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Mental Stress and Strain during Work and Leisure: A pilot study among marathon school participants

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In Loving Memory of Lois W. Newton, Teresa Cogan

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Abbreviations

ANS = Autonomic Nervous System

BMI = Body Max Index

CVD = Cardiovascular Disease

ERI = Effort Reward Imbalance

GAS= General Adaptation Syndrome

HRV= Heart Rate Variability

HF = High Frequency

HF/LF ratio = high frequency/low frequency ratio

JDJC= Job Demand Job Control

LF = Low frequency

MET = Metabolic Equivalents

NN intervals = normal to normal intervals in the QRS complex

RMSSD = Square Root of the mean squared differences of successive NN intervals

SDNN = Standard Deviation of NN intervals

VO2 Max = Maximal oxygen consumption

Contents

Abstract

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The aim of the study is to describe and measure the mental and physical stress and strain during a work day and a leisure day.

Methods

A cross-sectional study was conducted on 13 participants of a marathon school aged between 23 to 58 and a total of five men and eight women. The participants were given a physical fitness test at the beginning of the study. They were then asked to fill out questionnaires via cell phone asking about their physical and mental strain and capacity. The heart rate was monitored ambulatory and analyzed with a commercial software programme.

Results

The average stress time during the work day was 401 minutes and the free day stress time was 313,8 minutes. The average heart rate during the work day was 72 beats per minute and during the free day it was 93,3 beats per minute. The average high frequency during the work day was 2175,4, (indicating parasympathetic response) and the average low frequency was 3425,6, (indicating sympathetic response). The free day average high frequency was 1264,6 and the average low frequency was 1882,7. The work day MET Max was 13,2 and the free day MET Max was 12,7. The estimated oxygen consumption during the work day was 5,7 and during the free day it

was 10. The work day relaxation time was 111,6 minutes and the free day relaxation time was 46,2. Those who reported higher perceived fitness recorded higher work ability. The results for the crosstabulation of perceived fitness and stress were inconclusive. The cross tabulation of perceived fitness and free day relaxation was also inconclusive.

Conclusions

The subjects reported more stress time during the work day than the free day. The average low frequency was higher than the high frequency during the work day, which suggests sympathetic dominance (mental stress). During the free day the average low frequency was a little higher than the high frequency. The MET Max was a little higher during the work day than the free day; however, it is not high enough to make an association. The VO2 and the average heart rate were higher during the free day than the work day. This shows that there are less physical demands during the work day than during the free day. During the free day there was less relaxation time than during the work day. The subjects that rated higher perceived fitness rated higher work ability. The results of the crosstabulations of perceived fitness with stress and relaxation (recovery) were inconclusive.

Mental Stress and Strain during Work and Leisure: A pilot study among marathon school participants.

Introduction

1. 1 Background

Cardiovascular disease kills up to 16.7 million people globally every year, (WHO, 2006). It is one of the four biggest killers of people in the western world. The other three killers are diabetes, hypertension, and stroke (Grundy et al 1999). Physical inactivity and bad lifestyle habits are said to be the main cause of these diseases (Grundy et al, 1999). Stress and inadequate recovery are also said to be a cause of hypertension, cardiovascular disease, diabetes, and depression.

More European workers are suffering from "burn-out" which is characterized by feelings of extreme fatigue, (Peterson Ulla, 2008; Schaufeli W, 1998). A survey conducted in the European Union member states found that 90% of the respondents thought that in their countries stress is a major cause of disease, which together with burnout and bullying is attributed to poor work organization, (WHO, 2006) These feelings are believed to be caused by job stress, lack of sleep, or lack of adequate recovery, (van Veldhoven et al, 2003).

More jobs now are mentally demanding and less physically demanding which means that people are not moving around enough, (Kouvonen A et al, 2005). Many companies have downsized thus making workers feel as if they are doing more work with little time to accomplish their tasks, (Sparks et al, 2001). In a number of studies, it is reported that little control of tasks can also cause workers to feel stressed, (LaMontagne et al, 2008, Pickering T, 2001).

Stress is not the only thing affecting work capacity. Obesity afflicts increasing amount of people every year. Physical inactivity and unhealthy eating habits are the causes of obesity, (Struber J, 2004). Obesity is said to be a cause of work absenteeism which in turn causes loss of productivity, (Pronk et al, 2004). Obesity is also blamed for the rising health expenditures, (Quesnberry C et al, 1998). Obese people are at an increased risk for cardiovascular disease, diabetes, hypertension, and musculoskeletal problems. Physical activity is the main ingredient to preventing obesity. Physical activity is also important for increasing the maximal oxygen consumption (VO2 max) improving cardiovascular health, and improving the circulation to the muscles (Dehn et al, 1972). Physical activity is also an effective way to reduce stress, (Fox, 1999). The main thing I want to point out in this study is that everything is related. Stress affects the Sympathetic Nervous System which is in control of the heart and other body functions. Physical activity also affects the heart and the sympathetic nervous system.

Stress is a part of people's everyday lives. Stress can come from certain roles that people have to play in society such as being a student, a worker, or a parent, (Wainwright, 2002; Barling, 2005). Today's work environment can be stressful due to the constant downsizing which places more work demands on the worker and causes job insecurity, (Sparks et al., 2001). Occupational stress can also come from the effects of lack of recovery. Long work hours and shift work are to blame for inadequate recovery and sleep disturbances, (Hall et al., 2004). Overall occupational stress is attributed to the increased risk of fatigue, work related sickness and accidents. It is also attributed to the risk of cardiovascular disease and anxiety disorders.

If workers are distressed, they are said to be at more risk of living unhealthy lifestyles such as physical inactivity, smoking, high alcohol intake, and improper diet , (Kouvonen et al., 2006). These factors are also attributed to the cardiovascular disease, hypertension, non insulin dependent diabetes, and obesity.

2. Review of Literature

2.1 Stress

Stress is a part of people's everyday lives. Each individual perceives stress differently; therefore, it has been difficult to come up with one concrete scientific definition of stress. Stress research can be traced back to Hans Seyle and Walter Cannon, (Wainwright, 2002). Walter Cannon, a physiology professor at Harvard, wrote about emotional stress as early as 1914, (Wainwright, 2001). Although the physical responses to stress were already known by then, he was interested in the physiological responses to stress. He conducted laboratory experiments at Harvard, from where he published his results in various medical journals.

He later summarized his journal articles in a book he published in 1925, *Bodily Changes in Pain, Hunger, Fear and Rage*. From the social Darwinist and the eugenics movements, he developed the "fight or flight" theory that describes the body's physiological response to stressors, (Wainwright, 2001). Cannon believed that the body's reaction to stressors was simply instincts and that the body was trying to maintain a constant state of homeostasis. During the pre-war period, the social Darwinist movement and the eugenics movements were at their peak. Darwinist believed that the survival of a species depended on its ability to adapt to the constantly changing environment. It is also important to point out that during the pre-war period the research focused on physical stress, (Wainwright, 2001).

