Intensity of Physical Activity as Moderator of the Fitness-CHD Risk and Mental Health-illness Relationships

Terina McAleese
MSpEx

2017

Intensity of Physical Activity as Moderator of the Fitness-CHD Risk and Mental Health-illness Relationships

Terina McAleese

A thesis submitted to

Auckland University of Technology

in fulfilment of the requirements for the degree of Master of Sport and Exercise Science (MSpEx)

2017

School of Sport and Recreation, Faculty of Health and Environmental Sciences

Auckland University of Technology

Abstract

The aim of this study was to determine whether perceived intensity of training moderates the physical activity-health, physical activity-fitness, and fitness-health relationships. The participants (N=237) from eight different companies were assessed for participation in physical activity, cardiovascular fitness and health. Fasting blood samples, resting heart rate and blood pressure, as well as body composition measurements were taken. The YMCA three-stage cycle ergometer test was conducted and the ACSM (2010) metabolic and multi-stage equations were utilised to calculate functional capacity in METs. Physical activity was measured with two questionnaires (Sharkey index and Baecke questionnaire), that allows for comparison of relative intensity of training with absolute physical activity scores. ANCOVA and Stepwise Multiple Regression analyses were used to assess the relationships of perceived intensity of training and functional capacity with various measures of health. Perceived intensity of training had marginally moderating effects on physical activity-health (F=1.135; Eta^2=1.7% versus F=0.228; Eta^2=0.4%) and the physical activity-fitness (F=8.5; Eta^2=8.5% versus F=2.35; Eta^2=2.5%) relationships. Cardiovascular fitness (MET) contributed 9.5% (p=0.002) to the variance of a composite health score in comparison to the non-significant (p=0.470,) 1.2% contribution of intensity of training. Psychological health predicts physical health with 7.1% accuracy (odds ratio = 0.929) while the odds of being in the good physical health increased by 44.7% (odds ratio = 1.447) with 1 unit increase in cardiovascular capacity.

Key words: Perceived intensity of training; Cardiovascular fitness; Coronary risk; Metabolic syndrome; Mental Health.

Table of Contents

List of Tables

List of Figures

Table of Abbreviations

Abbreviation	Terminology
ANCOVA	Analysis of covariance
BAI	Beck Anxiety Inventory
BDI	Beck Depression Inventory
BP	Blood pressure
CAD	Coronary artery disease
CHD	Coronary heart disease
CRI	Coronary Risk Index
CV	Cardiovascular
CVD	Cardiovascular disease
CV-fitness	Cardiovascular fitness
DBP	Diastolic blood pressure
EQ-5D	The Euro Quality of Like ï 5 Dimensions
HDL	High density lipoprotein
HIIT	High intensity interval training
HR	Heart rate
HRQoL	Health Related Quality of Life
$HRSD_{17}$	The 17-item Hamilton Rating Scale
HSE	Health Survey for England
IPAQ	Interventional Physical Activity Questionnaire
IRS	Illness Rating Scale
Kcal	Kilocalorie
METs	Metabolic equivalents
MINI	Mini International Neuropsychiatric Interview
MVPA	Moderate to vigorous physical activity
PA	Physical activity
PANSS	Positive and Negative Syndrome Scale
PF	Physical fitness
PSS	Perceived Stress Scale
RPE	Rate of Perceived Exertion
SBP	Systolic blood pressure
VO_{2max}	Maximal oxygen uptake
VO_{2peak}	Highest uptake of oxygen but not the maximal oxygen uptake
WHO	World Health Organization

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signature: ________________________

Date: 09/01/2017

Acknowledgements

I would firstly like to thank my two wonderful supervisors, Lukas Dreyer and Scott Duncan, for their help over the past 2 years as I juggled my research and full time work. To Scott for his patience and willingness to help and keep things moving in the right direction. Lukas, I have enormous gratitude for your support and your immense patience, as you have been my main support through this new challenge and I wold not have completed this research if it were not for you.

To Sonja Dreyer who helped to develop me into the Clinical Exercise Physiologist I am today and for giving me the opportunity to work alongside her for the IWorkWell project.

