	4952	47 7	0.061	87.5	5361	52.3	0.26	0.672	0.947	10313
Posthuma	76.8	63.3	6133	53.5	0.093	24.9	5729	46.5	0.26	3.49	1.6	11862
Poupore	60.5	38.6	4435	36.6	0.097	80.7	7353	63.4	0.263	0.648	0.604	11788
Runggatsher	84.5	70.4	6658	63.4	0.084	22.9	3834	36.6	0.253	3.4	1.9	10492
Scott	61 1	75.7	7148	68.1	0.064	27 7	3375	31.9	0.278	3.64	2.28	10523
Seim	63	75.4	7163	66	0.064	26	3722	34	0.282	3.42	2.11	10885
Senner												
Sheppard	75	61	7193	63.1	0.082	30.4	4303	36.9	0.264	2.12	2	11496
Slater	65.1	69.8	6534	56.6	0.078	30.4	5003	43.4	0.219	2.68	1.47	11537
Slowey	61.5	59	6950	65.5	0.092	30.8	3781	34.5	0.217	2.08	2.03	10731
Strecker	61.5	68.5	6810	63.2	0.069	23.7	3981	36.8	0.274	3.23	1.95	10791
Walker	73.6	32.1	4127	38.4	0.11	36.4	6721	61.6	0.266	1.07	0.699	10848
Wilson B	81 1	67.2	7178	73.8	0.077	19.7	2513	26.2	0.263	3.66	2.93	9691
Wilson D	78.1	68.3	6746	61.2	0.078	31.5	4201	38.8	0.277	2.63	1.66	10947
Woods	76.8	91.5	7054	72.6	0.073	14.2	2759	27.4	0.221	7.06	2.86	9813

Subjects	Day 2 Time 1 HR	Day 2 Time 1 LFpk	Day 2 Time 1 LFA	Day 2 Time 1 %LFA	Day 2 Time 1 LFcf	Day 2 Time 1 HFpk	Day 2 Time HFA	Day 2 Time 1 %HFA	Day 2 Time 1 HFcf	Day 2 Time 1 LF:HFpk	Day 2 Time 1 LF:HFA	Day 2 Time 1 TA
Alger	59	75.5	6192	60.9	0.057	30.6	3986	39.1	0.176	3.44	1.96	10178
Amos	44.8	75.2	6464	65.2	0.064	24	3485	34.8	0.223	3.34	1.93	9949
Andoney	56.3	86.1	6211	60.3	0.055	31.3	4309	39.7	0.238	4.87	2.01	10520
Arsenault												
Baird	64.3	56	5673	52.2	0.11	57 7	5219	47.8	0.188	1 17	1 18	10892
Barrett	71.5	52.5	5836	52.5	0.082	31 7	5442	47.5	0.201	1.96	1.26	11278
Biggar												
Bissessar	83.6	66.2	6070	52.8	0.067	30.5	5523	47.2	0.258	2.41	1.27	11593
Borg	89.4	67.2	5947	52.6	0.056	34.9	5382	47.4	0.308	2.19	1 15	11329
Brown	52	47 7	6343	51 7	0.078	36	6083	48.3	0.279	1.43	1 19	12426
Cassar	61 1	72	6320	55.7	0.066	39.6	5037	44.3	0.259	2.62	1.41	11357
Charest	65.6	75.5	6786	65.5	0.064	25	3595	34.5	0.264	3.64	2.14	10381
Coons	60.5	57 7	5672	56.2	0.077	27.2	4497	43.8	0.224	2.34	1.4	10169
Cosentino												
Cove	65.6	38.4	5053	40.7	0.089	31 1	7614	59.3	0.257	1.34	0.725	12667
Currie	58.3	73.4	7564	69.1	0.072	25.2	3383	30.9	0.244	3.34	2.32	10947
Dawson	48.8	87.2	6202	64.6	0.072	26.8	3380	35.4	0.201	3.58	1.9	9582
Day	59.5	66.6	5628	48.1	0.061	48.5	6148	51.9	0.229	2.11	1.08	11776
Deboer	71.6	54.5	5367	47 1	0.085	63.1	5914	52.9	0.24	1.07	0.957	11281
Elaco	57.4	59.8	5254	49.2	0.062	53.9	5440	50.8	0.259	1.38	1.01	10694
Eramo	62	62.6	7430	64.8	0.069	48.8	4117	35.2	0.346	1.64	2	11547
Fagan	73.4	71 1	5555	57 1	0.078	36.7	4027	42.9	0.199	2.35	1.52	9582
Faiella	57	80.8	6601	58.2	0.06	26.5	4831	41.8	0.237	3.74	1.63	11432
Farr												
Galli	43.8	68.7	5862	58.5	0.064	29.3	4200	41.5	0.213	2.63	1.58	10062
Goromaru	67 7	78.5	5860	54.3	0.063	49.2	4992	45.7	0.235	3.02	1.5	10852
Guenther	58.5	49.6	5093	48	0.058	35.2	5777	52	0.284	2.01	1 13	10870
Hawkins	72	69.6	5469	53.4	0.091	56.7	4909	46.6	0.205	1.9	1.3	10378
Hill	55.8	58	5946	57.9	0.062	43.8	4292	42.1	0.215	2.16	1.58	10238
Irani	68.1	85.7	7253	68.9	0.071	22.4	3232	31 1	0.211	4.57	2.63	10485
Johnson	89.5	63.3	6504	57.3	0.068	51.8	4864	42.7	0.332	1.58	1.41	11368

Subjects	Day 2 Time 1 HR	Day 2 Time 1 LFpk	Day 2 Time 1 LFA	Day 2 Time 1 %LFA	Day 2 Time 1 LFcf	Day 2 Time 1 HFpk	Day 2 Time HFA	Day 2 Time 1 %HFA	Day 2 Time 1 HFcf	Day 2 Time 1 LF:HFpk	Day 2 Time 1 LF:HFA	Day 2 Time 1 TA
Kebic	67.6	76.5	6766	66.3	0.066	30.1	3515	33.7	0.22	3.58	2.26	10281
Kennedy	70.3	62.9	5292	44.4	0.071	64.1	6558	55.6	0.264	1 1	0.821	11850
Kergl	73.9	95.5	6151	65	0.054	21 7	3391	35	0.267	5.61	2.03	9542
Koklis	69.9	76.6	6286	59	0.055	24.8	4396	41	0.297	3.61	1.69	10682
Kostyk	70.2	55.9	6013	56.2	0.072	27.4	4764	43.8	0.276	2.18	1.35	10777
Koutstaal	70.3	89.1	5406	58.2	0.056	42.5	3797	41.8	0.192	3.43	1.6	9203
Loosemore	61.5	93.7	5894	64.2	0.056	21 7	3347	35.8	0.211	5.33	1.96	9241
Losee	67.5	89.5	6761	73.6	0.063	15.7	2424	26.4	0.238	6.94	2.93	9185
MacDonald	58.4	102	7057	73.2	0.064	20.7	2601	26.8	0.247	6.07	2.86	9658
MacInnis	65.1	86.1	7270	70.7	0.068	26.6	3028	29.3	0.251	4.02	2.59	10298
MacKenzie	62.6	58.7	5606	61.9	0.066	42.8	3452	38.1	0.278	1.6	1 7	9058
Marks	53.9	86.7	6621	60.2	0.069	29.3	4374	39.8	0.222	3.66	1.69	10995
Moore	56.2	65.7	5999	60.5	0.067	28.8	3992	39.5	0.224	3.34	1 78	9991
Mueller	68	64	6793	59.6	0.091	28.9	4639	40.4	0.182	2.48	1.55	11432
Oliver	60.8	70.9	6786	67.8	0.056	31 1	3141	32.2	0.33	2.62	2.32	9927
Pegado	54.1	54.7	3849	37 7	0.056	115	6248	62.3	0.26	0.524	0.615	10097
Posthuma	66.3	50.8	5820	50	0.085	44.4	5809	50	0.26	1 76	1.23	11629
Poupore	75.8	46.5	4646	40.6	0.067	60.8	6847	59.4	0.257	0.983	0.711	11493
Runggatsher	62.6	68.8	6180	57.8	0.073	30.7	4554	42.2	0.217	2.62	1.49	10734
Scott												
Seim	54.2	72.1	5901	68.8	0.064	16.4	2692	31.2	0.222	5.28	2.38	8593
Senner	62.6	76.3	6865	66.7	0.074	25.7	3853	33.3	0.198	3.74	2.48	10548
Sheppard	69	69.4	6650	62	0.071	37.5	4298	38	0.308	2.47	1.88	10948
Slater	70.4	51.4	6307	56.7	0.078	30.1	4911	43.3	0.23	1.91	1.4	11218
Slowey	41.8	62.1	5687	55	0.08	48.8	4574	45	0.224	1.84	1.39	10261
Strecker	55.2	79.1	6485	63.5	0.069	22.6	3833	36.5	0.239	4.36	1.84	10318
Walker	65.2	25.6	3215	26.5	0.1	58	8868	73.5	0.264	0.505	0.369	12083
Wilson B	70.1	75.6	6332	63.1	0.068	32.7	3717	36.9	0.294	3.4	1.95	10049
Wilson D	68.5	62.1	5815	51.2	0.13	61.3	5545	48.8	0.189	1 17	1 1	11360
Woods	61.4	80.4	6168	62.2	0.067	37	3868	37.8	0.224	2.85	1.84	10036

Subjects	Day 2 Time 2 HR	Day 2 Time 2 LFpk	Day 2 Time 2 LFA	Day 2 Time 2 %LFA	Day 2 Time 2 LFcf	Day 2 Time 2 HFpk	Day 2 Time 2 HFA	Day 2 Time 2 %HFA	Day 2 Time 2 HFcf	Day 2 Time 2 LF:HFpk	Day 2 Time 2 LF:HFA	Day 2 Time 2 TA
Alger	71.9	63.1	6324	55.7	0.071	26.4	5155	44.3	0.328	2.6	1.42	11479
Amos	58.3	92.5	7046	67	0.064	21.5	3515	33	0.254	4.77	2.35	10561
Andoney	54	76.8	6615	60.5	0.067	24	4317	39.5	0.233	3.4	1.59	10932
Arsenault												
Baird	60.8	49.5	5311	42.8	0.075	46.5	7053	57.2	0.235	1 16	0.829	12364
Barrett	77.9	52.6	5267	45.8	0.072	38.7	6211	54.2	0.273	1.49	0.871	11478
Biggar												
Bissessar	97.8	57.2	6732	61.2	0.087	23.3	4225	38.8	0.262	2.6	1.68	10957
Borg	95.3	78.1	6960	64.8	0.06	20.8	3796	35.2	0.275	4.49	1.97	10756
Brown	58.1	41.5	5458	51 7	0.097	27.4	4950	48.3	0.265	1.56	1 17	10408
Cassar	88	86.7	7068	67.3	0.065	19.3	3424	32.7	0.212	4.88	2.18	10492
Charest	77.6	73	6841	66.9	0.068	20.2	3407	33.1	0.18	3.83	2.09	10248
Coons	87.9	72.8	6910	62.6	0.068	23.5	4164	37.4	0.19	3.3	1 74	11074
Cosentino												
Cove	83.5	33.1	4566	37.9	0.12	31.4	7381	62.1	0.332	1.06	0.635	11947
Currie	74.2	82.5	6986	68.6	0.071	18.5	3190	31.4	0.173	4.83	2.25	10176
Dawson	59.5	80.5	6919	61 7	0.073	25.9	4398	38.3	0.238	3.82	1.8	11317
Day	76.6	71	6143	59.6	0.068	21.8	4235	40.4	0.297	3.94	1 77	10378
Deboer	64	54.5	5139	45	0.064	54.9	6238	55	0.228	1 15	0.874	11377
Elaco	68	80.8	6676	64.7	0.061	20.6	3627	35.3	0.271	4.12	1.96	10303
Eramo	57.8	71	6311	54.5	0.074	44	5321	45.5	0.246	211	1.44	11632
Fagan	87.9	72.6	6682	62.6	0.077	21.9	4028	37.4	0.218	3.75	1 77	10710
Faiella	61.5	81.8	6611	60.5	0.071	21.5	4478	39.5	0.235	4.27	1 73	11089
Farr												
Galli	71 7	64.6	6012	59.9	0.07	20.2	4184	40.1	0.271	3.64	1.65	10196
Goromaru	95.6	54.8	6331	57.4	0.077	27	4622	42.6	0.314	2.14	1.58	10953
Guenther	64.5	57 1	6661	59.7	0.073	32.2	5003	40.3	0.282	2.05	1.69	11664
Hawkins	79.2	76.4	7016	65.6	0.074	20.9	3819	34.4	0.193	4.05	2.13	10835
Hill	62.4	67 7	6577	65	0.066	19.1	3535	35	0.247	3.85	2.06	10112
Irani	78.7	81.5	6986	70.1	0.063	21.5	2881	29.9	0.218	4.39	2.57	9867
Johnson	92.5	56.3	6200	57.3	0.09	42.3	4672	42.7	0.316	1.45	1.39	10872