Stress research was broadened by Hans Seyle, an endocrinologist who was also concerned with the physiological reactions to stress, (Wainwright 2002). Like Cannon, Seyle was inspired by the social Darwinist and eugenics movements.

Unlike Cannon, Seyle proved that stress had hazardous effects on the body, and he opened up the research on psycho social stressors (Wainwright 2002). Seyle develop a theory similar to Cannon's fight or flight theory. Seyle's theory is called General Adaptation Syndrome, (GAS).

There were three stages to the GAS: alarm; resistance; and exhaustion. The first stage, alarm, is the stage where the person is confronted with some kind of threat with emphasis on the physiological responses to the threat. The second stage, resistance, is the stage where the person seems to have calmed down or relaxed, however, the body's stress fighting resources are still being taxed. The third stage, exhaustion; is the stage when the body's stress fighting resources are all taxed and the person is then at risk for health problems, (Wainwright, 2002). Selye did not focus on psychological stressors until the end of the Second World War, when the military began research on stress, (Wainwright, 2001). The military's research on stress paved the way for future research on work stress, (Wainwright, 2001).

According to Selye, there are two types of stress, eustress and distress. Stress is not always a negative thing; it can be beneficial, (Koslowksy, 1998).

Hans Seyle developed the stress model which was later modified into the stress strain model used today, (Nygård, 1988). Stress response occurs when the work demands exceeds the worker's abilities. Stressors are what cause a stress response or reaction. Stressors can be anything from time restraints at work, loud noises, overcrowded busses, or speaking in front of a large crowd. These stressors can come from time constraints at work, conflicts with family members, or long work hours.

Bad work positions can cause physical strain to the body which results in musculoskeletal problems. Long working hours plus family conflicts may cause psychological strain on the person. Stress response is the body's reaction to the stressor. Strain can also be viewed as a stress reaction.

The stress strain model shows the causes, acute reactions, and long term consequence to work stress, (Houtmen, 2005). Stress that one feels before a job interview or an athletic competition can be considered positive because it may enhance performance. It can also enhance work performance, (Kolskowsky, 1998). However, there is a point when stress can become hazardous to one's health.

Too much stress can put people at risk of developing cardiovascular disease, hypertension, and anxiety disorders, (Kivimäki et al, 2002). This harmful stress is called distress.

The sympathetic nervous system is dominant in the body's reaction to a stressor. The body's response to acute stress, or short term stress, is referred to as the fight or flight reaction, (Van De Graaff, Kent M., 2002). In the past, the fight or flight reaction was a way to help humans avoid or escape from dangerous predators.

This fight or flight reaction is characterized by an increase of the heart rate, increased blood flow to muscles, increased perspiration, the dilation of the bronchioles, and a decrease of digestion, (Van De Graaff, Kent M, Rhees W, 2002).

Sympathetic nervous system is activated by anything that the person perceives as a threat such as a loud explosion, public speaking, or an angry bear. After the threat has passed, the body returns back to normal, or the relaxation phase. This relaxation phase is controlled by the parasympathetic nervous system as is referred to as the "rest and digest" phase, (Van De Graaf, Kent M. 2002).

The parasympathetic nervous system decreases the heart rate, decreases the blood pressure, decreases the blood glucose levels, increases digestive activity and constricts bronchioles, (Van De Graaff, 2002). Over stimulation of the sympathetic nervous system can be hazardous to one's health.

Work Stress

Work stress can be defined as the harmful physical and emotional responses that occur when the requirements of the job do not match the capabilities, resources, or needs of the worker, (National Institute of Occupational Health and Safety, 2007). Work stress is not a disease but it is a cause of chronic diseases such as cardiovascular disease and hypertension, (Wainwright, 2001). The beginnings of work stress research can be traced back to Hans Seyle and his work with the military research centers. Because of the war, the military was interested in psychological stress for recruitment and training of personnel, (Wainwright, 2001). Hans Seyle was successful in gaining the support of the military in stress research. The military's reasoning for research was similar to the industry's reasoning for work stress research. They both were interested in improving work capacity, (Wainwright, 2001). Hans Seyle managed to get research positions with military research institutions in the United States. It was at this time when Hans Seyle began his work stress research. At first, the job stress research only focused on increasing work capacity to increase production. This was the focus of U. S job stress researchers.

The Scandinavian job stress researchers focused on the well being of the workers. Not until the 1980s, the focus of the research changed from productivity and well being to medical reasons. Now, the purpose of job stress research is to improve the workers health thus improving workers wellbeing and productivity (Wainwright, 2001).

Work stress is attributed to increased sick leaves and loss of productivity, (Rook and Zijlstra, 2006). Job insecurity, job demand/control, effort reward imbalance, and management methods affects the work environment, (Spark et al., 2001). Work stress can also be caused by the physical work environment. Due to the changing economy, companies have to streamline the work force by merging and downsizing. This of course can create distress among employees. According to Sparks et al, there is more perceived stress among "white collar" workers, (Sparks et al., 2001). This stress is caused by the fact that the workers perceive more demands. Downsizing may cause workers in general to be stressed because they have more work demands and little control over time. Work schedules may also create work stress. For example, the night shift workers are said to be at more risk for cardiovascular disease due to the lack of sleep. Night shift disrupts social interaction with family and friends which can also cause the worker to feel stress, (Sparks et al., 2001). Management styles are also attributed to work stress. Management may be too demanding to the employees by not letting them have control over working time, job duties, and other personal issues, (Sparks et al., 2001). Bad work ergonomics can cause physical stress thus causing musculoskeletal problems for the worker, which can then lead to psychological stress. It is important to note that different professions have different stress levels. Lorry drivers may be stressed because the work schedules or time limits.

Work Stress and Fitness

Walter Cannon suggested that war might be a good way for men to relieve stress; however, because of the harsh reality of war, Cannon realized that sports could be a better way to relieve stress, (Wainwright, 2002).

Physical activity is said to relieve stress by giving the person a "time out" from work. It is also a good way to let off steam, and to encourage social interaction, (McArldel W, Katch F, Katch V; 2001).

Exercise or sports may also give the person a feeling of mastering something or a feeling of accomplishment, which may boost the confidence and self esteem.

Also through exercise or participating in some sporting activity may give the participant social encouragement, (DeGues, 1993). Instead of seeing stressors as a threat, participants may see stressors as a challenge, (De Gues, 1993). On the other hand, some research notes that aerobically trained people have less sympathetic reaction to physical load. From this, they hypothesized that these aerobically trained athletes may have fewer reactions to emotional load, (De Gues, 1993). Other research suggests that physical activity has no effect on psychological variables, (De Gues et al, 1993). The problem with this particular study is that it was noted that the subjects have a prior history of rigorous exercise. It has been proven in various studies that fitness is useful in fighting work stress. It is also proven to improve overall work capacity.

Recovery

Recovery is vital part of wellbeing. Recovery is the process of replenishing the body's resources, (Rook and Zijlstra, 2006). Meijman and Mulder states that recovery occurs when the exposure ceases the psychobiological systems stabilize back to baseline, (Miejman and Mulder, 1998).