A big thankyou to my family wo have been my main support basis throughout all my studies as well as giving me a constant reminder that I need to be studying. Without your constant support and encouragement, I would never have been where I am today and I would never have enjoyed the ride half as much as I have.

A big thank you to Sport Manawatu/Manawatu Mid-Central DHB and the businesses involved in the study without them the study would never have been possible.

Chapter 1. Introduction

More than 20 years ago, the American Health Association identified physical inactivity as the fourth primary risk factor for Coronary Artery Disease (CAD) (Fletcher et al., 1996). However, there is on-going debate concerning the measurement of physical activity (PA), and the prescription dose to optimise health benefits. Williams (2001) ignited the prescription debate with a thought-provoking meta-analysis, concluding that the formalisation of the 1996 ACSM prescription guidelines ensued from inappropriate use of cardiovascular fitness (CV-fitness) studies. The consequential guidelines demote the importance of CV-fitness, while overstating the public health benefits of moderate amounts of PA, according to Williams (2001). It is a problem that developed due to the use of fitness as a 'surrogate' for PA. A practice historically based on the assumption that fitness reflects PA patterns. Fitness measurements are considered more accurate, while measurement of PA continues to be an elusive concept.

Various PA questionnaires have been developed and tested for validity and reliability over the years (Helmerhorst, Brage, Warren, Besson, & Ekelund, 2012; Strath et al., 2013). The majority correlate relatively poorly ($r = 0.27$-0.56) with measures of CV-fitness (Defina et al., 2015; Shephard, 2002; Warren et al., 2010; Williams, 2001). Most of these questionnaires are absolute scales that calibrate the intensity of activity based on effort required by healthy, young to middle-aged adults. The International Physical Activity Questionnaire (IPAQ), generally considered the gold-standard measuring tool, for instance, expresses PA in absolute terms as metabolic equivalents (MET) minutes per week. The IPAQ calculates MET minutes per week by multiplying fixed MET-values for walking (3.3 MET), moderate (4.0 MET) and vigorous activity (8.0 MET) with minutes (duration), and days (frequency) of activity. This process ignores the fact that relative intensity of effort required for the same activity changes as one moves across the physical fitness (PF) spectrum.

An increasing amount of studies have started to emphasise the importance of relative intensity of training in terms of health, fitness and measuring of PA (Defina et al., 2015; Franklin, 2007; Kemi & Wisloff, 2010; Ramos, Dalleck, Tjønna, Beetham, & Coombes, 2015; Rhen, Winett, Wisloff, & Rognmo, 2013; Swain, 2005). Lee, Sesso, Oguma, and Paffenbarger (2003), for example, found an inverse relationship between relative perceived intensity of PA and coronary heart disease (CHD) risk in older men. The fact that this applied even among those not satisfying current PA recommendations, endorse the importance of relative perceived intensity of training.

1.1 Not enough focus on training intensity

A mounting body of evidence has highlighted the importance of intensity of training as the most important factor in regards to ascertaining health benefits (Cornelissen, Arnout, Holvoet, & Fagard, 2009; Garber et al., 2011; Gibala, Little, MacDonald, & Hawley, 2012; Warburton, Nicol, & Bredin, 2006). This is backed-up with exercise intervention studies and the few studies that reported volume or duration of training to be as important as intensity was flawed by lack of re-prescription (O'Donovan et al., 2005). It is fascinating therefore that none of the activity versus fitness studies seemed to have honed in on perceived exertion during habitual PA when correlating PA and CV-fitness measures.

To be effective in terms of lowering risk and improving fitness exercise should drive/challenge the cardiovascular (CV) system. Lee et al. (2003) for example found an inverse relationship between relative intensity of PA as measured by an individualọs perceived exertion and CHD risk in older men, even among those not satisfying current activity recommendations. During rehabilitation, fitness improvements in the very unfit are often obtained with very low workloads such as 30 to 50 watts as long as the set workload pushes the client up to a symptom limit aerobic threshold. Establishing a CV challenge therefore seems to be crucial and might be more important than the wattage or overall workload/volume.

The Borg perceived exertion (RPE) scale is an established measuring tool in rehabilitation settings and has been proven to be an accurate, reliable and valid measure of true exertion (Borg, 1998). It seems reasonable therefore to explore whether perceived hardness of exercise might reveal better correlations with fitness and coronary risk factors/health than overall PA scores as obtained with questionnaires.