Subjects	Day 2 Time 2 HR	Day 2 Time 2 LFpk	Day 2 Time 2 LFA	Day 2 Time 2 %LFA	Day 2 Time 2 LFcf	Day 2 Time 2 HFpk	Day 2 Time 2 HFA	Day 2 Time 2 %HFA	Day 2 Time 2 HFcf	Day 2 Time 2 LF:HFpk	Day 2 Time 2 LF:HFA	Day 2 Time 2 TA
Kebic	64.2	68.2	6177	62	0.073	33.4	3979	38	0.207	3.07	1.95	10156
Kennedy	82.5	87 1	7446	69.3	0.064	17.4	3306	30.7	0.292	5.34	2.43	10752
Kergl	66.4	74.7	5971	60.2	0.074	40	3888	39.8	0.215	3.01	1.82	9859
Koklis	81.5	63.4	6729	63.2	0.056	29.8	3885	36.8	0.343	2.44	1.87	10614
Kostyk	76.5	62.4	6867	58.8	0.068	25.1	4955	41.2	0.235	2.77	1.56	11822
Koutstaal	83.5	85.3	6669	71.6	0.072	15.6	2619	28.4	0.181	5.8	2.6	9288
Loosemore	64.9	88.3	6246	59.1	0.059	44	4293	40.9	0.2	3.7	1 74	10539
Losee	60.5	78	5933	62.3	0.056	19.9	3495	37 7	0.228	5.16	1.94	9428
MacDonald	70.7	68.2	6250	64.6	0.064	20.9	3544	35.4	0.27	3.74	1.95	9794
MacInnis	73.3	80.7	7167	68.9	0.066	17.4	3226	31 1	0.201	4.86	2.41	10393
MacKenzie	72	72.7	7007	65.1	0.065	23.3	3790	34.9	0.237	3.43	1.9	10797
Marks	78.3	70.3	6499	62.5	0.076	20.5	3934	37.5	0.28	4.14	1.92	10433
Moore	77.8	53.7	6388	56.1	0.079	28.8	5027	43.9	0.223	2.05	1.39	11415
Mueller	80.3	67.5	7648	67.4	0.052	21.3	3772	32.6	0.0973	3.46	2.22	11420
Oliver	62.5	90.7	6593	69.4	0.062	23.7	2896	30.6	0.299	5.07	2.6	9489
Pegado	88.4	76.3	6565	66.9	0.064	15.8	3307	33.1	0.285	5.66	2.25	9872
Posthuma	84.6	70.9	6776	65.7	0.075	18.3	3551	34.3	0.263	4.17	2.17	10327
Poupore	91.8	55.7	6768	55.6	0.069	34.7	5421	44.4	0.307	1.81	1.33	12189
Runggatsher	93.5	79.4	7011	64.6	0.087	20.9	3824	35.4	0.259	4.13	1.96	10835
Scott												
Seim	68.2	83.4	7245	66.6	0.071	20	3813	33.4	0.199	4.95	2.17	11058
Senner												
Sheppard	113	66.7	6538	64.5	0.081	19.7	3642	35.5	0.225	3.94	1.93	10180
Slater	60.6	48	5815	48.8	0.098	51.6	6057	51.2	0.266	1.02	0.999	11872
Slowey	88.9	67.4	6613	61 1	0.085	21 1	4190	38.9	0.246	3.39	1.8	10803
Strecker	64.9	48.1	5013	49.4	0.088	26.2	5316	50.6	0.199	2.04	1.04	10329
Walker	67.8	30.5	4027	33.2	0.13	33.9	8064	66.8	0.297	0.929	0.542	12091
Wilson B	79.8	78.3	7076	69.3	0.074	20.6	3136	30.7	0.212	4.09	2.49	10212
Wilson D	74.6	56.9	5604	50.8	0.079	50.2	5338	49.2	0.226	1.98	1.2	10942
Woods	84.9	92.4	6484	72.6	0.069	12.8	2425	27.4	0.291	8.28	3.05	8909

Subjects	Day 2 Time 3 HR	Day 2 Time 3 LFpk	Day 2 Time 3 LFA	Day 2 Time 3 %LFA	Day 2 Time 3 LFcf	Day 2 Time 3 HFpk	Day 2 Time 3 HFA	Day 2 Time 3 %HFA	Day 2 Time 3 HFcf	Day 2 Time 3 LF:HFpk	Day 2 Time 3 LF:HFA	Day 2 Time 3 TA
Alger	88.3	53.4	5923	54.5	0.053	24.6	5015	45.5	0.382	2.79	1.54	10938
Amos	58.5	66.3	7016	59.9	0.069	27 1	4659	40.1	0.294	2.55	1.83	11675
Andoney	49.9	69.3	7026	65	0.063	21.5	3705	35	0.22	3.37	2.02	10731
Arsenault												
Baird	61.8	49	4714	40.5	0.081	63.4	6821	59.5	0.237	0.921	0.713	11535
Barrett	75	61 1	6636	60.2	0.084	33.8	4384	39.8	0.277	1.99	1.62	11020
Biggar												
Bissessar	91.8	59.8	6574	59.1	0.08	23	4602	40.9	0.239	2.75	1.52	11176
Borg	107	65.5	6174	53.9	0.059	37	5252	46.1	0.331	1.85	1 18	11426
Brown	85.4	28	4308	38.8	0.11	31.9	6806	61.2	0.322	0.969	0.709	11114
Cassar	80.9	75.8	6993	63.1	0.079	20.2	4082	36.9	0.205	3.94	1 78	11075
Charest	75.2	88.3	7538	69.2	0.068	19.7	3348	30.8	0.248	4.85	2.34	10886
Coons	82.7	59.4	6580	60.8	0.078	25.4	4344	39.2	0.25	2.54	1 76	10924
Cosentino												
Cove	76.2	36.3	5084	41.2	0.11	31.6	7305	58.8	0.315	1 18	0.767	12389
Currie	79.4	61.5	6574	64.9	0.076	21.5	3558	35.1	0.185	3.14	1.93	10132
Dawson	54.4	57.5	6229	57.3	0.072	36.3	4665	42.7	0.274	1.84	1.43	10894
Day	57 1	79.7	6052	53.3	0.065	39.3	5296	46.7	0.233	2.61	1.36	11348
Deboer	75.1	61	5178	45.8	0.084	59.2	6100	54.2	0.222	1.28	0.881	11278
Elaco	59.8	67.2	6727	59.6	0.063	43.6	4553	40.4	0.33	1 79	1.6	11280
Eramo	61.8	70.6	7395	63.6	0.069	30.3	4262	36.4	0.264	2.53	1.91	11657
Fagan	95.1	83.8	7437	68.9	0.075	23.2	3357	31 1	0.173	3.9	2.32	10794
Faiella	66.6	78.8	6385	64.9	0.06	18.3	3494	35.1	0.324	5.13	2.08	9879
Farr												
Galli	52.7	78	6663	65.9	0.065	21.4	3482	34.1	0.195	4.04	2.11	10145
Goromaru	82	59.4	6239	64.4	0.078	21.6	3463	35.6	0.203	2.87	1.89	9702
Guenther	62	70.3	7054	62.5	0.068	32.4	4396	37.5	0.271	3.1	1.85	11450
Hawkins	80	90.6	6831	69.6	0.072	14.9	3279	30.4	0.23	7.43	2.71	10110
Hill	61.3	65.9	6453	65.2	0.053	19.6	3438	34.8	0.284	3.69	2.01	9891
Irani	88.2	83.8	6833	70.8	0.082	18.2	2793	29.2	0.175	4.94	2.55	9626
Johnson	96.5	44.7	5256	45.9	0.074	38.5	6208	54.1	0.348	1.23	0.86	11464

Subjects	Day 2 Time 3 HR	Day 2 Time 3 LFpk	Day 2 Time 3 LFA	Day 2 Time 3 %LFA	Day 2 Time 3 LFcf	Day 2 Time 3 HFpk	Day 2 Time 3 HFA	Day 2 Time 3 %HFA	Day 2 Time 3 HFcf	Day 2 Time 3 LF:HFpk	Day 2 Time 3 LF:HFA	Day 2 Time 3 TA
Kebic	71.9	73.4	7099	69.7	0.074	21 1	3092	30.3	0.182	3.57	2.36	10191
Kennedy	82.3	68.6	7061	64.9	0.064	18.8	3954	35.1	0.286	3.98	2.02	11015
Kergl	82.5	79.6	7123	68.1	0.079	21	3386	31.9	0.22	3.97	2.26	10509
Koklis	101	40.4	6559	54	0.077	32.5	5574	46	0.32	1.3	1.24	12133
Kostyk	68.7	62.8	6744	63.2	0.068	29.9	4023	36.8	0.275	2.63	1.89	10767
Koutstaal	71.9	74.2	6862	64.2	0.07	23.2	3764	35.8	0.242	3.88	2.01	10626
Loosemore	72.1	67.6	6146	66.2	0.068	16.3	3129	33.8	0.237	4.37	2.04	9275
Losee	65.3	40	5369	44.4	0.083	45.9	6856	55.6	0.291	1.07	0.902	12225
MacDonald	69.6	80.2	6632	64.7	0.067	20.6	3595	35.3	0.232	4.08	1.91	10227
MacInnis	59.6	68.8	7237	68.1	0.073	23.6	3393	31.9	0.225	3.32	2.26	10630
MacKenzie	69.4	66.5	7215	67.4	0.074	24.9	3523	32.6	0.258	2.9	2.19	10738
Marks	66.9	66.1	6333	59.7	0.077	30.2	4313	40.3	0.269	2.82	1.58	10646
Moore	90.4	73.4	6621	61.5	0.081	23.4	4241	38.5	0.182	3.46	1 7	10862
Mueller	79.3	56.1	6843	61.2	0.068	29	4403	38.8	0.301	2.28	1 76	11246
Oliver	67.6	71	6471	61.5	0.069	21.5	4126	38.5	0.248	3.83	1.81	10597
Pegado	95.7	78.1	6619	72.2	0.06	13.2	2549	27.8	0.207	6.38	2.83	9168
Posthuma	73.3	73.8	6605	63.5	0.078	22.5	3842	36.5	0.238	3.65	1.87	10447
Poupore	71.8	46.9	5726	46.2	0.063	37.6	6475	53.8	0.288	1.37	1.03	12201
Runggatsher	76.1	65.8	6651	57.6	0.082	33.7	4996	42.4	0.278	2.13	1.49	11647
Scott												
Seim	69.8	80.7	7669	69.6	0.068	20.8	3420	30.4	0.186	4.46	2.48	11089
Senner	59.1	69.5	5897	55.4	0.082	40	4651	44.6	0.178	1.96	1.38	10548
Sheppard	103	56.1	6166	65.7	0.083	19	3234	34.3	0.213	3.17	2.04	9400
Slater	70.8	72.5	7299	59	0.088	28.3	5157	41	0.193	2.86	1.56	12456
Slowey	59.2	69.7	7115	62.3	0.085	32.4	4403	37 7	0.197	2.19	1 74	11518
Strecker	60.5	69.6	7190	63.5	0.081	23.1	4189	36.5	0.27	3.2	1.95	11379
Walker	73.1	32	4399	34.8	0.11	49.3	8372	65.2	0.297	0.695	0.586	12771
Wilson B	71 1	74.5	7485	66.8	0.079	27.8	3736	33.2	0.229	3.04	2.14	11221
Wilson D	77.8	66	6484	59.4	0.073	25.3	4406	40.6	0.222	2.92	1.54	10890
Woods	75.4	86.1	7075	70.1	0.074	17.5	3002	29.9	0.182	5.1	2.4	10077