Taking short breaks can help one recover during the work day. I want to focus on leisure time/free day recovery. For many people, work does not end when they leave their work place. When they return home, they are faced with demands from family, friends, and household chores.

Insufficient recovery is a risk factor for developing work fatigue, and cardiovascular disease (van Amelsvoort LG et al., 2002). Working overtime is also attributed to poor work recovery. According to the European Foundation for the Improvement of Living and Working Conditions, 17% of full time employees work 45 or more hours per week. They also mentioned that more men than women work overtime and that white collar worker are more prone to work overtime, (Boisard P et al, 2002). Inadequate recovery is attributed to increased sick leaves from work, which then causes loss of productivity, (Rook J, Zijlstra F, 2006).

On average, most adults need seven to eight hours of sleep in a night. However, people's bodies are different. Some people need only five hours of sleep a night and others need ten hours of sleep during the night, (National Institute of Neurological Disorders and Stroke, 2007). When a person does not get enough sleep in one night, it is suggested that he or she should make up or that loss of sleep the following night. If the sleep is not made up, this creates a "sleep debt". Eventually the debt has to be paid back. Sleep deprivation can cause a persons reaction time and judgement to be impaired, (National Institute of Neurological Disorders and Stroke, 2007).

Circadian rhythms are regular changes in mental and physical characteristics that occur in the course of a day, (National Institute of Neurological Disorders and Stroke, 2007). The circadian rhythm is controlled by the body's biological clock. Humans are a diurnal species. The human body is accustomed to being awake during the day and sleeping during the night, (Barling J. et al., 2005).

Night shift workers are said to have a higher risk of adverse health because of the fact that their circadian systems is offset, (Barling J et al., 2005).

Jet lag is a good example of what happens when there is a disruption in the body's circadian rhythm. The factors that contribute to inadequate recovery or disruption of

sleep are shift work and longer work hours, (Barling J et al., 2005). Jobs today require that workers work longer hours. In the third European survey, 17% of full time employees are working 45 or more hours a week. There is evidence that long work hours are associated with fatigue, reduced motivation, prolonged exposure to work stressors, and the use of poor lifestyle habits such as smoking and lack of exercise, (Barling J et al., 2005). According to the survey, 30% of the Swedish working population works overtime every week, (Dahlgren et al, 2006). One study conducted on 18 office workers concluded that there was an association between overtime and feelings of exhaustion. They also noticed that during the weeks with overtime work, the participants had slept less, (Dalhgren et al, 2006; van der Hulst M, et al., 2006).

2.1 Physical Capacity

Physical Capacity

Physical capacity, along with social and mental capacity is a component of functional capacity, (Savinainen, 2004). Physical capacity includes anatomical and physiological factors such as: aerobic capacity; muscular strength; muscle endurance; and joint flexibility. Factors that may have an impact on physical capacity are age, gender, physical activity levels, lifestyle factors, and diseases, (Savinainen, 2004). As people age, their VO2max decreases and physical capacity is said to begin a gradual decrease by the age of 30 and a drastic decrease by the age of 50, (Savinainen, 2004).

Physical Activity and Physical Fitness

Physical activity is an important tool for the fight against CVD, hypertension, non insulin dependent diabetes, certain types of cancers, and other complication from obesity, (Peluso Mam et al. 2005).

Physical activity can also be important in the treatment of stress, anxiety, and mild depression. Physical activity is important to humans because it enhances muscular strength, joint function and endurance thus improving physical capacity, (Leino-Arjas P, et al 2004). People taking part in regular physical activity have lower blood pressure, and BMI. People involved in vigorous exercise such as training for a marathon may have lower heart rates and a more variability of the heart rate. Physical activity is defined as any body movement that is produced by muscular movement and that increases energy expenditure, (McArdle W, Katch F, Katch Victor, 2001). Exercise is defined as a structured, repetitive, purposeful form of physical activity. This same author states that physical fitness is attributed to how well one performs during physical activity.

The UKK Institute in Tampere Finland developed a physical activity pie chart. The different physical activities are classified as either life style activities or structured exercise. Life style activities include activities that one does in everyday life situations. Gardening and house hold work is good examples of lifestyle physical activities. Structured exercises include activities such as aerobics, jogging, cycling, and team sports, (Fogelholm et al, 2005).

Physical fitness can be measured by how much physical activity or exercise one participates in, (McArdle, Katch F, Katch V, 2001). There are different ways to measure one's physical fitness.

Physical Fitness can be measured by using metabolic equivalents, VO2 Max, and HRV. Researchers also use self reported methods such as questionnaires and exercise journals or diaries to assess one's fitness level.

It is suggested by the Centre for Disease Control and Prevention recommends that people should take part in moderate intensity activity for five or more days a week for 30 minutes a session. It also mentions that adults can take part in vigorous activities for three or more days a week for 20 minutes a session, (Center for Disease Control, 2001).

After controlling for covariates, Schmier et al, reported that within BMI ranges, as physical activity increased, the medical costs decreased, (Schmier et al, 2006).

Taking part in routine aerobic physical activity will increase oxygen consumption and increase muscle tone. This is beneficial to workers because it improves work capacity by improving muscle endurance, strength and cardiovascular exercise. By increasing the cardiovascular health and muscle tone, the brain is able to get more oxygen from the blood, thus improving mental capacity.

Measurements of physical fitness

Researchers and Exercise Physiologist use various fitness tests to determine subjects' cardio, muscular, or respiratory fitness. There are various fitness test used to test cardiovascular health, muscle strength and muscle endurance. This is considered to be more objective and more reliable way to test one's fitness.

Maximum Oxygen Consumption (VO2 Max)

VO2 Max represents the maximum oxygen consumed by the body during exercise or work. VO2 Max is used to determine one's cardiopulmonary health or fitness, (Williams, 2004).

According to the American College of Sports Medicine, it is the most accurate variable to evaluate the intensity of aerobic activity (ACSM 2001).

VO2 Max is measured in laboratory settings which can be time consuming, expensive, and not appropriate for field settings, (First Beat Technologies 2005). Studies have shown that the heart rate is a reliable and a non invasive means for measuring VO2 Max, (First Beat Technologies 2005). VO2 max can also be estimated by using the heart. Studies have shown that VO2 max increases linearly with heart rate during exercise.

Heart Rate Variability (HRV)

Heart rate variability (HRV) has proven to be a non invasive way of measuring cardiovascular health and autonomic function, (Ramaekers D et al., 1998; Dishman R, 1999; Winsley, 2002).

Heart rate variability is the variance in the instantaneous heart rate and R to R intervals, (Malik, 1996). Researchers like to use heart rate variability as a non invasive way to check autonomic functioning of the cardiovascular system, (Sandercock G, et al., 2006; Agelink M, et al., 2001; Ramaekers D, et al., 1998).

It can also be defined as the interplay between the sympathetic and parasympathetic nervous systems, (Lewis, 2005). Studies have suggested that heart rate variability can be used to determine if a patient will suffer from cardiovascular disease, emotional disorders, or sudden cardiac death, (Gang et al. 2003).