A major problem with PA questionnaires is that the impact of perceived hardness (intensity) is ócontaminatedô by duration and frequency measures in the process of calculating overall scores. This ócontaminationô of perceived intensity might be the reason why PA questionnaires correlate poorly with CV-fitness, they believe the true correlations between fitness and habitual PA to be considerably higher than reflected in the studies used by Williams (2001) in his meta-analysis.

A more complete evaluation of the role of exercise intensity on the relationship of PA and fitness with CV risk and health is required according to Blair and Jackson (2001). Warren et al. (2010) opinionated that the perfect tool to measure PA does not exist; selection of questionnaires/measuring instruments must be based on careful consideration of pros and cons and supported by well thought out research questions. In the current study, special emphasis will be given to the role of intensity of exercise and PA questionnaires were selected with that purpose in mind.

1.2 Contaminating influence of psychological health

The optimal intensity and amount of exercise necessary for reduction of risk factors is largely unknown and differs from one risk factor to the next. Finding the optimal exercise prescription dose is complicated by the fact that the various risk factors respond differently on diverse training permutations. Some require high intensity exercise while others respond well to longer duration low intensity exercise. Constructs of psychological health, for instance, respond positively to moderate amounts of exercise and seem to impact on health independent from level of fitness or participation in PA (Stathopoulou, Powers, Berry, Smits, & Otto, 2006; Teychenne, Ball, & Salmon, 2008). The potential impact of psychological health on the intricate fitness/PA/health-relationships has not been thoroughly investigated. Psychological distress as a precursor of cardiac risk, CV disease and CV reactivity has recently received much attention; the general conclusion is that psychological distress is a health concern of utmost importance (Bergh, Udumyan, Fall, Almroth, & Montgomery, 2015; Biddle & Mutrie, 2008; Cezaretto et al., 2015). The prevailing theory is that chronic psychological distress leads to higher allostatic load and the clustering of the traditional coronary risk factors such as blood pressure (BP), waist/hip ratio, and percentage body fat, total cholesterol/high density lipoprotein (HDL) ratio and glucose intolerance (Bergh et al., 2015; Cezaretto et al., 2015). Psychological distress has, in particular, been linked to abdominal obesity and insulin resistance (metabolic syndrome) which both seems to be instrumental with regard to the clustering of risk factors (Epel et al., 2000; Kinder, Carnethon, Palaniappan, King, & Fortmann, 2004).

Limited information is available on the relationships between psychological health, fitness and cardiac risk profiles of the general workforce in New Zealand. Further, there is scarcity of scientific studies on the intricate relationship between psychological health, certain morphological variables such as abdominal obesity, and markers of psychological distress and coronary risk. The optimal dose and relative importance of intensity of exercise required for reduction of risk factors in the presence of psychological distress is largely unknown. There is also a dearth of research examining habitual physical exercise and PF as moderators of the stress-illness and or the stress-coronary-heart-disease-risk relations. Carmack, Boudreaux, Amaral-Melendez, Brantley, and de Moor (1999) found that participation in leisure PA as opposed to level of fitness provides a stress-illness buffering effect. Both moderate and high intensity exercise show a clear illness buffering effect ï with high intensity being significantly better than low intensity- against stress (measured as major and minor events) but not against depression (Carmack et al., 1999). Dreyer, Dreyer, and Rankin (2012) reduced the CV risks profiles of College staff with psychological burnout, multiple coronary risk factors and elevated waist-hip ratio with high intensity exercise within 10-weeks. The researchers concluded that the results had much to do with the careful/closely monitoring of training sessions to ensure consistent high intensity training over the 10-weeks. It is unclear whether similar results can be obtained with moderate and high intensity self-managed habitual physical exercise. The impact of psychological resourcefulness on the relationships between physical exercise, PF, morphological variables and the traditional coronary risk factors has also not really been investigated. Kobasa (1979) found that psychologically resourceful people flourish on stress and that their psychological constitution provides the same buffering affect against illness as regular physical exercise. It is unclear whether that applies to the coronary risk factors and whether level of PF and intensity of physical training will negate or strengthen the buffering value of psychological resourcefulness.