Subjects	Day 2 Time 4 HR	Day 2 Time 4 LFpk	Day 2 Time 4 LFA	Day 2 Time 4 %LFA	Day 2 Time 4 LFcf	Day 2 Time 4 HFpk	Day 2 Time 4 HFA	Day 2 Time 4 %HFA	Day 2 Time 4 HFcf	Day 2 Time 4 LF:HFpk	Day 2 Time 4 LF:HFA	Day 2 Time 4 TA
Alger	58.9	85.2	5252	53.6	0.055	44.6	4659	46.4	0.211	3.49	1.26	9911
Amos	51.3	69	6763	60.7	0.057	24.2	4358	39.3	0.252	3	1 7	11121
Andoney	57.4	73.9	6803	71.4	0.063	18.7	2777	28.6	0.254	4.59	2.69	9580
Arsenault												
Baird	63	56.7	5493	47.5	0.09	55.9	6009	52.5	0.206	1.3	0.984	11502
Barrett	78.5	64.8	6599	64.5	0.078	21.9	3603	35.5	0.267	3.13	1.91	10202
Biggar												
Bissessar	78.5	53.6	6381	58.5	0.071	31	4648	41.5	0.297	1.97	1.57	11029
Borg	104	65.2	6875	65	0.065	19.7	3754	35	0.278	3.65	2.18	10629
Brown	57.2	49.8	6474	52.1	0.094	36.1	6199	47.9	0.263	1.56	1 19	12673
Cassar	75.4	79	6955	67.8	0.075	33.7	3348	32.2	0.272	3.12	2.27	10303
Charest	69.5	89.3	7083	72.3	0.062	23.2	2821	27 7	0.285	5.6	2.95	9904
Coons	65.6	62.6	6762	60.1	0.072	24.9	4549	39.9	0.203	2.76	1.58	11311
Cosentino												
Cove	68	39.8	5495	41.6	0.11	34.8	7938	58.4	0.287	1.33	0.886	13433
Currie	70.5	77.2	7028	64.1	0.075	24.4	3945	35.9	0.202	3.36	1.88	10973
Dawson	56.1	72.2	7179	64.3	0.073	27 7	3987	35.7	0.24	2.86	1.91	11166
Day	70.4	85.3	7139	67 7	0.064	19.4	3460	32.3	0.275	5.24	2.34	10599
Deboer	68.9	59	6938	57 7	0.082	43	5056	42.3	0.284	1.6	1.43	11994
Elaco	62.5	64.5	6443	56.3	0.067	33.7	5085	43.7	0.293	2.27	1.39	11528
Eramo	61.9	67 7	7086	59.7	0.072	26.3	48.16	40.3	0.289	2.88	1.62	11902
Fagan	76	74.1	7109	63.1	0.065	30.7	4234	36.9	0.268	2.86	1 77	11343
Faiella	61 7	64.4	6825	60.2	0.059	31.6	4529	39.8	0.33	2.35	1 78	11354
Farr												
Galli	53.7	76.2	6629	62.8	0.07	22.5	4145	37.2	0.21	3.96	1.84	10774
Goromaru	95.8	49.8	5623	58.3	0.081	20.1	4241	41 7	0.254	2.79	1.54	9864
Guenther	60.4	51 1	6065	56.5	0.08	32.3	5163	43.5	0.314	1.97	1.69	11228
Hawkins	73.8	69.6	5549	62.6	0.07	15.7	3423	37.4	0.205	4.74	1.83	8972
Hill	62	74.6	7060	61.3	0.084	28.5	4480	38.7	0.252	2.97	1.64	11540
Irani	81	74.8	7709	70.1	0.074	20.2	3282	29.9	0.262	4.35	2.48	10991
Johnson	97.6	59.9	6335	53.9	0.08	36.7	5358	46.1	0.322	1 7	1.21	11693

Subjects	Day 2 Time 4 HR	Day 2 Time 4 LFpk	Day 2 Time 4 LFA	Day 2 Time 4 %LFA	Day 2 Time 4 LFcf	Day 2 Time 4 HFpk	Day 2 Time 4 HFA	Day 2 Time 4 %HFA	Day 2 Time 4 HFcf	Day 2 Time 4 LF:HFpk	Day 2 Time 4 LF:HFA	Day 2 Time 4 TA
Kebic	80.2	80.9	7412	71.6	0.073	20.2	2951	28.4	0.224	4.23	2.64	10363
Kennedy	77 7	72.4	6696	65.2	0.069	19.5	3591	34.8	0.194	4.04	2.01	10287
Kergl	78.6	74.1	7147	68.2	0.072	23.3	3509	31.8	0.309	3.51	2.35	10656
Koklis	89.3	39.6	6188	53.1	0.078	38.8	5489	46.9	0.348	1 15	1 18	11677
Kostyk	73.2	65.1	6455	61.8	0.072	21.8	4135	38.2	0.245	3.69	2.05	10590
Koutstaal	80.4	72.1	6454	61.9	0.068	29.4	3884	38.1	0.243	2.94	1 77	10338
Loosemore	63.1	74.3	7068	63.7	0.076	22.8	4003	36.3	0.185	3.5	1.82	11072
Losee	65.6	49.3	5047	43.8	0.057	28.1	6279	56.2	0.303	1.91	0.863	11326
MacDonald	69.9	87.6	6858	68.6	0.069	23.4	3155	31.4	0.23	4.24	2.32	10013
MacInnis	53.6	72.8	6819	68.5	0.065	34.3	3110	31.5	0.281	2.85	2.42	9929
MacKenzie	68.5	71.5	6524	69.8	0.073	20.7	2833	30.2	0.204	4	2.46	9357
Marks	69.8	81.8	6816	64.5	0.072	21 1	3799	35.5	0.202	4.37	1.96	10615
Moore	60.2	34.8	5552	44.6	0.11	37.3	6953	55.4	0.3	1.04	0.983	12505
Mueller	80.7	72	6790	66.9	0.069	23	3430	33.1	0.293	3.48	2.18	10220
Oliver	65.9	66.2	6686	62.2	0.066	32.9	4144	37.8	0.384	2.69	1.85	10830
Pegado	71.9	83.3	6214	63.6	0.06	30.9	3622	36.4	0.256	4.28	2.05	9836
Posthuma	63.6	67.5	6259	65.9	0.066	22.7	3284	34.1	0.297	3.42	2.18	9543
Poupore	63.1	42.8	4460	38.9	0.078	82.4	6880	61 1	0.279	0.622	0.653	11340
Runggatsher	81 7	76.7	6926	64.8	0.08	24.6	3812	35.2	0.287	3.54	2.01	10738
Scott												
Seim	56	83.4	7006	71 7	0.072	17.3	2720	28.3	0.191	5	2.65	9726
Senner	62.1	84.1	5621	51.3	0.065	46.6	5363	48.7	0.197	2.35	1 13	10984
Sheppard	74.8	61.5	6856	64.1	0.082	27 1	3901	35.9	0.253	3.01	1.99	10757
Slater	77.6	66.6	6722	58.2	0.087	26.2	4900	41.8	0.194	2.77	1.45	11622
Slowey	55.5	63.6	7305	60.1	0.087	35.6	4912	39.9	0.174	1.92	1.58	12217
Strecker	62.4	64.4	6610	60.1	0.072	25.9	4515	39.9	0.238	2.89	1.62	11125
Walker	72.4	31.6	4070	38.3	0.092	38.1	6684	61 7	0.31	0.899	0.67	10754
Wilson B	74.1	89.3	7837	73.8	0.078	24.2	2806	26.2	0.271	4.16	2.96	10643
Wilson D	82.7	69.4	6687	63.4	0.08	23	3889	36.6	0.229	3.74	1.86	10576
Woods	82.8	79	6223	76	0.071	11.6	2007	24	0.226	7 73	3.49	8230

Subjects	Day 3 Time 1 HR	Day 3 Time 1 LFpk	Day 3 Time 1 LFA	Day 3 Time 1 %LFA	Day 3 Time 1 LFcf	Day 3 Time 1 HFpk	Day 3 Time 1 HFA	Day 3 Time 1 %HFA	Day 3 Time 1 HFcf	Day 3 Time 1 LF:HFpk	Day 3 Time 1 LF:HFA	Day 3 Time 1 TA
Alger												
Amos	44.3	64.3	5821	53.4	0.057	44.3	5311	46.6	0.259	1 73	1.31	11132
Andoney												
Arsenault												
Baird	76.8	42.9	4600	39.7	0.11	60.8	6976	60.3	0.2	0.753	0.667	11576
Barrett	65.2	75	6622	63.7	0.067	28.2	3715	36.3	0.178	2.91	1.89	10337
Biggar	57 7	61.3	4819	47 1	0.058	47 7	5596	52.9	0.284	1.47	0.975	10415
Bissessar												
Borg	86.5	70.2	6242	59.7	0.062	24.2	4247	40.3	0.272	3.32	1.58	10489
Brown	51	49.6	6336	50.3	0.094	42.9	6406	49.7	0.286	1.25	1.08	12742
Cassar	69.2	74	7240	65	0.061	25.1	3887	35	0.276	3.35	1.99	11127
Charest												
Coons	66	68.5	6410	61 1	0.073	33.7	4038	38.9	0.248	2.53	1 72	10448
Cosentino												
Cove												
Currie	61 7	67.4	6776	62.7	0.073	34.6	4017	37.3	0.297	2.42	1.87	10793
Dawson												
Day	51.5	78	5726	56.9	0.065	42.7	4412	43.1	0.208	2.95	1.51	10138
Deboer	63.4	51 7	5517	49.3	0.07	72	5616	50.7	0.252	1.02	1.07	11133
Elaco	57.4	53.7	5051	50.3	0.055	59.5	4979	49.7	0.24	1 75	1.21	10030
Eramo												
Fagan												
Faiella	63.1	75.8	6455	62.5	0.064	29.5	3984	37.5	0.247	4.57	2.03	10439
Farr												
Galli	46.5	98.7	6375	67.5	0.057	24.2	3055	32.5	0.196	5.38	2.42	9430
Goromaru												
Guenther	54.6	79.3	5963	61.4	0.057	21.9	3827	38.6	0.231	4.5	1.82	9790
Hawkins	58.4	78	6353	61 7	0.094	42.2	3905	38.3	0.197	2.08	1 72	10258
Hill	70.6	83.4	7113	64.9	0.05	18.4	3961	35.1	0.218	4.98	1.93	11074
Irani	76.5	78.9	6829	73.6	0.068	17 1	2464	26.4	0.211	5.05	3.01	9293
Johnson	81.4	44.8	4820	43	0.09	66.6	6325	57	0.268	0.959	0.816	11145

Subjects	Day 3 Time 1 HR	Day 3 Time 1 LFpk	Day 3 Time 1 LFA	Day 3 Time 1 %LFA	Day 3 Time 1 LFcf	Day 3 Time 1 HFpk	Day 3 Time 1 HFA	Day 3 Time 1 %HFA	Day 3 Time 1 HFcf	Day 3 Time 1 LF:HFpk	Day 3 Time 1 LF:HFA	Day 3 Time 1 TA
Kebic	62.1	70.5	6601	62.1	0.079	33.4	3969	37.9	0.213	2.34	1 74	10570
Kennedy												
Kergl	71.4	79.6	5936	61.4	0.064	27.6	3809	38.6	0.235	4.16	1.96	9745
Koklis												
Kostyk	64.9	73.3	6038	61.2	0.066	24.1	4178	38.8	0.245	3.84	1.96	10216
Koutstaal	60.4	90.4	6247	61.5	0.065	35.1	3900	38.5	0.186	3.93	2.03	10147
Loosemore	53.6	96	6489	72	0.057	16.8	2515	28	0.243	7.46	2.98	9004
Losee	63	91.8	6687	66.1	0.064	20	3851	33.9	0.217	6.25	2.35	10538
MacDonald	60	81.8	6676	66.4	0.065	16.4	3368	33.6	0.219	5.17	2.08	10044
MacInnis	53.9	71.6	5914	56	0.063	42.8	4565	44	0.253	1.9	1.34	10479
MacKenzie	62.6	67	6838	68	0.07	28.4	3202	32	0.246	3.01	2.26	10040
Marks	49.9	69	6079	61.2	0.069	26.4	3949	38.8	0.218	2.98	1 78	10028
Moore	48.9	67.6	6056	67.9	0.058	17 1	3018	32.1	0.232	4.85	2.36	9074
Mueller	62	66.9	7395	64.5	0.087	27 7	4072	35.5	0.21	2.61	1.89	11467
Oliver	55.8	64.3	5981	57	0.07	63.4	4488	43	0.29	1.52	1.4	10469
Pegado	72.2	79.2	5634	56.9	0.056	47 7	4261	43.1	0.251	2.82	1.51	9895
Posthuma	58.2	61	6286	60.4	0.07	75.5	4147	39.6	0.281	2.13	1 79	10433
Poupore	72.9	64.4	5219	47	0.066	71.2	5860	53	0.236	1.36	0.953	11079
Runggatsher	73.4	71.5	6285	54.2	0.073	29.6	5264	45.8	0.232	2.72	1.33	11549
Scott												
Seim												
Senner	72	66.4	5829	53	0.063	34.2	5326	47	0.244	2.22	1.37	11155
Sheppard	52.8	75.8	8133	64.7	0.075	35.7	4393	35.3	0.294	2.32	1.99	12526
Slater	65.3	45.4	5419	46.8	0.091	60.2	6101	53.2	0.257	0.929	0.925	11520
Slowey	39.6	43.9	4547	50.2	0.066	65.4	4613	49.8	0.223	1.02	1.06	9160
Strecker												
Walker	67 1	27.4	3218	26.5	0.085	54.1	8663	73.5	0.26	0.589	0.379	11881
Wilson B	63.5	84.9	6451	65.1	0.068	34.3	3493	34.9	0.271	3.23	1.93	9944
Wilson D	74.3	71.5	5793	56.4	0.074	45.9	4611	43.6	0.221	2.37	1.48	10404
Woods	60.7	92.4	6636	65.3	0.07	40.8	3647	34.7	0.212	3.73	2.26	10283