Ventricular contractions are caused by electrical depolarization, which is detected on the skin, (Rennie 2003). This aids in the detection of the heart rate variability by various modalities. The QRS complex is produced by the ventricular contraction. One can see the QRS complex with an electrocardiogram which is displayed in figure 1.

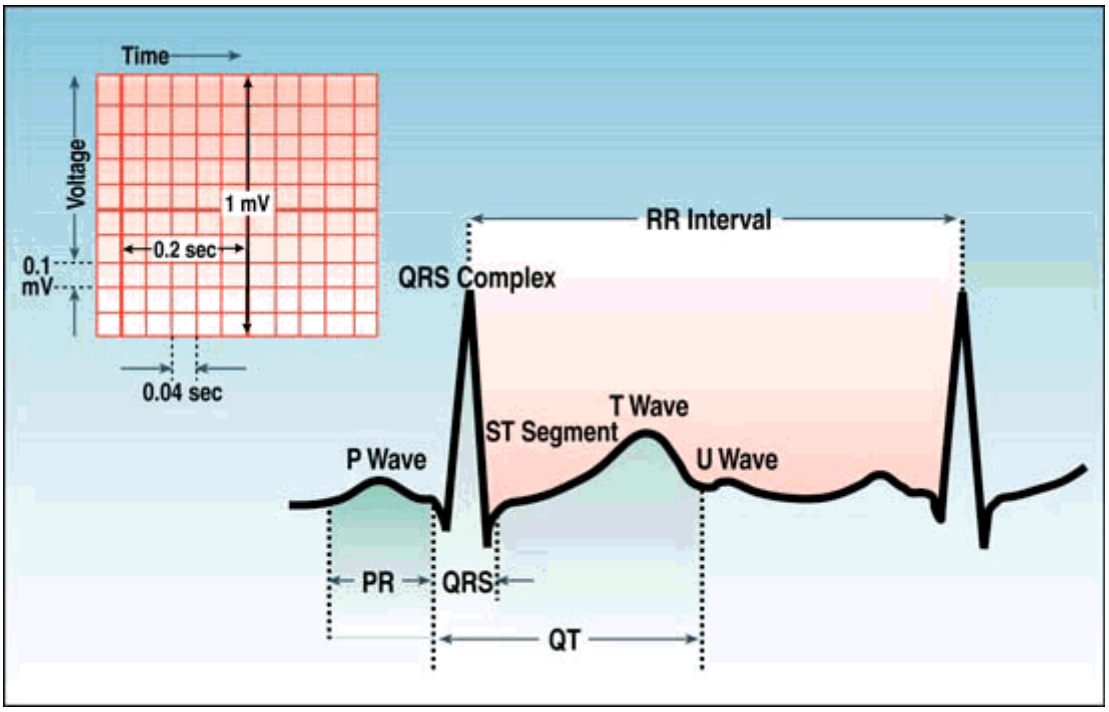

Figure 1: ECG Intervals and Waves-KH, Frank G. Yanowitz, M.D., copyright 1997

N to N beats represent the normal to normal beats within the QRS complex. The QRS complex can also be referred to as the QRS waves. The P wave begins when there is electrical activity in the atrium. The P wave is normally upward. The PR interval is the time between the P wave and the beginning of the QRS wave. The ventricular activation begins the QRS wave. The R wave represents the upward deflection and the S wave represents the downward deflection. The T wave represents repolarisation.

Heart rate variability is controlled by the ANS. People who are taking part in regular physical activity are said to have greater variability with their heart rate, (Sandercock G.R H., Brodie D.A., 2006). Rennie et al conducted a study on non industrial British civil servants aged 35-55 years old.

The study concluded that men with a BMI >25 and who took part in vigorous physical activity had higher HRV, (Rennie et al., 2003).

Some studies question physical activity's affect on heart rate variability. Some have proven that physical activity has no effect on heart rate variability. Having weak heart rate variability is dangerous to one's health and can lead to sudden cardiac death, (Malik M., 1996). Low resting heart rate variability represents a risk of cardiovascular disease and ventricular arrhythmias, (Rennie et al. 2003). There are two ways of analyzing HRV, time domain analysis and spectral frequency domain analysis, (Malik M, 1996). The common measurements of the time domain analysis are heart rate, pNN50, RMSSD, SDNN, and SD. The time domain analyses are statistical quantifications of the R to R intervals, (Winsley, 2002). Heart rate is not used because it is constantly changing due to the activity of the person. The RMSSD and the SDNN are commonly used.

Low frequency, high frequency, and low frequency/high frequency ratio are spectral frequency domain measurements, (Ramaekers D et al., 1998; Hautala A, 2004). Fourier transformation algorithm or the autoregressive approach is used to calculate the power spectral density form the R-R interval. The ratio of high frequency and low frequency are used to describe sympathovagal balance, (Dishman et al, 2000, Ramaekers et al, 1998). High frequency (0.15–0.45 Hz), is attributed to the sympathetic system and the low frequency (0.04–0.15 Hz), is attributed to the parasympathetic system, (Winsley, 2002; Lewis, 2005). Researchers look use the HF/LF ratio to determine balance between the sympathetic system and the parasympathetic system.

Research suggest that if the sympathetic nervous system is more dominate than the parasympathetic system, they person has an increased risk of cardiovascular disease.

Ventricular contractions are caused by electrical depolarization, which is detected on the skin, (Rennie 2003). This aids in the detection of the heart rate variability by various modalities.

Metabolic equivalents are used to determine the intensity level of exercise or other physical activities, (Rennie et al., 2003) Activities are given a MET level based on the amount of energy burned during that particular activity. MET is one kilocalorie per kilogram of weight per hour, 1 kcal/kg/hour, (Rennie et al. 2003). One MET is the energy expended while sitting or lying quietly which burns 1kcal/hour, (Rennie et al., 2003). It can also be used as an estimation oxygen uptake. 1 MET is equivalent to 3.5 ml of oxygen per kilogram of weight per minute, (Brooks et al, 2003).

4 Methods of Measurement

Stress Strain Research Methodologies

Stress factors and stress response can be measured either quantitatively or qualitatively. Questionnaires are used to measure work stress. Some research supports the use of qualitative methods because it is believed that a person's perception of his or her own health is accurate. The self report method is questioned in studies because the researchers believe that the self report method leads to bias, (Kouvonen et al, 2005). These researchers actually prefer using more objective measures to determine stress.

Stress response can be measured, quantitatively by taking cortisol from saliva, catecholamine from urine samples, the blood pressure, and the heart rate variability. In some studies researchers used cortisol detected through the saliva to determine the subject's stress levels.

In other studies, researchers used catecholamines found in urine to determine the stress levels of their subjects. Cortisol can be measured by using samples of saliva.