1.3 Research problem and purpose

The current study proposes that the amalgamation of perceived intensity, duration and frequency into one overall absolute PA score impact negatively on the prediction (CV-fitness and health) qualities of PA questionnaires. It is postulated in the current study that when measuring PA, using a relative scale, like the RPE and Pain Scale, to gauge the intensity of activity would be more appropriate than absolute scales. Surprisingly, there is a limited amount of published data examining the associations of relative measures of perceived intensity of training with CV-fitness and measures of health. The aim of this study is to investigate the interrelationships between PA, PF, CHD risk and psychological health measures by utilizing instruments that distinguish between leisure, sport and work activity and which provides separate scores for intensity, duration and frequency of exercise.

This study consequently focuses on relative perceived intensity of exercise as moderator of health and fitness. Relative and absolute measures of PA were used to study the inter-relationships between PA, PF, psychological constructs and health.

The aims of this study were to:

1. Compare the associations among PA (relative and absolute constructs), functional capacity, and measures of physical, and CV health;
2. Determine whether the associations between psychological health and measures of health are moderated or mediated by CV-fitness and intensity of physical training.

Chapter 2: Literature Review
Intensity of training as predictor of physical fitness and health

2.1 Introduction

In this chapter the scientific literature reporting on the interactions between PA, fitness and health are discussed, with specific focus, on intensity of training.

This chapter starts with a short outline of the main concepts under investigation, namely PF, PA and health. A tabulated summary of studies reporting on PA, fitness and physical health are then discussed.

2.2 Definition of physical activity

The most popular and widely cited definition of PA was published by Caspersen and colleagues (Powell & Christenson) in 1985, PA is defined as any bodily movement produced by skeletal muscles that result in energy expenditure measured in kilocalories (kcal).

2.2.1 Physical activity questionnaire measuring issues

Physical activity is a complex concept that is determined by different indicators/subcomponents separately (e.g. frequency which refers to the ónumber of events of PA during a specific time periodö, duration which refers to the ótime of participation of a single bout of PAö, intensity which refers to the psychological effort associated with participation in a special type of PAö) or in combination. This is further complicated by different types of PA such as leisure, sport and on-job PA. Assessment of PA ï primarily assessed through questionnaire based quantification of the mentioned subcomponents ī is fraught with difficulties as it is multidimensional, and no single method can capture all subcomponents and domains in the activity of interest.

The IPAQ is widely considered the gold-standard PA questionnaire. The IPAQ questionnaire classifies all activity as either low, moderate or vigorous and not on a relative intensity continuum like the RPE scale. Metabolic equivalents (METs) for walking and activities perceived to be moderate and vigorous are multiplied by days and minutes in the process of calculating MET/minute/week scores. In this way job, transportation, domestic, and sport/recreation physical activities are expressed in absolute terms as MET/minutes/week (IPAQ, 2005). Defining intensity using an absolute scale in METs may be limited because it neglects variations in PF. In terms of the aims of the current study, the IPAQ scores were consequently considered 'contaminated' by fitness level, as well as by duration and frequency of training.

Shephard (2002) published an article ñLimits to the improvement of PA by questionnaireò and Vanhees et al. (2005) published a review on how to assess PA and PF. After reviewing the pros and cons of criterion, objective and subjective measures of PA the above-mentioned authors concluded that questionnaires still remain the cheapest, easiest and -although not the most accurate- the most popular and practical way to measure PA. In a comprehensive review Helmerhorst et al. (2012) investigated the validity and reliability of PA questionnaires developed over the last 15 years. Physical activity questionnaires were classed for validity and reliability against older questionnaires. They also evaluated the questionnaires accuracy to estimate total energy expenditure as an outcome measure. The researchers exposed some problems with total energy expenditure as criterion for validation and stated that time spent in different intensities of exercise might be more appropriate as criterion method. They emphasize the importance of accurate assessment of intensity levels as part of improving the validity of PA questionnaires. Strath et al. (2013) published a guide to the assessment of PA and stated that there is no single best instrument appropriate for every situation.

Questionnaires remains the cheapest, easiest and ī although not the most accurate ī the most popular and practical way to measure PA.