Subjects	Day 3 Time 2 HR	Day 3 Time 2 LFpk	Day 3 Time 2 LFA	Day 3 Time 2 %LFA	Day 3 Time 2 LFcf	Day 3 Time 2 HFpk	Day 3 Time 2 HFA	Day 3 Time 2 %HFA	Day 3 Time 2 HFcf	Day 3 Time 2 LF:HFpk	Day 3 Time 2 LF:HFA	Day 3 Time 2 TA
Alger												
Amos	57.4	86.8	7173	64.3	0.063	20.7	4038	35.7	0.25	4.52	2	11211
Andoney												
Arsenault												
Baird	98.2	49.4	5789	49.8	0.08	37.4	5783	50.2	0.304	1.44	1.03	11572
Barrett	72.8	66.6	6229	54.7	0.069	42.8	5130	45.3	0.27	1.85	1.32	11359
Biggar	89	58.6	6849	58.1	0.076	29.1	4928	41.9	0.293	2.21	1.51	11777
Bissessar												
Borg	80.5	72.1	6504	57.9	0.052	34.1	4759	42.1	0.306	2.44	1.49	11263
Brown	65.2	58.5	6885	58	0.091	43.3	4963	42	0.336	1.41	1.41	11848
Cassar	83.2	66.2	6273	61.3	0.059	21.2	3978	38.7	0.289	3.3	1.66	10251
Charest												
Coons	81	85.6	7319	67.2	0.071	20	3621	32.8	0.225	4.45	2.18	10940
Cosentino												
Cove												
Currie	72	66	7018	67.2	0.07	21.6	3450	32.8	0.206	3.11	2.23	10468
Dawson												
Day	78.2	56.7	6158	57.4	0.072	23.4	4567	42.6	0.317	2.72	1.86	10725
Deboer	70.2	48.9	5316	45.9	0.076	58.5	6238	54.1	0.247	0.973	0.897	11554
Elaco	62.1	50.8	6147	54.8	0.069	30.7	5043	45.2	0.28	1.89	1.26	11190
Eramo												
Fagan												
Faiella	63.7	57.4	6449	58.5	0.072	24.3	4770	41.5	0.31	3.12	1 74	11219
Farr												
Galli	61.8	81	6588	66.8	0.062	20.1	3541	33.2	0.236	4.85	2.23	10129
Goromaru												
Guenther	52.7	48.6	5961	47 1	0.091	39.8	6846	52.9	0.255	1.28	0.946	12807
Hawkins	69.2	67.3	6521	60.3	0.078	24.6	4417	39.7	0.225	3.01	1.67	10938
Hill	75.9	55.4	6346	54.9	0.076	27 7	5249	45.1	0.278	2.22	1.33	11595
Irani	79.6	66.8	6762	65.3	0.074	23.2	3579	34.7	0.231	3.29	2	10341
Johnson	98.2	49.4	5789	49.8	0.08	37.4	5783	50.2	0.304	1.44	1.03	11572

Subjects	Day 3 Time 2 HR	Day 3 Time 2 LFpk	Day 3 Time 2 LFA	Day 3 Time 2 %LFA	Day 3 Time 2 LFcf	Day 3 Time 2 HFpk	Day 3 Time 2 HFA	Day 3 Time 2 %HFA	Day 3 Time 2 HFcf	Day 3 Time 2 LF:HFpk	Day 3 Time 2 LF:HFA	Day 3 Time 2 TA
Kebic	63.4	72.4	6923	70.2	0.066	20.6	2920	29.8	0.209	3.75	2.43	9843
Kennedy												
Kergl	81.3	85.1	6966	63.6	0.08	24.9	4000	36.4	0.176	3.76	1.81	10966
Koklis												
Kostyk	63.8	52.8	6353	53.4	0.082	31	5667	46.6	0.262	1.98	1 18	12020
Koutstaal	74.6	82.2	6866	67.2	0.066	21.2	3344	32.8	0.226	4.18	2.12	10210
Loosemore	65.3	68.1	6582	66.1	0.063	20.2	3414	33.9	0.241	3.55	2.02	9996
Losee	67.2	71	5871	62.6	0.067	21.6	3747	37.4	0.25	4.41	1.9	9618
MacDonald	74.1	67.8	5917	57.2	0.066	28	4386	42.8	0.252	2.82	1.4	10303
MacInnis	81.6	61.5	6157	61.6	0.06	22.3	3892	38.4	0.438	2.95	1.88	10049
MacKenzie	78.2	72.2	7138	65.7	0.091	27 1	3741	34.3	0.172	2.82	2	10879
Marks	58.5	66.6	6696	63.2	0.07	27.8	3895	36.8	0.249	3.32	1.84	10591
Moore	61	38.2	5640	48.2	0.1	36.5	6151	51.8	0.33	1.2	1 13	11791
Mueller	71 7	72.4	7164	65.9	0.063	20.5	3752	34.1	0.208	3.66	2.08	10916
Oliver	58.2	82.2	7203	67.6	0.058	24.9	3448	32.4	0.254	4.56	2.26	10651
Pegado	80.3	66.3	5878	53.8	0.071	32.9	5108	46.2	0.298	2.25	1.22	10986
Posthuma	94.1	67.4	6134	60.4	0.074	20	4172	39.6	0.324	3.8	1.86	10306
Poupore	108	32.7	4481	44.6	0.074	36.8	5623	55.4	0.346	1.05	0.846	10104
Runggatsher	79.6	54.6	5931	52.2	0.087	25.5	5535	47.8	0.244	2.27	1 13	11466
Scott Seim												
Senner	69.9	52.8	6083	50.4	0.074	31 7	5964	49.6	0.246	1.84	1 15	12047
Sheppard	63.5	70	7318	60.6	0.073	26.9	4882	39.4	0.254	2.83	1 74	12200
Slater	60.6	41.5	4433	41.2	0.089	88.7	6219	58.8	0.226	0.669	0.752	10652
Slowey	63.1	63	7281	62.4	0.076	29.2	4363	37.6	0.207	2.28	1 75	11644
Strecker												
Walker	73.7	27.5	3786	34	0.11	34.9	7212	66	0.261	0.819	0.558	10998
Wilson B	73.3	62.8	6606	63.7	0.074	20.9	3795	36.3	0.295	3.36	1.85	10401
Wilson D	77.9	72.2	5709	52.8	0.068	40.1	5119	47.2	0.247	2.43	1.2	10828
Woods	77.6	70.4	6371	67.8	0.068	15.5	3015	32.2	0.264	4.76	2.29	9386

Subjects	Day 3 Time 3 HR	Day 3 Time 3 LFpk	Day 3 Time 3 LFA	Day 3 Time 3 %LFA	Day 3 Time 3 LFcf	Day 3 Time 3 HFpk	Day 3 Time 3 HFA	Day 3 Time 3 %HFA	Day 3 Time 3 HFcf	Day 3 Time 3 LF:HFpk	Day 3 Time 3 LF:HFA	Day 3 Time 3 TA
Alger												
Amos	60.7	70.7	6253	58.6	0.067	19.8	4443	41.4	0.224	3.81	1.49	10696
Andoney												
Arsenault												
Baird	71.8	52.6	5409	45.2	0.084	44.6	6433	54.8	0.316	1.28	0.901	11842
Barrett	71.3	59.4	6208	54.7	0.07	40.5	5139	45.3	0.288	2.03	1.38	11347
Biggar	75.2	60.5	7577	65.1	0.067	24.1	4140	34.9	0.32	2.49	2	11717
Bissessar												
Borg	108	53.9	6525	66.8	0.073	19	3295	33.2	0.346	3.07	2.36	9820
Brown	57.8	50.1	5859	56.4	0.094	25.8	4196	43.6	0.25	1.93	1.36	10055
Cassar	89.4	71.5	7019	64.4	0.076	22.2	3887	35.6	0.203	3.41	1.86	10906
Charest												
Coons	78.3	64.8	6739	66.6	0.073	20.6	3435	33.4	0.212	3.4	2.16	10174
Cosentino												
Cove												
Currie	72.9	88.6	6888	69.2	0.071	18.8	3069	30.8	0.181	5.08	2.33	9957
Dawson												
Day	58.2	63.7	6585	56.9	0.07	26.4	4966	43.1	0.234	2.59	1.41	11551
Deboer	71.3	49.8	6487	54.8	0.08	46.6	5216	45.2	0.269	1.3	1.34	11703
Elaco	64.2	47.5	5920	52.3	0.076	30.5	5502	47 7	0.327	1.66	1.35	11422
Eramo												
Fagan												
Faiella	63.2	81.6	6827	58.3	0.052	26.1	4950	41 7	0.308	3.77	1.56	11777
Farr												
Galli	53.7	76.1	6927	61.5	0.066	25.1	4355	38.5	0.272	3.28	1 77	11282
Goromaru												
Guenther	55	69.2	6491	62.6	0.077	23.5	3824	37.4	0.233	3.4	1.93	10315
Hawkins	63	80.1	7050	67 1	0.066	20.8	3618	32.9	0.203	4.43	2.29	10668
Hill	71.9	65.9	6791	58.7	0.066	22.9	4681	41.3	0.264	3.01	1.61	11472
Irani	90.7	68.7	6547	66.3	0.075	17.4	3315	33.7	0.236	4.25	2.08	9862
Johnson	89.7	42.2	5674	48.8	0.095	29	5900	51.2	0.327	1.55	0.993	11574

Subjects	Day 3 Time 3 HR	Day 3 Time 3 LFpk	Day 3 Time 3 LFA	Day 3 Time 3 %LFA	Day 3 Time 3 LFcf	Day 3 Time 3 HFpk	Day 3 Time 3 HFA	Day 3 Time 3 %HFA	Day 3 Time 3 HFcf	Day 3 Time 3 LF:HFpk	Day 3 Time 3 LF:HFA	Day 3 Time 3 TA
Kebic	79.6	81.8	7219	68.5	0.07	20.8	3331	31.5	0.182	4.17	2.23	10550
Kennedy												
Kergl	87	57.8	6020	51.4	0.093	31 1	5890	48.6	0.235	2.21	1 15	11910
Koklis												
Kostyk	62.3	72.7	7142	60.6	0.076	31.4	4602	39.4	0.246	2.93	1.68	11744
Koutstaal	67.6	79.4	6498	62.4	0.069	24.5	3938	37.6	0.242	3.79	1 77	10436
Loosemore	63.6	77 1	7345	67.5	0.067	20.3	3551	32.5	0.243	4.37	2.18	10896
Losee	81.3	82	6804	68.2	0.063	16.4	3219	31.8	0.244	5.81	2.34	10023
MacDonald	69.8	80.9	6694	61	0.07	26.7	4423	39	0.222	3.53	1 72	11117
MacInnis	53.4	69.1	7019	68.4	0.062	23.5	3217	31.6	0.225	3.16	2.65	10236
MacKenzie	66.6	67.3	7115	66.5	0.068	24.2	3563	33.5	0.258	3.17	2.14	10678
Marks	61.3	61.2	7006	64.9	0.068	25	3745	35.1	0.238	2.67	1.97	10751
Moore	59.3	42.2	5600	46.1	0.091	38.6	6516	53.9	0.296	1.25	1.01	12116
Mueller	71 1	69.9	7385	63.2	0.055	27.8	4359	36.8	0.301	2.98	1.89	11744
Oliver	64.2	84.4	7151	70.2	0.059	23	3025	29.8	0.339	4.73	2.98	10176
Pegado	77.3	71 1	6971	64.2	0.073	24.6	3883	35.8	0.248	3.6	1.9	10854
Posthuma	76.1	77	7133	69.2	0.069	18.7	3351	30.8	0.256	4.67	2.78	10484
Poupore	89.8	42.1	4439	39.6	0.085	68	6717	60.4	0.284	0.741	0.683	11156
Runggatsher	101	61.5	6394	57 1	0.092	28.2	4772	42.9	0.294	2.33	1.38	11166
Scott												
Seim												
Senner	72.5	39.4	5413	44.2	0.1	32.8	6682	55.8	0.262	1.25	0.859	12095
Sheppard	55.5	62.2	6741	59.8	0.068	26.4	4744	40.2	0.282	2.69	2.01	11485
Slater	56.1	50.2	5418	44.1	0.094	56	6843	55.9	0.229	1	0.814	12261
Slowey	58.7	61	6924	62.6	0.093	33	4217	37.4	0.17	2.09	1 76	11141
Strecker												
Walker	66.3	45.5	5131	42.8	0.085	31.6	7021	57.2	0.243	1.54	0.807	12152
Wilson B	74	63.7	7007	67 7	0.068	22.1	3318	32.3	0.198	3.1	2.22	10325
Wilson D	79.7	56.6	6042	52.9	0.077	26.8	5439	47 1	0.251	2.45	1 18	11481
Woods	79.5	69.5	6093	61 7	0.076	17.9	3917	38.3	0.321	4.44	1.91	10010