In healthy persons, the cortisol can be used to measure acute stress because during the stressful event, the cortisol level increases, (Dahlgren et al. 2006). In the past, researchers tried to use heart rate as a way to measure stress and strain. Later, it was determined that heart rate was not a valid way of measuring stress and strain because the change in heart rate only last a few seconds after the stressful event. It was discovered that heart rate variability is a better way to measure stress and strain. Heart rate variability has proven to be a non invasive way of measuring cardiovascular health and autonomic function. The autonomic nervous system (ANS) controls many visceral organs including the heart. Ventricular contractions are caused by electrical depolarization, which is detected on the skin, (Rennie 2003). This aids in the detection of the heart rate variability by various modalities. Van Amelsvoort et al. conducted a study on 396 shift workers taking part in a cohort study.
He found that night shift workers had a weaker heart rate variability which explains why cardiac disease is more prevalent among night shift workers, (van Ameslvoort et al. 2000). Catecholamines are also used in studies to measure stress in subjects. Catecholamines are measured by using urine samples from subjects.

Job Strain Models

Two researchers, Robert Karasek and Johannes Siegerist, came up with two different models to measure job strain. Robert Karasek, developed the Karasek Model which associates work strain with increased job demands and low decision latitude or control. Karasek suggest that low control or decision latitude with high job demands increases ones risk of heart disease. Karasek developed the demand control model, illustrated below.

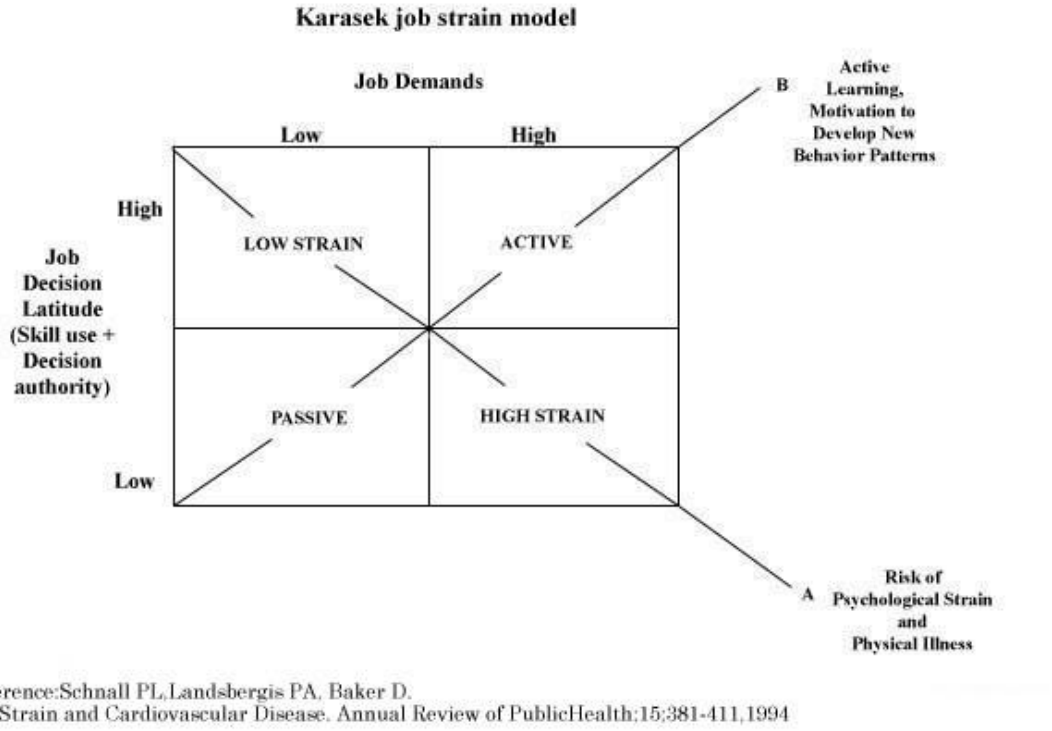

Figure 2: Karasek job strain model.

The Karasek model is divided into four categories: Active; Passive; High Strain and Low Strain. The high strain jobs are jobs that have high demands and low control. The active jobs have high demand and high control. The low strain jobs have low demand and high control. The passive jobs have low demand and low control, (Karasek and Theorell, 1990).

Siegerist developed the effort reward model. This model is used in various researches to determine effort reward imbalance. People who work a lot of overtime (effort) may not feel that they are getting paid (reward) enough.

This may lead to over commitment. People with over commitment are said to be at a higher risk of cardiovascular disease. People who are suffering from too much work stress can also be at risk of developing gastro intestinal problems, and depression.

Fitness Tests

Researchers and Exercise Physiologist use various fitness tests to determine subjects' cardio, muscular, or respiratory fitness. There are various fitness test used to test cardiovascular health, muscle strength and muscle endurance. This is considered to be more objective and more reliable way to test one's fitness.

Self Rated Fitness

Perceived fitness is one's own perception of his or her fitness. Researchers gather data on perceived health by used questionnaires, surveys, and diaries for their research. These questionnaires can be a convenient and a low cost way to measure physical fitness.

Some researchers argue that the questionnaires can lead to under or over estimation of fitness. The validity and reproducibility of the questionnaires regarding physical activity was questioned by Norman et al. They found that men with a BMI below 26 kg/m2 had significantly higher validity than heavier men, (Norman et al., 2001). This reaffirms the belief that subjects may put inaccurate information on surveys or questionnaires to make them seem healthier. The questionnaire was only valid with the healthier subjects.

Body Max Index (BMI)

Body Mass Index is said to be an important indicator of cardiovascular mortality in sedentary individuals. BMI is calculated as the ratio of body mass/ height² or kg/m², (Ozcelik et al. 2004). People are considered over weight when BMI is between 25.0 and 29.9. Studies suggest that obese people with a BMI of 30 or higher are prone to cardiovascular disease, hypertension, or stroke, (Kouvonen, 2005). Obesity can be a result of genetics or high energy intake and physical inactivity, (Kouvonen, 2005).

There is a weak association between BMI and mortality however; there is a strong association between BMI and morbidity, (Schmier et al, 2006). There is a strong association between BMI and obesity meaning that people with high BMI are more likely to be obese. Obese people or people with higher BMI are said to have more absenteeism at work. They are also more prone to suffer from injuries which lead to increased use disability, (Shcmier et al, 2006).

5.0 Aims of the Study

The aim of this study was to describe the mental and physical stress during a work day and a leisure day among marathon school participants. To fully assess the aim of the study, we must ask the following questions:

1) What is the mental and physical strain level during a work day and during a leisure day?

2) Do the participants get adequate recovery during a work day and during a leisure day?

3) What association does physical activity have on the stress, recovery, physical capacity of the participants?

6.0 Materials and Methods

6.1 Subjects

The subjects were participants of a marathon school in Tampere, Finland. There were a total of 13 subjects for this study. A total of eight women and five men participated in this study. The ages of the participants range from 23 to 58 years with the average of 42.7 years. The average age for female participants was 43,2 years and the average age for male participants was 42,4 years of age.

The female participants' average BMI (22, 7) was less than the male participants' BMI (24,8) and less than the average of the total sample (23,4).

		total sample N 13		female N 8		male N 5	
		M	SD	M	SD	M	SD
Age	Years	42,7	9,2	42,4	9,5	43,2	9,9
Height	m	1,7	0,1	1,7	0,1	1,83	0,1
Weight	kg	70,0	13,1	62,3	7,6	82,3	10,0
BMI		23,4	2,4	22,7	2,4	24,5	2,2
VO2 Max	Ml/kg/min	45,8	5,3	44,0	3,2	48,6	7,0
MET Max		13,0	1,3	12,5	0,8	13,7	1,7
Activity Class		6,7	0,8	6,5	0,7	7,1	1,7

Table 1: Means and standard deviations of age, height, weight, VO2 Max, Met Max, and activity class of total sample and of male and female participants.

The V02 max,(maximal oxygen consumption in 1/min), was lower for women than for men (table 1) and the MET max (metabolic equivalent) was higher for men than for women. It is normal for the men to have higher V02 max and BMI than women. The activity class is slightly higher for men (7,1) than for women (6,5).

When asked what job rank they had, four people considered themselves employees. Two people reported that they were supervisors and six reported that they were office workers. The job titles ranged from project manager to construction worker.

There were three people in the health care industry, two people were construction workers, two people were taking care of children, two people were office workers, three managers in three different fields, and one marketing assistant. The marketing assistant reported that she also worked as a kindergarten teacher.

Twelve people completed the questionnaires by cell phone and one person completed the questionnaire by paper. All subjects had high perceived fitness levels. The mode for perceived fitness was 9, (six subjects), with a minimum of 8, (five subjects) and a maximum of 10 (one subject). They also gave higher scores for work ability. One subject chose 7, two subjects chose 8, and nine subjects chose 9.

When asked about work satisfaction, only one person was dissatisfied with work. The rest rated their workplace satisfaction from mildly satisfied (6) to very satisfied (9). The physical work load had equal results. Six subjects rated their jobs as low physically demanding and the other six rated their jobs as a mixture of physically and mentally demanding.

The means for the perceived physical load during the work day (4.5, ± 3.1) is lower than the mean for the free day (5.3, ± 1.8). All of the subjects stated that their jobs were mentally demanding. The means for the mental load during the work day (7, ± 1.2) were much higher than the means for the mental load during the free day (3.4, ± 2.1). The subjects reported that their work is more mentally demanding even among those who reported that their jobs were a mixture of mental and physical demand reported higher mental demands. This of course goes along with the modern trend of physically demanding jobs becoming more obsolete, (Kouvonen A et al, 2005). The people who reported that their jobs were mixed mentally and physically reported higher physical demands. When asked to rate life satisfaction, only one subject rated his/her self as having low life satisfaction. The rest of the subjects rated their life satisfaction from mildly satisfied, (5) to highly satisfied (9).

In order to stay in shape for the upcoming marathon, the subjects must train regularly. Most of the participants trained from three to seven times a week. Seven subjects reported that they exercised three to seven days a week.

The remaining four subjects reported that they exercised one to three days during the week. All participants reported that they take part in some form of strength training. Along with the marathon school training, they also mentioned doing other physical activities such as berry picking, hiking, riding a bike or walking to work and garden work.

6.2 Study Design

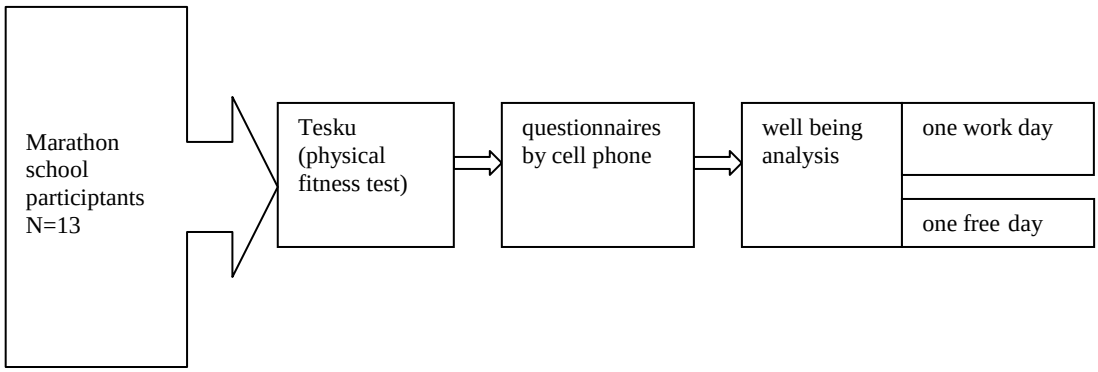

Figure 3: Study design.

This is a cross-sectional study that was conducted on 13 participants taking part in a marathon school at the Varala Sport School in Tampere, Finland. The project began in January 2006. The overall aim of this project was to evaluate the usability of the smart belts and wrist top computers. The results collected from these devices were used to create a well being analysis.

6.3 Methods

This study used a combination of subjective and objective measurements. The fitness test was conducted at the Varala Sports Institute located in Tampere, Finland.
The subjects were asked to run or walk three or six times one thousand meter from low intensity to their subjective maximal capacity.

After every 1000 meters, the subjects' running/walking time, heart rate, and blood lactate concentration were measured. The participants were asked to fill out questionnaires by cell phone, (CMT Ltd). The questionnaire consisted of 17 different questions. The questions asked about the subjects' perceived health, mental, and physical load at work and leisure time. There were other questions asking subjective fitness level compared with their own age group, stress, and life satisfaction. The subjects were asked to rate their physical/mental load, fitness level, stress, and life satisfaction from 0 to 10, (0=poor, 10=excellent).

The participants were asked to wear for two days, one work day and one free day, wrist top computers (Suunto T6, Finland) and Smart Belts (Sense Wear Pro, Finland). Data from the wrist top computers and the smart belts were analyzed with commercial software, (First Beat Technologies, Finland) to create a wellbeing analysis.

The following figure is an example of the well being analysis. The graph is normally in colour; however, in this thesis, it will be in black and white.