Subjects	Day 3 Time 4 HR	Day 3 Time 4 LFpk	Day 3 Time 4 LFA	Day 3 Time 4 %LFA	Day 3 Time 4 LFcf	Day 3 Time 3 HFpk	Day 3 Time 4 HFA	Day 3 Time 4 %HFA	Day 3 Time 4 HFcf	Day 3 Time 4 LF:HFpk	Day 3 Time 4 LF:HFA	Day 3 Time 4 TA
Alger												
Amos	51.2	73.7	6880	61.2	0.07	25	4447	38.8	0.225	3.34	1 71	11327
Andoney												
Arsenault												
Baird	82.7	53.7	4933	41.9	0.083	44.4	6877	58.1	0.304	1.27	0.762	11810
Barrett	75.6	55.5	6866	62.3	0.075	31.4	4169	37 7	0.282	1.94	1 74	11035
Biggar	69.5	41.3	5708	55.5	0.061	27.2	4539	44.5	0.344	1.55	1.34	10247
Bissessar												
Borg	111	62.7	6529	61.8	0.064	21.5	3971	38.2	0.294	3.18	1.8	10500
Brown	54.4	51	5753	53.2	0.096	31.4	51 71	46.8	0.257	1 73	1 16	10924
Cassar	77.4	78	7122	64.8	0.069	37.8	3850	35.2	0.35	2.5	1.98	10972
Charest												
Coons	82.8	73.5	6836	68.7	0.067	17.9	3125	31.3	0.223	4.24	2.38	9961
Cosentino												
Cove												
Currie	75.6	72.4	6874	69.5	0.073	19.4	2996	30.5	0.172	4.04	2.34	9870
Dawson												
Day	57.6	79.5	7014	65.7	0.068	21.8	3636	34.3	0.18	3.89	2.02	10650
Deboer	72.5	58.5	6596	56	0.064	31.9	5252	44	0.214	1.97	1.41	11848
Elaco	59.1	60.5	6525	53.7	0.069	37.6	5669	46.3	0.318	1 7	1.25	12194
Eramo												
Fagan												
Faiella	59.5	72.9	7154	63.4	0.059	25	4168	36.6	0.303	3.2	2.36	11322
Farr												
Galli	53.4	70.8	6493	67.4	0.063	19.9	3182	32.6	0.212	4.05	2.24	9675
Goromaru												
Guenther	60.7	55.3	5580	48.7	0.076	29	6374	51.3	0.263	2.55	1.24	11954
Hawkins	59.8	83	6684	67.8	0.071	20.7	3393	32.2	0.237	4.75	2.37	10077
Hill	66.8	56.6	5987	57.9	0.073	26.8	4602	42.1	0.277	2.64	1.58	10589
Irani	81.2	66	7089	65.1	0.071	22.6	3838	34.9	0.222	3.11	1.99	10927
Johnson	89.9	68.2	7801	67.8	0.084	34.3	3647	32.2	0.345	2.16	2.16	11448

Subjects	Day 3 Time 4 HR	Day 3 Time 4 LFpk	Day 3 Time 4 LFA	Day 3 Time 4 %LFA	Day 3 Time 4 LFcf	Day 3 Time 3 HFpk	Day 3 Time 4 HFA	Day 3 Time 4 %HFA	Day 3 Time 4 HFcf	Day 3 Time 4 LF:HFpk	Day 3 Time 4 LF:HFA	Day 3 Time 4 TA
Kebic	76.5	73.4	7087	68.6	0.076	24.4	3169	31.4	0.211	3.27	2.42	10256
Kennedy												
Kergl	80.3	67.6	6429	62.4	0.083	22.1	3951	37.6	0.19	3.36	1 75	10380
Koklis												
Kostyk												
Koutstaal	68.2	88.7	6820	65.7	0.071	23	3652	34.3	0.217	4.62	2.15	10472
Loosemore	56.4	72	7483	70.6	0.064	21.9	3138	29.4	0.272	3.62	2.58	10621
Losee	74.8	63.6	6424	56.9	0.061	27.9	4800	43.1	0.355	2.76	1 74	11224
MacDonald	78	79.1	6966	69.7	0.069	16.3	3063	30.3	0.259	5.52	2.64	10029
MacInnis	62.6	69.9	7154	68	0.07	36	3386	32	0.31	2.46	2.29	10540
MacKenzie	67	68.4	7438	69.3	0.08	30.1	3298	30.7	0.273	2.62	2.46	10736
Marks	59.7	65.4	6623	58.6	0.075	28	4686	41.4	0.212	2.7	1.53	11309
Moore	57.8	43.8	5547	43.8	0.085	32.7	7233	56.2	0.29	1.38	0.888	12780
Mueller	81.5	65.4	7288	63.7	0.063	27 7	4159	36.3	0.315	2.91	1.96	11447
Oliver	63.5	80.2	7281	70.7	0.065	19.5	2997	29.3	0.261	4.95	2.6	10278
Pegado	74.8	65.5	6361	60.2	0.067	30.3	4328	39.8	0.204	3.33	1.68	10689
Posthuma	61 7	82.8	7331	67.2	0.073	21.5	3592	32.8	0.231	4.35	2.26	10923
Poupore	64.7	41	5208	46.3	0.079	51.2	5836	53.7	0.266	1.2	0.93	11044
Runggatsher	83.7	68.7	6641	61 1	0.084	29.8	4196	38.9	0.321	2.51	1 73	10837
Scott												
Seim												
Senner	77.8	42.7	5487	44.1	0.086	32.7	6953	55.9	0.316	1.38	0.844	12440
Sheppard	57.8	52.7	7179	59	0.071	36	5114	41	0.381	1.61	1 74	12293
Slater	70.5	65.6	6400	58.5	0.088	38.7	4717	41.5	0.195	2.55	1.56	11117
Slowey	50.8	59.9	6477	62.5	0.081	28.8	3940	37.5	0.22	2.2	1 74	10417
Strecker												
Walker	70.3	28.5	3740	32.2	0.13	42.3	8115	67.8	0.28	0.852	0.515	11855
Wilson B	77.2	72.6	7421	72.4	0.073	23.6	2845	27.6	0.279	3.4	2.83	10266
Wilson D	77 1	72.9	6706	63.7	0.077	23	3860	36.3	0.218	3.51	1.81	10566
Woods	72.5	73.5	7524	64.6	0.072	22.8	4243	35.4	0.235	3.63	1.97	11767

Subjects	Day 4 Time 1 HR	Day 4 Time 1 LFpk	Day 4 Time 1 LFA	Day 4 Time 1 %LFA	Day 4 Time 1 LFcf	Day 4 Time 1 HFpk	Day 4 Time 1 HFA	Day 4 Time 1 %HFA	Day 4 Time 1 HFcf	Day 4 Time 1 LF:HFpk	Day 4 Time 1 LF:HFA	Day 4 Time 1 TA
Alger												
Amos	45.5	95.2	6235	61.4	0.058	33.7	3910	38.6	0.228	3.8	1 75	10145
Andoney												
Arsenault												
Baird	58.2	63.4	5060	45.4	0.14	71 1	6107	54.6	0.182	0.912	0.846	11167
Barrett	69.5	88	6575	63.8	0.074	28.7	3739	36.2	0.193	3.44	1.9	10314
Biggar	77.3	51 7	5796	55.2	0.054	25.5	4604	44.8	0.338	2.58	1.5	10400
Bissessar												
Borg	93.8	64.9	6441	57 1	0.063	33.3	4805	42.9	0.283	2.2	1.36	11246
Brown	53.1	47.2	57 19	48	0.085	36.8	6431	52	0.265	1.6	1.04	12150
Cassar	62.7	58.2	6304	53.6	0.075	64.4	5227	46.4	0.258	1 73	1.29	11531
Charest												
Coons												
Cosentino												
Cove	67.5	29.8	3837	33.1	0.084	31	8226	6.9	0.285	1.06	0.53	12063
Currie	58	74.4	7110	67 1	0.07	25.3	3520	32.9	0.234	3.69	2.24	10630
Dawson												
Day	52.6	82	5375	52.5	0.062	61.5	4836	47.5	0.201	2.13	1.21	10211
Deboer	66.9	58.7	5474	50.9	0.066	63	5226	49.1	0.23	1 17	1.09	10700
Elaco	61.2	38.4	4119	37 7	0.06	77.4	6483	62.3	0.264	0.899	0.651	10602
Eramo	66.6	84.5	7362	68.2	0.062	27	3429	31.8	0.269	4.2	2.43	10791
Fagan												
Faiella	62.5	67.5	6496	65.4	0.071	20.6	3487	34.6	0.224	3.61	2.05	9983
Farr												
Galli	46.9	90.4	5170	58.5	0.057	46.8	3731	41.5	0.211	2.55	1.48	8901
Goromaru												
Guenther												
Hawkins	60.5	76.5	6545	68.1	0.074	22.8	3105	31.9	0.204	3.68	2.28	9650
Hill	57.9	81 1	6679	64.3	0.059	20.4	3799	35.7	0.232	4.84	2.12	10478
Irani	62.1	99.7	7404	80.3	0.067	15.2	1809	19.7	0.17	6.98	4.23	9213
Johnson	89.3	57.8	5470	51.3	0.072	45.4	5245	48.7	0.285	1.55	1.08	10715

Subjects	Day 4 Time 1 HR	Day 4 Time 1 LFpk	Day 4 Time 1 LFA	Day 4 Time 1 %LFA	Day 4 Time 1 LFcf	Day 4 Time 1 HFpk	Day 4 Time 1 HFA	Day 4 Time 1 %HFA	Day 4 Time 1 HFcf	Day 4 Time 1 LF:HFpk	Day 4 Time 1 LF:HFA	Day 4 Time 1 TA
Kebic	64.5	77 1	6574	67.4	0.078	21.4	3189	32.6	0.218	3.97	2.28	9763
Kennedy												
Kergl	72.9	87 1	6242	65.2	0.063	22	3349	34.8	0.246	4.75	2.07	9591
Koklis												
Kostyk												
Koutstaal	59.1	82.2	5152	55.4	0.07	66.2	4182	44.6	0.183	1.69	1.53	9334
Loosemore	53.9	98.2	6869	70.2	0.055	18.6	2981	29.8	0.238	6.47	2.7	9850
Losee	65.1	92.4	6462	67	0.061	19.4	3206	33	0.253	5.56	2.26	9668
MacDonald	53.7	79.1	6338	62.1	0.068	24.1	3965	37.9	0.211	4.29	1.86	10303
MacInnis	54	66	5549	55.9	0.066	56.3	4366	44.1	0.266	2.01	1.49	9915
MacKenzie	63.8	65.8	7339	65.6	0.077	41.6	3813	34.4	0.271	2.21	2.04	11152
Marks	54.3	70.9	7128	67	0.074	29.1	2476	33	0.197	2.7	2.15	9604
Moore	49.1	64.9	6385	57 7	0.066	27.9	4938	42.3	0.234	2.87	1.51	11323
Mueller	64.5	61.8	6843	59.4	0.071	30.9	4585	40.6	0.265	2.26	1.57	11428
Oliver	58.2	72.7	5692	55.6	0.057	41.9	4551	44.4	0.285	2.07	1.37	10243
Pegado	67.6	83.6	6204	63.8	0.061	26.2	3421	36.2	0.211	3.99	1.92	9625
Posthuma	60.3	57.6	6054	58.4	0.069	43.6	4249	41.6	0.28	2.1	1.58	10303
Poupore	71 1	43.2	4406	40.3	0.072	86	6347	59.7	0.249	0.673	0.701	10753
Runggatsher	70.5	67.2	6441	54.4	0.083	32.7	5383	45.6	0.238	2.21	1.23	11824
Scott												
Seim												
Senner	68.1	53.1	6248	61	0.082	24.6	4119	39	0.235	2.23	1.69	10367
Sheppard	50	62.9	7540	65	0.081	49.2	4035	35	0.318	1 72	2.07	11575
Slater	71 1	65.9	6734	59.6	0.084	28.3	4638	40.4	0.208	2.58	1.57	11372
Slowey	46.8	60.2	5633	57.5	0.073	33.9	4395	42.5	0.21	2.55	1.52	10028
Strecker												
Walker	68.7	31 1	3571	30.6	0.094	48.2	8023	69.4	0.255	0.829	0.472	11594
Wilson B	67.6	77.8	6253	58.5	0.081	42.9	4514	41.5	0.261	2.33	1.49	10767
Wilson D	65.9	68.4	5984	56.8	0.11	56.6	4586	43.2	0.177	1.41	1.45	10570
Woods	64.8	83.1	6097	63.3	0.069	31.6	3555	36.7	0.236	3.56	2.01	9652