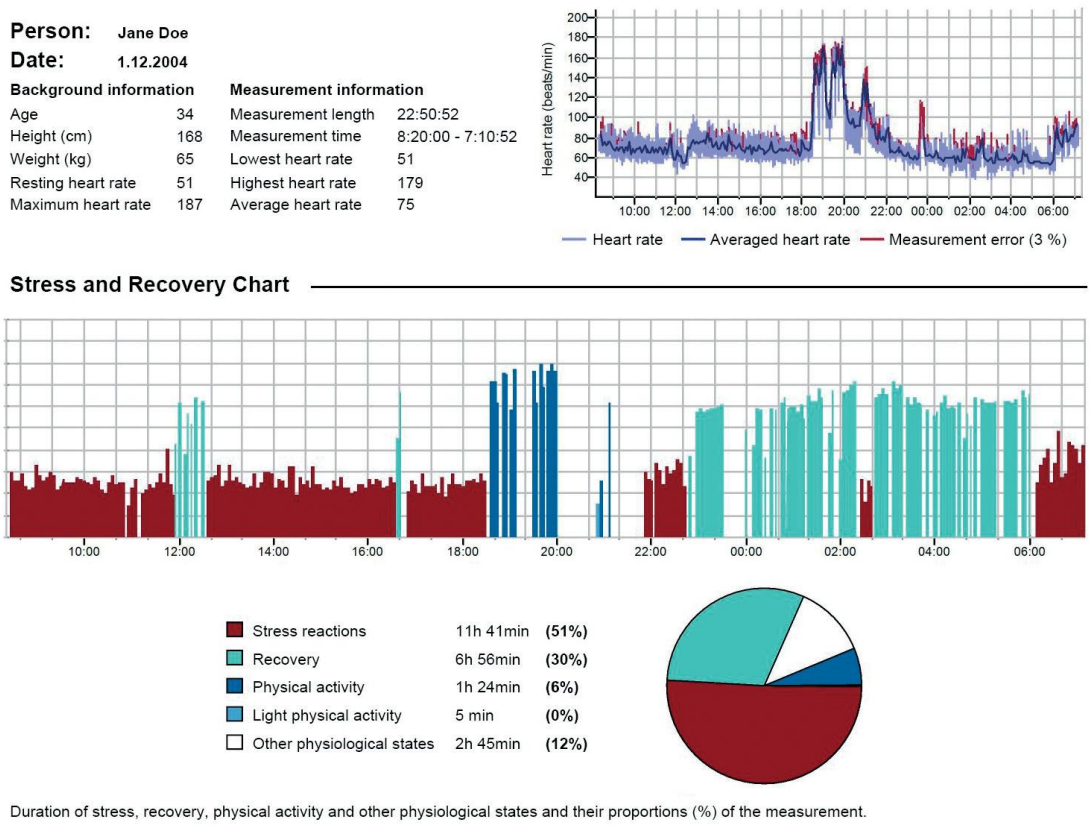

Figure 1: Sample from well being analysis by First Beat Technologies.

The graph makes it easier for one to see the work load, exercise load, and free time activity load and how it affects the heart rate variability. There was a graph for the work day and another graph representing the free day. Each graph shows the age, height, weight, BMI, times when the watch was worn, average heart rate, resting heart rate and the max heart rate. The graph at the top right corner shows the heart rate variability. The light and dark blue lines represent the heart rate variability. The bottom chart represents the stress and recovery during the day. The red colour represents the load. The blue represents exercise, the green represents recovery and white represents other measures. The stress time, average heart rate, beat by beat RMSSD, beat by beat SD, average high frequency and average low frequency were estimated. The MET max and average VO2 was also estimated. The RMSSD is a time domain variable of HRV.

It is the square root of the mean of the sum of the squares of the differences between adjacent R-R intervals. SD is the standard deviation of R-R intervals. High frequency and low frequency are spectral analysis variable of heart rate variability. High frequency shows the parasympathetic control of the heart and the low frequency shows the sympathetic and parasympathetic control of the heart, (Winsley, 2002).

6.4 Data Analysis

6.4.1 Statistical Analysis

Since there are such a small number of people taking part in this study, I am only using descriptive statistical analysis. Means, Standard deviations and cross tabulations will be used. I used SPSS 13.0 to create the results and graphs.

7.0 Results

		Work Day			Free Day	
	N	Mean	SD	N	Mean	SD
stress time	8	400,9	189,3	6	**313,8**	**156,2**
average low frequency	8	**3425,6**	**3090,7**	6	**1882,7**	**1828,6**
average high frequency	8	**2175,4**	**3225,5**	6	**1264,6**	**2340,5**
average heart rate	8	72	10,9	6	93,3	15,9

Table 2: Means and standard deviations of work and free day variables. Stress time is in minutes and average heart rate is average beats per minute.

During the work day the average low frequency was higher than the average high frequency which can suggest sympathetic dominance, (Table 2). During the free day the average low frequency was a little higher than the average high frequency. The low average of the high and low frequencies during the free day could mean that there was less stress during the free day.

However, it is important to note that there was a difference between the data. We used data for eight people during the work day. We only had data for six people during the free day. This may have affected the results.

When the means of stress time and work demands were compared, mixture of mentally and physically demanding jobs had higher stress time. This may be due to the occupations of the subjects.

Table 3 shows the means of the MET Max, average VO2, and average hear rate which represents physical load during the work day and during the free day. There is not a significant difference in the MET max between the work day and the free day. However there is a difference in the average VO2 and average hear rate between the work day and the free day. There were no significant correlations between VO2 and physical load during work and free day.

	Work Day			Free Day		
	N	Mean	SD	N	Mean	SD
MET Max	8	13.2	1.5	6	12.7	1.7
Avg VO2	8	5.7	1.2	6	10	3.6
Avg HR	8	72	10.9	6	93.3	15.9

Table 3: Measured physical load during work day and free day. Avg HR= Average Heart Rate. HR-beats/min.

Recovery

Below, table four shows that during the leisure day, the participants recorded less relaxation time and stress time than during the work day. Participants experienced more stress time during the work day (400.9 mins/7 hrs) than during the free day (313.8 mins/5 hrs 23 min).

	Work Day			Free Day		
	N	Mean	SD	N	Mean	SD
relaxation time min	8	111,6	113,9	6	46,2	57,9
stress time min	8	400,9	189,3	6	313,8	156,3
valid N	8			6		

Table 4: Means and Standard deviations of work day and leisure relaxation time and stress times in minutes.

Perceived fitness, stress, recovery, and work ability

The subjects rated their perceived fitness as high. When the perceived fitness was compared with stress time, the results were inconclusive. In this thesis, one is unable to draw a conclusion whether physical activity has any affect on the subjects' stress level.

Work day and leisure day relaxation time in minutes were compared to perceived fitness. Subjects who reported higher perceived fitness levels reported lower work day relaxation times. The results for the leisure day relaxation times were inconclusive.

Work ability was compared to perceived fitness. Subjects reported higher work ability and perceived fitness. There was a small trend that the subjects with lower perceived fitness reported lower work ability.

8 Discussion

The mean for the stress time during work day was higher than the stress time mean for the free day. The heart rate was higher during the free day than the work day. The heart is unstable throughout the day, meaning that it changes during activities.

So if the subjects have exercised harder then it could affect the average heart rate. It is also possible that the subjects engaged in house hold chores during their free day which could also affect the average heart rate.

MET max, average VO2, average heart rate was used to get objective results of physical load at work. There was very little difference of MET max during the work day and free day. On the other hand average heart rate and average VO2 was higher during the free day. This proves that the jobs are more mentally demanding and that during the week day the subjects' don't engage in physical activity as much as they do during the free day. This may be due to harder exercise or house hold chores during the free day. Literature states that VO2 is linear with the heart rate, meaning that as the heart rate increases the oxygen consumption increases, (S.S Hillman, 1982). When work increases, the heart rate increases and then the VO2 increases.

The average stress time was higher during the work day. However there is not the much difference in average stress time between the work day and the free day. The recording was taken during one free day.

Literature suggests that stress can still be high on the first free day. Also workers can become distressed if they are worrying about the coming work week, (Madelon et al, 2006). The relaxation time during the work day was higher than the relaxation time for the leisure day. The reason for such a low recording of the relaxation time during the leisure day is because three participants recorded zero relaxation time. Only one participant recorded higher relaxation time than stress time during the free day.

The subjects rated themselves as having high perceived fitness. When perceived fitness was compared to work ability, the subjects rated themselves as having high work ability. However, one subject who rated him or herself as having excellent perceived fitness rated his or her self lower work ability. This person works as a nurse which can be a physically demanding job. The person who rated the lowest work ability works as an office worker which is considered mentally demanding job.

Perceived fitness was compared to stress. Current media reports that physical activity should decrease stress. However the results of the cross tabulation were in conclusive. Three people who recorded that their perceived fitness as eight recorded lower stress levels, between one and three. Two of the people who recorded that their perceived fitness level as eight recorded mild stress, levels between five and seven. Three people who stated that their perceived fitness was nine recorded low stress. The other three people that reported their perceived fitness as nine, recorded mild stress levels. The one person whose perceived fitness was excellent recorded mild stress. The fitter the person is doesn't necessarily mean that there is less stress.

It has been said in studies that perceived fitness predicts coping to stress, (Plante et al., 2000). None of the subjects reported high stress. Physical activity was compared to work day and free day relaxation time or recovery time.

The people who chose eight as their fitness level recorded higher work day recovery times than the people who chose nine as their perceived fitness level. The person that perceived his or her fitness as excellent recorded only two minutes of relaxation during the work day. The results for the cross tabulations of perceived fitness and free day mental load were inconclusive. This may be due to the number of people. The cross tabulation of perceived fitness and free day physical load showed no association between perceived fitness and free day physical load.

There was a slight increase in physical load compared to the mental load. This may be due to the fact that these subjects do so many activities like physical fitness and non athletic activities. If there were more people, it would be possible to find and association between the perceived fitness and the free day mental load.

The risk factors for cardiovascular disease are obesity, high cholesterol, hypertension, physical inactivity, smoking, and stress, (Wilson et al., 1998; Hubert et al., 1983; Anderson et al., 1991; Kivimäki et al., 2002).

Stress is inevitable. Everybody experiences stress. There comes to a point when eustress becomes distress and when acute stress becomes chronic stress. There are many different environmental stressors. The main topic in this thesis is work stress. There are many different causes of work stress. The most studied models of work stress are the Karasek demand control model and Siegerist's effort and reward model. The Karasek model points out that jobs with high demands and low control increases the risk of cardiovascular disease, (Karasek and Theorell, 1990). The Siegerist model points out that when the job has high effort and low reward that it increases the risk of cardiovascular disease, (Kuper et al., 2002). These two models have been used in a number of research articles about job stress. The subjects in this study recorded higher mental load than physical load. This of course goes along with the trend that due to modern technological advances that jobs are becoming more mentally demanding, (Kouvonen A et al, 2005). The subjects only recorded that their jobs were either mentally demanding or physically demanding. The subjects also reported mild to low stress in their lives. It is unclear exactly what they considered to be stressful in the work and free day because diaries were not used. It is the way one copes with stress that determines health outcome. Some people cope with stress by eating unhealthy, smoking, and alcohol abuse which causes harm which increases the risk of morbidity and then mortality. Others cope by using physical activity. Stress is not cured by physical activity but it is a means of coping with the stress. It was mentioned earlier in this thesis that physical activity is a way to get away from the stress (Carmack et al, 1999).

It is also a way of socializing with others, and it is a way to blow off steam. Physical activity has so many benefits to the human body. It is also unknown the reason why the participants took participated in physical activity. Did they take part in physical activity to blow off steam, to get away from the stressors, or to maintain weight? There is a lot of literature regarding the effects that physical activity has on the human body. The subjects in this study had high perceived fitness. They not only participated in the marathon school they also took part in other fitness and non fitness related activities. It is safe to say that these subjects have a reduced risk of contracting cardiovascular disease, (Wannamethee and Shaper, 2002). This research is unique in that it uses both subjective self report surveys and objectives methods in measuring mental and physical load. When the various devices are collecting the data from the subject, the devices can not know the difference between stress and exercise. It is important that the researchers collect daily diaries so they will know exactly what is going on. Heart rate variability is a non-invasive technique to study the autonomic control, (Sandercock and Brodie, 2006). Heart rate variability is the interplay of the sympathetic and parasympathetic nervous system. Studies have pointed out that reduced heart rate variability is a precursor to cardiac problems, (Ramaekers D et al., 1998). The sympathetic system is the nervous system that responds to a stressor by increasing the heart rate. It prepares the body for fight or flight. The parasympathetic system prepares the body for the relaxation phase. The subjects' heart rate variability was recorded. The average low frequency was higher than the high frequency which suggests that there was sympathetic dominance. There was less stress during the free day because there was little difference between the low frequency and high frequency. Heart rate variability is a good objective technique to measure the sympathovagal balance.

The subjects may perceive that their stress levels are low but the objective heart rate variability measure will show the stress level by using the LF/HF balance. The VO2 Max is another good objective technique to measure cardio respiratory health. The VO2 max was measured in this study. The subjects' VO2 max was higher during the free day than the work day. This proves that the jobs are more mentally demanding. It also shows that the subjects engage in more physical activity during the weekends. The main limitation to this study was the number of people. Due to the lack of people it was nearly impossible to make any significant comparisons. Sometimes the modalities did not function right. It is hard to assess the job demands and efforts of the subjects. There were discrepancies with number of people using armband and wrist top computers.

Thirteen people filled out the questionnaires and took the physical fitness test at Varala. Nine people used the wrist top computers and six people used the armbands. It is also important to note possible confounding factors. Stress is not the only factor that causes ill health. First of all, some people have a type "A" personality that causes them to have a tendency to be more nervous and stressed out easier. Each individual reacts to stress different than the other person. Something that may be stressful to one person is not stressful to another person. Also nutrition plays a role in overall health of people.

The watches could only store information for one day. In this study using the heart rate alone is not efficient for detecting stress. The use of diaries would have also been helpful.

10 Conclusions

The subjects perceive themselves as having low to mild stress. They showed more mental strain during the workday than during the free day.

On the other hand they had more physical strain during the free day than during the work day. The subjects did not get that much time to recover both during the work day and the free day. They had less relaxation time during the free day than the work day.

The subjects' perceived fitness levels were high. In this thesis perceived fitness had no effect on the subjects' stress levels. The subjects with higher perceived fitness ratings had less recovery during the work day. The subjects with higher perceived fitness also rated themselves as having higher work ability. This study was interesting because it used both subjective self report and objective measures from the wrist top computer and smart belt. One could see the perceived measures and compare them to the objective measures. The only problem was that there were no diaries.

It is not known what the subjects considered to be stressful during the work day and the free day. For future studies of this nature it would be useful to have diaries with the self report questionnaires and the wrist top computers and smart belt.

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