Subjects	Day 4 Time 2 HR	Day 4 Time 2 LFpk	Day 4 Time 2 LFA	Day 4 Time 2 %LFA	Day 4 Time 2 LFcf	Day 4 Time 2 HFpk	Day 4 Time 2 HFA	Day 4 Time 2 %HFA	Day 4 Time 2 HFcf	Day 4 Time 2 LF:HFpk	Day 4 Time 2 LF:HFA	Day 4 Time 2 TA
Alger												
Amos	55.3	70.7	6775	62.4	0.065	23.7	4128	37.6	0.217	3.22	1 76	10903
Andoney												
Arsenault												
Baird	70.4	51.8	5546	45.5	0.074	41.5	6599	54.5	0.315	1.34	0.881	12145
Barrett	84.6	66.5	6710	57.6	0.08	32.3	4895	42.4	0.287	2.21	1.4	11605
Biggar	68.6	66.7	6470	57.9	0.07	29.4	4790	42.1	0.383	2.73	1 7	11260
Bissessar												
Borg	97.6	63.1	6746	60.5	0.06	25.4	4466	39.5	0.25	2.85	1 73	11212
Brown	54.8	41.9	5630	44.7	0.077	36.1	7020	55.3	0.225	1.21	0.898	12650
Cassar	78.2	68.9	6754	61.4	0.067	29.6	4220	38.6	0.283	2.65	1 71	10974
Charest												
Coons												
Cosentino												
Cove	84.4	28.9	3993	36.9	0.1	27.5	6877	63.1	0.281	1.07	0.614	10870
Currie	76.4	75.8	7060	68.4	0.076	21.4	3272	31.6	0.178	4.02	2.27	10332
Dawson												
Day	71.3	52.3	6027	52.1	0.069	29.8	5476	47.9	0.339	2.02	1.47	11503
Deboer	77 7	57.5	6028	56.1	0.08	44	4572	43.9	0.217	2.02	1.43	10600
Elaco	74.5	46.6	5740	49.6	0.07	30.6	5953	50.4	0.279	1.91	1.08	11693
Eramo	57.5	94.9	5946	55.5	0.072	36.1	4781	44.5	0.238	3.29	1.29	10727
Fagan												
Faiella	65.1	78.9	7190	61.9	0.063	21.9	4472	38.1	0.283	3.96	1.86	11662
Farr												
Galli	59.8	65	6094	62	0.071	21	3996	38	0.194	3.53	1.9	10090
Goromaru												
Guenther												
Hawkins	60	50.1	6057	48.4	0.075	36.8	6585	51.6	0.312	1.67	1 15	12642
Hill	68.9	64	6284	57.2	0.073	25.2	4659	42.8	0.251	2.76	1.41	10943
Irani	74.7	62.3	6284	60.8	0.067	28.5	4143	39.2	0.262	2.79	1.68	10427
Johnson	84.3	70.2	5957	51	0.074	40.7	5630	49	0.248	2.07	1 1	11587

Subjects	Day 4 Time 2 HR	Day 4 Time 2 LFpk	Day 4 Time 2 LFA	Day 4 Time 2 %LFA	Day 4 Time 2 LFcf	Day 4 Time 2 HFpk	Day 4 Time 2 HFA	Day 4 Time 2 %HFA	Day 4 Time 2 HFcf	Day 4 Time 2 LF:HFpk	Day 4 Time 2 LF:HFA	Day 4 Time 2 TA
Kebic	62.7	67 1	6248	59.7	0.076	36	4177	40.3	0.208	2.22	1.65	10425
Kennedy												
Kergl	78.8	73.6	6353	61.2	0.074	22.3	4015	38.8	0.219	3.65	1.67	10368
Koklis												
Kostyk	79	26.4	3410	39.9	0.087	30.7	5563	60.1	0.34	1.25	0.813	8973
Koutstaal	71.5	70.4	6704	62	0.072	34	4137	38	0.267	2.51	1.69	10841
Loosemore	70.9	78.8	6587	63.5	0.069	21.3	3824	36.5	0.258	4.27	1.91	10411
Losee	64.8	82.4	6277	63.1	0.059	19.1	3811	36.9	0.251	5.55	2.07	10088
MacDonald	65.9	72.6	6119	58.6	0.073	31	4261	41.4	0.198	2.77	1.5	10380
MacInnis	74.8	73.4	7197	65	0.071	21	3902	35	0.26	3.76	2.17	11099
MacKenzie	77.6	63.8	6894	64.3	0.08	25.9	3818	35.7	0.214	2.93	1.92	10712
Marks	57.5	72.8	7394	65	0.073	26.6	3970	35	0.288	2.94	2.04	11364
Moore	69.9	52.6	6226	51.6	0.092	35.1	5846	48.4	0.309	1.68	1 16	12072
Mueller	71.4	63.3	7064	61.5	0.077	26	4430	38.5	0.187	2.53	1.63	11494
Oliver	60.7	73	7518	67 7	0.068	23.5	3753	32.3	0.3	3.87	2.54	11271
Pegado	93	59.7	5602	51 1	0.069	36.2	5377	48.9	0.285	2.1	1 1	10979
Posthuma	81.6	69.2	6543	63.5	0.071	19.5	3890	36.5	0.281	3.87	1.95	10433
Poupore	84.6	58.2	5056	46.2	0.063	70.4	5719	53.8	0.242	1 17	0.904	10775
Runggatsher	84.5	57.9	6767	57 1	0.095	27.2	5089	42.9	0.24	2.35	1.51	11856
Scott												
Seim												
Senner	62.9	46.8	5513	47.3	0.11	31	6296	52.7	0.197	1.62	0.93	11809
Sheppard	61.6	44.7	5731	48.2	0.091	27 7	6258	51.8	0.266	1.69	1 1	11989
Slater	58.4	51.3	5475	46.4	0.086	52.9	6147	53.6	0.228	1.23	0.926	11622
Slowey	54.2	56.6	6436	58.4	0.093	29.7	4605	41.6	0.202	2.11	1.63	11041
Strecker												
Walker	76.9	23	3286	32	0.12	28.1	6878	68	0.347	0.819	0.525	10164
Wilson B	74.7	67 7	7207	66.5	0.068	22.7	3649	33.5	0.394	3.38	2.52	10856
Wilson D	81.2	60.4	5935	51.4	0.08	38.8	5730	48.6	0.268	2.26	1 17	11665
Woods	67.8	86	6814	67.3	0.071	27.4	3426	32.7	0.235	4.05	2.29	10240

Subjects	Day 4 Time 3 HR	Day 4 Time 3 LFpk	Day 4 Time 3 LFA	Day 4 Time 3 %LFA	Day 4 Time 3 LFcf	Day 4 Time 3 HFpk	Day 4 Time 3 HFA	Day 4 Time 3 %HFA	Day 4 Time 3 HFcf	Day 4 Time 3 LF:HFpk	Day 4 Time 3 LF:HFA	Day 4 Time 3 TA
Alger												
Amos	63.6	74.6	7056	67.3	0.072	19.2	3458	32.7	0.247	4.17	2.15	10514
Andoney												
Arsenault												
Baird	75.1	55.9	5116	41.9	0.086	44.7	7091	58.1	0.327	1.28	0.735	12207
Barrett	70.6	57.6	5623	49.4	0.079	64.7	5683	50.6	0.278	1 13	1.01	11306
Biggar	63.1	42.1	4993	42.1	0.06	34.4	6840	57.9	0.334	1.26	0.734	11833
Bissessar												
Borg	108	67.9	7104	65	0.074	21 1	3789	35	0.258	3.59	2	10893
Brown	62.4	44.1	5725	48.3	0.091	31.2	6258	51 7	0.265	1.39	1.05	11983
Cassar	75.9	57.9	6297	55.4	0.075	42.7	5071	44.6	0.299	1.9	1.38	11368
Charest												
Coons												
Cosentino												
Cove	66.8	32.7	4972	40.6	0.12	32.8	7278	59.4	0.275	1.05	0.75	12250
Currie	63.7	73.2	6736	61 7	0.084	26.3	4234	38.3	0.191	3.06	1.68	10970
Dawson												
Day	59.9	64.5	6518	62.7	0.058	20.8	3956	37.3	0.201	3.38	1.86	10474
Deboer	92.3	64.3	6678	58.5	0.085	25.6	4728	41.5	0.241	2.78	1.47	11406
Elaco	76.1	41 7	4856	44.5	0.078	27.5	6102	55.5	0.345	1.66	0.911	10958
Eramo	59.7	70.2	7574	67.2	0.065	27.3	3746	32.8	0.295	2.98	2.2	11320
Fagan												
Faiella	67.8	86.4	6642	61 1	0.056	23.3	4569	38.9	0.277	4.51	1.85	11211
Farr												
Galli	56.2	73.1	6987	65.6	0.064	21.8	3718	34.4	0.202	3.65	1.96	10705
Goromaru												
Guenther												
Hawkins	62.3	54.3	6925	60.4	0.077	26.5	4611	39.6	0.352	2.32	2.08	11536
Hill	75.5	56.8	6358	56.6	0.065	27 7	4908	43.4	0.314	2.28	1.49	11266
Irani	76.6	70.2	7278	65.1	0.06	24.7	3959	34.9	0.311	3.29	2.04	11237
Johnson	86.7	52	6585	56.3	0.086	30.1	5122	43.7	0.313	1.82	1.4	11707

Subjects	Day 4 Time 3 HR	Day 4 Time 3 LFpk	Day 4 Time 3 LFA	Day 4 Time 3 %LFA	Day 4 Time 3 LFcf	Day 4 Time 3 HFpk	Day 4 Time 3 HFA	Day 4 Time 3 %HFA	Day 4 Time 3 HFcf	Day 4 Time 3 LF:HFpk	Day 4 Time 3 LF:HFA	Day 4 Time 3 TA
Kebic	73.3	76.9	6908	68.9	0.073	20	3142	31 1	0.187	4.19	2.3	10050
Kennedy												
Kergl	82.4	71.5	6716	62.4	0.084	23.7	4061	37.6	0.192	3.28	1 71	10777
Koklis												
Kostyk												
Koutstaal	71.9	70.8	6202	67 1	0.074	19.7	3052	32.9	0.239	4.21	2.27	9254
Loosemore	71.9	92.1	7315	70.2	0.07	17.3	3110	29.8	0.202	5.53	2.4	10425
Losee	68.7	49.2	5624	50.3	0.066	34	5849	49.7	0.31	1.88	1 11	11473
MacDonald	71.2	71.2	5960	65.7	0.067	18.1	3157	34.3	0.239	4.19	2.16	9117
MacInnis	66.1	73.6	7574	65.2	0.074	24.6	4081	34.8	0.286	3.4	2.23	11655
MacKenzie	67 1	66.1	7693	70.7	0.075	31.5	3190	29.3	0.298	2.42	2.57	10883
Marks	59.6	76.6	6948	65.4	0.068	31.3	3728	34.6	0.28	3.29	1.96	10676
Moore	63.1	61.9	6701	60.6	0.075	24.5	4437	39.4	0.201	2.74	1.64	11138
Mueller	65.9	63.5	7016	60.9	0.068	26.7	4559	39.1	0.251	2.56	1.67	11575
Oliver	62.2	80	7482	69.6	0.068	21 7	3161	30.4	0.28	4.18	2.87	10643
Pegado	74.3	71.9	5862	53	0.068	39.7	5199	47	0.242	2.49	1.25	11061
Posthuma	91 1	61.3	5814	56.4	0.085	22.6	4391	43.6	0.323	3.08	1.53	10205
Poupore	66.2	29.8	4295	39.6	0.077	91 7	6578	60.4	0.323	0.473	0.672	10873
Runggatsher	81	59.2	6679	56.9	0.096	26.4	5079	43.1	0.233	2.36	1.44	11758
Scott												
Seim												
Senner	57.9	56.8	6704	51.7	0.1	37 7	6391	48.3	0.181	1.62	1 11	13095
Sheppard	53.3	51.3	6227	56.6	0.076	25.7	4942	43.4	0.274	2.13	1.52	11169
Slater	57.2	50.2	5183	46.9	0.092	54	5950	53.1	0.231	1.2	0.951	11133
Slowey	51	59.6	7038	60.4	0.089	36.7	4642	39.6	0.218	1.83	1.63	11680
Strecker												
Walker	70.3	33.1	4476	38	0.12	33.8	8047	62	0.279	1.05	0.673	12523
Wilson B	103	61.2	6609	60.5	0.077	20.3	4221	39.5	0.286	3.15	1.9	10830
Wilson D	82.2	67 7	6023	57.3	0.079	30.1	4488	42.7	0.251	2.67	1.49	10511
Woods	69.9	68.9	6658	61.9	0.079	21.8	4134	38.1	0.274	3.4	1.82	10792

Subjects	Day 4 Time 4 HR	Day 4 Time 4 LFpk	Day 4 Time 4 LFA	Day 4 Time 4 %LFA	Day 4 Time 4 LFcf	Day 4 Time 4 HFpk	Day 4 Time 4 HFA	Day 4 Time 4 %HFA	Day 4 Time 4 HFcf	Day 4 Time 4 LF:HFpk	Day 4 Time 4 LF:HFA	Day 4 Time 4 TA
Alger												
Amos	50.2	59.4	6890	61 1	0.072	30.1	4396	38.9	0.284	2.21	1 72	11286
Andoney												
Arsenault												
Baird	64.7	54.7	5261	42.4	0.077	45.8	7065	57.6	0.248	1.39	0.789	12326
Barrett	77.4	65.3	7260	63.8	0.078	32.5	4158	36.2	0.255	2.28	1.85	11418
Biggar	70	50.8	7940	63	0.079	29.3	4736	37	0.422	1.87	2.15	12676
Bissessar												
Borg	109	64.2	6596	63.7	0.073	22.5	3742	36.3	0.264	3.03	1.89	10338
Brown	58.3	46.4	5430	55.9	0.08	31.9	4340	44.1	0.299	1.61	1.33	9770
Cassar	66.6	57 1	6877	61 7	0.088	32.1	4194	38.3	0.299	1.94	1 7	11071
Charest												
Coons												
Cosentino												
Cove	74	38.6	4950	42.6	0.085	28.1	6736	57.4	0.272	1.49	0.771	11686
Currie	61.2	68.8	6851	62.5	0.087	26.2	4125	37.5	0.189	2.83	1 77	10976
Dawson												
Day	51 7	62.2	6591	59.3	0.05	26.5	4479	40.7	0.228	2.56	1.53	11070
Deboer	75	57 7	6673	63.4	0.076	31	3834	36.6	0.264	2.23	1.82	10507
Elaco	67.9	58.6	6225	54	0.075	26.3	5376	46	0.289	2.37	1.29	11601
Eramo	74	50.3	6222	53.3	0.063	24.8	5495	46.7	0.251	2.31	1.28	11717
Fagan												
Faiella	65.7	61.3	6848	58.3	0.062	27.9	4742	41 7	0.327	2.42	1.53	11590
Farr												
Galli	50.6	62.2	6273	62.1	0.068	23.3	3892	37.9	0.211	3.17	1.85	10165
Goromaru												
Guenther												
Hawkins	59.3	69.6	6510	65.3	0.072	22.6	3584	34.7	0.185	3.39	2.01	10094
Hill	64.5	67.2	6647	60.3	0.079	27.4	4470	39.7	0.276	2.92	1.69	11117
Irani	71.9	69.8	7113	67.4	0.072	22.2	3413	32.6	0.292	3.95	2.22	10526
Johnson	86.1	61.3	7066	61.6	0.087	32.1	4489	38.4	0.303	2.18	1 72	11555

Subjects	Day 4 Time 4 HR	Day 4 Time 4 LFpk	Day 4 Time 4 LFA	Day 4 Time 4 %LFA	Day 4 Time 4 LFcf	Day 4 Time 4 HFpk	Day 4 Time 4 HFA	Day 4 Time 4 %HFA	Day 4 Time 4 HFcf	Day 4 Time 4 LF:HFpk	Day 4 Time 4 LF:HFA	Day 4 Time 4 TA
Kebic	81 7	86.3	7148	73.4	0.067	16.7	2542	26.6	0.199	5.55	2.97	9690
Kennedy												
Kergl	81.9	79.4	6513	65.1	0.078	18.6	3466	34.9	0.235	4.66	1.93	9979
Koklis												
Kostyk												
Koutstaal	72.4	75	6380	63	0.07	29.9	3706	37	0.237	3.52	1.97	10086
Loosemore	56.4	75.6	7084	65.6	0.07	22	3753	34.4	0.231	3.9	2.04	10837
Losee	70	40.2	4838	40.5	0.062	43.8	6988	59.5	0.359	1.02	0.701	11826
MacDonald	71.8	82.1	6717	64.9	0.067	21.2	3728	35.1	0.224	4.19	1.95	10445
MacInnis	57.2	69.7	6748	61.9	0.078	60.8	4065	38.1	0.314	1.49	1 74	10813
MacKenzie	69.8	67	6812	68.4	0.071	20.4	3195	31.6	0.245	3.31	2.29	10007
Marks	66.5	76.5	6981	69.4	0.066	18	3189	30.6	0.25	4.65	2.54	10170
Moore	52.8	37.9	5620	48.4	0.1	36.7	6104	51.6	0.328	1 15	1.05	11724
Mueller	88.6	66.7	6928	62.9	0.069	22.6	4217	37 1	0.26	3.61	1.98	11145
Oliver	56	70.9	7317	68.1	0.073	24.1	3419	31.9	0.303	3.14	2.33	10736
Pegado	80.6	64.1	6512	56	0.068	36.1	5052	44	0.275	2.51	1.52	11564
Posthuma	61 1	82.3	7495	70.9	0.072	22.4	3079	29.1	0.284	3.97	2.54	10574
Poupore	69.6	66.5	4902	45.3	0.065	67.8	5890	54.7	0.268	1 16	0.846	10792
Runggatsher	75.8	59	6546	57.6	0.082	29.9	5019	42.4	0.281	2.12	1.49	11565
Scott												
Seim												
Senner	62.1	55.1	6233	51.8	0.09	31.8	5801	48.2	0.222	1.82	1 15	12034
Sheppard	58.3	52.2	6937	58.8	0.076	28	4735	41.2	0.33	1.97	1 73	11672
Slater	77	68.6	6861	61.9	0.085	24	4329	38.1	0.203	3.23	1 74	11190
Slowey	55.1	63.2	6339	63.1	0.087	27.9	3630	36.9	0.175	2.36	1.81	9969
Strecker												
Walker	72.1	34.5	4393	37.5	0.12	34.8	7282	62.5	0.252	1.02	0.648	11675
Wilson B	93.5	77.5	6946	64.5	0.083	22.1	3867	35.5	0.193	3.75	1.91	10813
Wilson D	80.4	66.8	6664	59.5	0.07	25	4643	40.5	0.258	3.11	1.63	11307
Woods	74.3	76.4	7118	70.3	0.068	17.3	3036	29.7	0.218	4.88	2.51	10154

APPENDIX B:

RELIABILITY DATA

FORMULA: Intraclass Correlation Coefficient

$$\text{Reliability Coefficient} = \frac{\text{MS subjects} - \text{MS error}}{\text{MS subjects}}$$

DEPENDENT VARIABLES	MS Subjects	MS Error
Time Domain		
SDNN	2282.81	206.91
SDANN	1649.05	242.09
pNN50	257.85	14.06
Heart Rate		
0300-h	188.31	20.82
0900-h	199.84	44.10
1500-h	264.36	52.67
2100-h	275.30	24.49
Frequency Domain		
LF Area		
0300-h	1327000	184212.6
0900-h	999000	179170.1
1500-h	913750	268954.7
2100-h	1014750	154070.1
HF Area		
0300-h	2599500	320387.2
0900-h	1880000	237538.5
1500-h	2312250	553811.8
2100-h	2418250	302114.5
LF:HF Area		
0300-h	0.6605	0.0922
0900-h	0.4060	0.0466
1500-h	0.5064	0.1149
2100-h	0.4687	0.0961
TA		
0300-h	1115500	214967.9
0900-h	785750	162611.5
1500-h	712171	358673.3
2100-h	784250	277865.6
LFcf		
0300-h	0.000339	0.000059
0900-h	0.000231	0.000049
1500-h	0.000249	0.000092
2100-h	0.000245	0.000038

APPENDIX C:

ANALYSIS OF VARIANCE TABLES

ANOVA Summary Tables

1 a. The circadian pattern of HR (Day 4).

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Time	**3**	**684.4830**	**126**	**43.92051**	**15.58459**	**0.000000**

Marked effects p<0.05

b. The circadian pattern of HR following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	1278.281	41	354.4710	3.60617	0.064618
Time (T)	**3**	**705.581**	**123**	**44.2548**	**15.94359**	**0.000000**
G x T	3	30.213	123	44.2548	0.68270	0.564256

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	966.2164	41	362.0824	2.66850	0.110010
Time (T)	**3**	**686.6929**	**123**	**43.2920**	**15.86191**	**0.000000**
G x T	3	69.6909	123	43.2920	1.60979	0.190553

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	261.8081	41	379.2631	0.69031	0.410872
Time (T)	**3**	**600.2484**	**123**	**41.6206**	**14.42191**	**0.000000**
G x T	**3**	**138.2163**	**123**	**41.6206**	**3.32086**	**0.022106**

Marked effects p<0.05

2. a. The circadian pattern of LF area (Day 4).

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Time	**3**	**1568850**	**126**	**284717.5**	**5.510197**	**0.001374**

Marked effects p<0.05

b. The circadian pattern of LF area following the division of subjects based on LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	747444.3	41	2005591	0.372680	0.544916
Time (T)	**3**	**1522630**	**123**	**286479.7**	**5.314966**	**0.001772**
G x T	3	212467.4	123	286479.7	0.741649	0.529200

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs(G)	1	728651.3	41	2006049	0.363227	0.550039
Time (T)	**3**	**1566126**	**123**	**288015.3**	**5.437647**	**0.001519**
G x T	3	149509.0	123	288015.3	0.519101	0.669913

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	**1**	**8629810**	**41**	**1813338**	**4.759075**	**0.034933**
Time (T)	**3**	**1240910**	**123**	**284294.3**	**4.364880**	**0.005871**
G x T	3	302069.8	123	284294.3	1.062525	0.367653

Marked effects p<0.05

3. a. The circadian pattern of HF area (Day 4).

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Time	**3**	**2041555**	**126**	**483889.2**	**4.219054**	**0.007021**

Marked effects p<0.05

b. The circadian pattern of HF area upon the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	46788.23	41	4367435	0.010713	0.918068
Time (T)	**3**	**1811079**	**123**	**479376.9**	**3.777993**	**0.012362**
G x T	3	668933.2	123	479376.9	1.395425	0.247431

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	90205.25	41	4366376	0.020659	0.886416
Time (T)	**3**	**2057314**	**123**	**490957.7**	**4.190409**	**0.007323**
G x T	3	194079.6	123	490957 7	0.395308	0.756599

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	16063002	41	3976795	4.039183	0.051067
Time (T)	**3**	**2212032**	**123**	**470435.3**	**4.702097**	**0.003833**
G x T	3	1035500	123	470435.3	2.201153	0.091324

Marked effects p<0.05

4. a. The circadian pattern of LF·HF area ratio (Day 4).

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Time	3	0.272948	126	0.146854	1.858643	0.139986

Marked effects p<0.05

b. The circadian pattern of LF·HF area ratio following group division by LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	0.347684	41	0.827963	0.419927	0.520586
Time (T)	3	0.255143	123	0.145097	1 758428	0.158663
G x T	3	0.218872	123	0.145097	1.508452	0.215701

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	0.000297	41	0.836436	0.000355	0.985050
Time (T)	3	0.295171	123	0.147566	2.000256	0.117463
G x T	3	0.117630	123	0.147566	0.797132	0.497738

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	**1**	**5.179535**	**41**	**0.710113**	**7.293959**	**0.010011**
Time (T)	3	0.308445	123	0.143507	2.149334	0.097463
G x T	3	0.284062	123	0.143507	1.979430	0.120557

Marked effects p<0.05

5. a. The circadian pattern of TA (Day 4).

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Time	**3**	**3715564**	**126**	**336595.9**	**11.03865**	**0.000002**

Marked effects p<0.05

b The circadian pattern of TA following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	420218.6	41	1201250	0.349818	0.557463
Time (T)	**3**	**3435007**	**123**	**336642.1**	**10.20373**	**0.000005**
G x T	3	334700.6	123	336642.1	0.994233	0.397986

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	306106.4	41	1204033	0.254234	0.616808
Time (T)	**3**	**3582160**	**123**	**339000.0**	**10.56684**	**0.000003**
G x T	3	238026.9	123	339000.0	0.702144	0.552510

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	1145358	41	1183563	0.967720	0.331019
Time (T)	**3**	**3848469**	**123**	**329456.6**	**11.68126**	**0.000001**
G x T	3	629307 1	123	329456.6	1 910136	0.131434

Marked effects p<0.05

6. a. The circadian pattern of LFcf (Day 4)

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Time	3	0.000201	126	0.000081	2.470410	0.064923

Marked effects p<0.05

b. The circadian pattern of LFcf following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	0.000335	41	0.000476	0.702776	0.406714
Time (T)	3	0.000163	123	0.000080	2.049179	0.110494
G x T	3	0.000150	123	0.000080	1.884993	0.135611

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	0.000247	41	0.000478	0.517212	0.476113
Time (T)	3	0.000206	123	0.000083	2.487731	0.063638
G x T	3	0.000018	123	0.000083	0.216412	0.884862

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	**1**	**0.003120**	**41**	**0.000408**	**7.643255**	**0.008501**
Time (T)	3	0.000152	123	0.000081	1.887639	0.135165
G x T	3	0.000108	123	0.000081	1.345506	0.262791

Marked effects p<0.05

7 a. The overall effect of stress (Day 1 versus Day 4) on SDNN

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day	1	1410.493	28	404.4696	3.487266	0.072344

Marked effects at p<0.05

b. The effect of stress on SDNN following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	420.431	27	2141.987	0.196281	0.661269
Day (D)	**1**	**1816.925**	**27**	**323.317**	**5.619639**	**0.025159**
G x D	**1**	**2595.588**	**27**	**323.317**	**8.027998**	**0.008609**

Marked effects at p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	49.969	27	2155.708	0.023180	0.880123
Day (D)	1	879.379	27	352.329	2.495903	0.125788
G x D	**1**	**1812.267**	**27**	**352.329**	**5.143679**	**0.031544**

Marked effects at p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	84.4316	27	2154.432	0.039190	0.844556
Day (D)	1	862.3800	27	404.013	2.134534	0.155555
G x D	1	416.7910	27	404.013	1.031627	0.318793

Marked effects at p<0.05

8. a. The overall effect of stress (Day 1 versus Day 4) on SDANN.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day	1	957 1697	28	510.2506	1.875881	0.181688

Marked effects at p<0.05

b. The effect of stress on SDANN following group division according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	81.220	27	1428.648	0.056851	0.813344
Day (D)	1	1296.581	27	434.269	2.985661	0.095428
G x D	**1**	**2561.745**	**27**	**434.269**	**5.898978**	**0.022085**

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	0.720	27	1431.630	0.000503	0.982268
Day (D)	1	596.038	27	483.379	1.233065	0.276604
G x D	1	1235.772	27	483.379	2.556525	0.121478

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	19.0955	27	1430.949	0.013345	0.908889
Day (D)	1	522.3572	27	512.624	1.018988	0.321721
G x D	1	446.1823	27	512.624	0.870390	0.359116

Marked effects p<0.05

9. a. The overall effect of stress (Day 1 versus 4) on pNN50.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day	1	47.33527	28	27.00496	1 752836	0.196228

Marked effects p<0.05

b. The effect of stress on pNN50 following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	512.9904	27	364.6212	1.406913	0.245903
Day (D)	1	45.0632	27	27.9464	1.612484	0.214978
G x D	1	1.5850	27	27 9464	0.056716	0.813562

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	23.54572	27	382.7488	0.061517	0.805990
Day (D)	1	30.02859	27	25.9086	1 159020	0.291195
G x D	1	56.60669	27	25.9086	2.184861	0.150945

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	3.95250	27	383.4745	0.010307	0.919885
Day (D)	1	32.96080	27	27 7595	1 187369	0.285491
G x D	1	6.63172	27	27 7595	0.238899	0.628949

Marked effects p<0.05

10. a. The overall effect of stress (Day 1 versus Day 4) on HR.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day (D)	1	85.388	39	72.09214	1 18443	0.283137
Time (T)	**3**	**1643.604**	**117**	**54.26558**	**30.28815**	**0.000000**
D x T	3	84.876	117	35.26587	2.40674	0.070763

Marked effects p<0.05

b. The effect of stress on HR following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	**1**	**2718.677**	**38**	**648.4069**	**4.19286**	**0.047552**
Day (D)	1	83.898	38	73.9861	1 13396	0.293651
Time (T)	**3**	**1647.005**	**114**	**55.4048**	**29.72674**	**0.000000**
G x D	1	0.120	38	73.9861	0.00162	0.968064
G x T	3	10.974	114	55.4048	0.19808	0.897512
D x T	3	92.139	114	35.3799	2.60429	0.055300
G x D x T	3	30.931	114	35.3799	0.87427	0.456721

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	2423.722	38	656.1688	3.69375	0.062139
Day (D)	1	93.194	38	72.0904	1.29274	0.262662
Time (T)	**3**	**1665.250**	**114**	**51.7537**	**32.17648**	**0.000000**
G x D	1	72.157	38	72.0904	1.00093	0.323415
G x T	**3**	**149.719**	**114**	**51.7537**	**2.89291**	**0.038420**
D x T	3	85.944	114	34.6982	2.47689	0.064922
G x D x T	3	56.837	114	34.6982	1.63803	0.184516

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	193.295	38	714.8643	0.27039	0.606084
Day (D)	1	141.361	38	71.2252	1.98471	0.167026
Time (T)	**3**	**1425.412**	**114**	**50.3607**	**28.30404**	**0.000000**
G x D	1	105.036	38	71.2252	1.47470	0.232098
G x T	**3**	**202.649**	**114**	**50.3607**	**4.02396**	**0.009204**
D x T	3	81.555	114	36.1678	2.25491	0.085794
G x D x T	3	0.992	114	36.1678	0.02743	0.993839

Marked effects p<0.05

11 a. The overall effect of stress (Day 1 versus Day 4) on LF area.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day (D)	1	244757.8	39	321913.1	0.760323	0.388564
Time (T)	**3**	**1799463**	**117**	**250574.1**	**7.181360**	**0.000182**
D x T	3	153108.4	117	208495.2	0.734350	0.533557

Marked effects p<0.05

b. The effect of stress on LF area following group division based on LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	1359754	38	3494722	0.389088	0.536506
Day (D)	1	281662.5	38	326490.2	0.862698	0.358847
Time (T)	**3**	**1805944**	**114**	**255492.3**	**7.068487**	**0.000212**
G x D	1	147984.3	38	326490.2	0.453258	0.504866
G x T	3	63683.88	114	255492.3	0.249260	0.861719
D x T	3	153062.3	114	212470.6	0.720393	0.541806
G x D x T	3	57431.88	114	212470.6	0.270305	0.846697

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	1452803	38	3492273	0.416005	0.522813
Day (D)	1	238964.6	38	330092.0	0.723933	0.400187
Time (T)	**3**	**1799165**	**114**	**257054.5**	**6.999156**	**0.000231**
G x D	1	11113.95	38	330092.0	0.033669	0.855388
G x T	3	4317.961	114	257054.5	0.016798	0.997018
D x T	3	142247.2	114	192986.9	0.737082	0.532021
G x D x T	**3**	**797813.4**	**114**	**192986.9**	**4.134029**	**0.008012**

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	11397759	38	3230564	3.528102	0.068026
Day (D)	1	75774.61	38	319074.8	0.237482	0.628830
Time (T)	**3**	**1322747**	**114**	**245973.3**	**5.377605**	**0.001690**
G x D	1	429769.8	38	319074.8	1.346925	0.253056
G x T	3	425404.2	114	245973.3	1 729473	0.164908
D x T	3	105603.8	114	212416.9	0.497153	0.684983
G x D x T	3	59470.55	114	212416.9	0.279971	0.839760

Marked effects p<0.05

12. a. The overall effect of stress (Day 1 versus Day 4) on HF area.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day (D)	1	1610565	39	548830.3	2.93454	0.094644
Time (T)	3	1250763	117	547146.5	2.28597	0.082365
D x T	3	752832.9	117	444494.0	1.69369	0.172169

Marked effects p<0.05

b. The effect of stress on HF area following group division according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	2824229	38	8691420	0.324945	0.572006
Day (D)	1	1453373	38	554675.2	2.620224	0.113781
Time (T)	3	1103731	114	549123.2	2.009988	0.116504
G x D	1	326724.1	38	554675.2	0.589037	0.447535
G x T	3	472032.3	114	549123.2	0.859611	0.464329
D x T	3	742085.9	114	448484.5	1.654652	0.180792
G x D x T	3	292856.5	114	448484.5	0.652991	0.582679

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	263212.4	38	8758815	0.030051	0.863294
Day (D)	1	1733790	38	537749.9	3.224156	0.080515
Time (T)	3	1186512	114	539829.5	2.197938	0.092138
G x D	1	969885.8	38	537749.9	1.803600	0.187245
G x T	3	825192.1	114	539829.5	1.528616	0.210904
D x T	3	810061.8	114	433035.3	1.870660	0.138515
G x D x T	3	879927.3	114	433035.3	2.031999	0.113353

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	**1**	**39155552**	**38**	**77353330**	**5.061909**	**0.030329**
Day (D)	1	1794070	38	558422.2	3.212749	0.081031
Time (T)	**3**	**1629054**	**114**	**544529.8**	**2.991672**	**0.033912**
G x D	1	184337.5	38	558422.2	0.330104	0.568984
G x T	3	646582.9	114	544529.8	1 187415	0.317790
D x T	3	562451.3	114	429474.4	1.309627	0.274770
G x D x T	3	1015240	114	429474.4	2.363914	0.074829

Marked effects p<0.05

13. a. The overall effect of stress (Day 1 versus Day 4) on LF·HF area ratio.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day (D)	**1**	**0.731149**	**39**	**0.140727**	**5.195514**	**0.028198**
Time (T)	3	0.193969	117	0.162345	1 194793	0.314900
D x T	3	0.088901	117	0.112129	0.792839	0.500244

Marked effects p<0.05

b. The effect of stress on LF·HF area ratio following group division according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	1 112976	38	1 722438	0.646163	0.426488
Day (D)	**1**	**0.741511**	**38**	**0.144150**	**5.144034**	**0.029094**
Time (T)	3	0.173908	114	0.161681	1.075625	0.362393
G x D	1	0.010659	38	0.144150	0.073944	0.787151
G x T	3	0.187575	114	0.161681	1 160156	0.328186
D x T	3	0.096767	114	0.111959	0.864308	0.461879
G x D x T	3	0.118605	114	0.111959	1.059363	0.369326

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	0.046589	38	1 750501	0.026614	0.871273
Day (D)	**1**	**0.750208**	**38**	**0.142878**	**5.250678**	**0.027572**
Time (T)	3	0.190483	114	0.166472	1 144237	0.334397
G x D	1	0.058976	38	0.142878	0.412772	0.524424
G x T	3	0.005536	114	0.166472	0.033254	0.991819
D x T	3	0.103431	114	0.101912	1 014905	0.388878
G x D x T	**3**	**0.500403**	**114**	**0.101912**	**4.910170**	**0.003025**

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	**1**	**9.567753**	**38**	**1.499944**	**6.378739**	**0.015840**
Day (D)	**1**	**0.607817**	**38**	**0.144050**	**4.219487**	**0.046888**
Time (T)	3	0.289203	114	0.159585	1.812221	0.148903
G x D	1	0.014449	38	0.144050	0.100302	0.753200
G x T	3	0.267237	114	0.159585	1.674576	0.176424
D x T	3	0.066528	114	0.108935	0.610711	0.609402
G x D x T	3	0.233519	114	0.108935	2.143661	0.098610

Marked effects p<0.05

14. a. The overall effect of stress (Day 1 versus Day 4) on TA.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day (D)	1	592626.4	39	459275.7	1.290350	0.262916
Time (T)	**3**	**3527416.0**	**117**	**367869.1**	**9.588778**	**0.000010**
D x T	3	688515.3	117	406852.8	1.692296	0.172464

Marked effects p<0.05

b. The effect of stress on TA following the division of subjects based on LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	261504.4	38	2360330	0.110792	0.741074
Day (D)	1	449762.7	38	447451.6	1.005165	0.322406
Time (T)	**3**	**3377870**	**114**	**371389.5**	**9.095221**	**0.000019**
G x D	1	908591.4	38	447451.6	2.030592	0.162323
G x T	3	234094.1	114	371389.5	0.630320	0.596907
D x T	3	675512.6	114	409569.4	1.649324	0.181977
G x D x T	3	303622.1	114	409569.4	0.741320	0.529558

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	2936441	38	2289937	1.282324	0.264562
Day (D)	1	677549.4	38	440354.3	1.538646	0.222424
Time (T)	**3**	**3365678**	**114**	**358262.2**	**9.394455**	**0.000013**
G x D	1	1178289	38	440354.3	2.675775	0.110143
G x T	3	732932.7	114	358262.2	2.045800	0.111421
D x T	3	696281.8	114	414037.6	1.681687	0.174890
G x D x T	3	133831.4	114	414037.6	0.323235	0.808554

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	8321527	38	2148224	3.873678	0.056377
Day (D)	1	1125370	38	440197.2	2.556514	0.118123
Time (T)	**3**	**3384522**	**114**	**358315.8**	**9.445641**	**0.000013**
G x D	1	1184258	38	440197.2	2.690291	0.109215
G x T	3	730897.4	114	358315.8	2.039814	0.112255
D x T	3	630160.7	114	400322.6	1.574132	0.199517
G x D x T	3	655001 1	114	400322.6	1.636183	0.184933

Marked effects p<0.05

15. a. The overall effect of stress (Day 1 versus Day 4) on LFcf

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Day (D)	1	0.004234	39	0.003802	1 113709	0.297771
Time (T)	3	0.004076	117	0.004070	1.001368	0.394907
D x T	3	0.002810	117	0.003976	0.706838	0.549799

Marked effects p<0.05

b. The effect of stress on LFcf following the division of subjects according to LVF, beta-blocker therapy and MI status.

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
LVF (G)	1	0.016559	38	0.005855	2.828348	0.100815
Day (D)	1	0.005480	38	0.003675	1.491165	0.229558
Time (T)	3	0.004713	114	0.004098	1 150092	0.332100
G x D	1	0.008619	38	0.003675	2.345248	0.133949
G x T	3	0.002993	114	0.004098	0.730362	0.535945
D x T	3	0.003450	114	0.003982	0.866546	0.460715
G x D x T	3	0.003741	114	0.003982	0.939555	0.424072

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
Drugs (G)	1	0.002302	38	0.006230	0.369506	0.546890
Day (D)	1	0.004329	38	0.003895	1 111425	0.298430
Time (T)	3	0.004261	114	0.004029	1.057519	0.370120
G x D	1	0.000260	38	0.003895	0.066807	0.797439
G x T	3	0.005625	114	0.004029	1.396178	0.247626
D x T	3	0.002984	114	0.003939	0.757584	0.520186
G x D x T	3	0.005349	114	0.003939	1.357867	0.259318

Marked effects p<0.05

Effect	df Effect	MS Effect	df Error	MS Error	F	p-level
MI (G)	1	0.016542	38	0.005855	2.825279	0.100994
Day (D)	1	0.001831	38	0.003793	0.482724	0.491417
Time (T)	3	0.002378	114	0.004132	0.575338	0.632374
G x D	1	0.004131	38	0.003793	1.089107	0.303263
G x T	3	0.001697	114	0.004132	0.410586	0.745699
D x T	3	0.001558	114	0.004044	0.385260	0.763821
G x D x T	3	0.001374	114	0.004044	0.339850	0.796546

Marked effects $p<0.05$