2.2.2 Physical fitness

To date there is no universally agreed upon definition of PF in the literature. The World Health Organisation (WHO) defined fitness as ñthe ability to perform muscular work satisfactorilyò (WHO, 1968). Fitness implies that the individual has attained those characteristics that permit an acceptable performance of a given physical task in a specified physical, social and psychological environment (Bouchard, Blair, & Haskell, 2012). Physical fitness can be further broken down into health-related fitness and skill related fitness. For the purpose of this study more emphasis will be put on health-related fitness.

Health-related fitness has been defined as state characterised by an ability to perform daily activities with vigour and by traits and capacities that are associated with low risk for development of chronic diseases and premature death (Patte, 1988). Shephard and Bouchard (1994) and Caspersen, Powell, and Christenson (1985) however broadened the definition of health-related fitness by referring to the morphological, muscular, motor, CV and metabolic components that make up health-related fitness. The underlying functional capabilities of CV endurance, muscular strength and mobility are in varying degrees a result of genetics the stage in lifespan as well as the PA levels of an individual (Biddle, Fox, & Boutcher, 2003). The development of health-related fitness components has been related to specific increase in ôhealthô and a decrease in disease outcomes such as morbidity and mortality statistics. Pate (1988) has argued that ôPFô should be defined solely in terms of health-related aspects by stating that fitness should refer to the functional capacities required for comfortable and productive involvement of day-to-day activities and should encompass manifestations of the health-related outcomes associated with high levels of habitual activity.

2.2.3 Fitness and health

The CV health benefits of PA and cardiorespiratory fitness are well established and are not only associated with lower cardiovascular disease (CVD) morbidity but also with lower prevalence of risk factors for CVD such as hypertension, selected dyslipidemias and diabetes (Committee, 2008). Research that has started as early as the 1980ôs has reported inverse associations between cardiorespiratory fitness and all-cause as well as CVD mortality in different populations in both young and old men and women (Blair et al., 1989). A review by Myers et al. (2015) concluded that no matter what an individual's health status, higher levels of PA and cardiorespiratory fitness improve the overall CVD risk profile. They recommend using exercise as medicine given the poor outcomes associated with low cardiorespiratory fitness and physical inactivity.

The accepted standard to measure cardiorespiratory fitness is maximal oxygen uptake (VO_{2max}). Direct measurement is considered the golden standard and is used majority for clinical settings and research (ACSM, 2010, 2013). VO_{2peak} is another measurement often used in lieu of VO_{2max}; it measures the highest rate of oxygen consumption achieved and is used when sedentary adults and cardiac patients are unable to reach their physiological maximum at point of maximum volitional fatigue and discomfort preventing them from reaching their true VO_{2max} (Buskirk & Taylor, 1957). Due to the high cost of equipment and expertise needed to run direct testing a variety of submaximal and maximal testing can be used to estimate VO_{2max}.

Research into genetic determinants of cardiorespiratory fitness indicate that a wide variety of genes may influence a personœ VO_{2max}. A change as large as 40%ï 50% can occur in VO_{2max} in response to endurance exercise training (Bouchard et al., 1999). O'Donovan et al. (2005) indicated a relationship between higher fitness levels and high intensity training.

2.3 Defining training dose

The American Heart Association identified physical inactivity as the fourth major modifiable CHD risk factors in 1992 (Fletcher et al., 1996). In that report the health value of moderate amounts and intensities of exercise was recognized and emphasized. This culminated in intensified attempts to define/formalize the dose-prescription; exactly how much activity is required to produce health benefits. The National Institutes of Health consensus development conference stated in 1996 that: ñThe most active individuals have lower CV morbidity and mortality rates than those who are least active; however, much of the benefits appear to be accounted for by comparing the least active individuals to those who are moderately activeò (Health, 1996).

The dose-response relationship has been a research topic for the last 40 years. As indicated in the introduction chapter 1 Williams (2001) have reignited this discussion with his thought proving publication.

2.3.1 Training intensity as a new focus in physical activity studies

As indicated in Chapter 1 there seems to be a mounting body of evidence suggesting that intensity of training is the most important factor in regards to ascertaining health benefits. This is backed-up with exercise intervention studies that reported volume or duration of training to be as important as intensity which were flawed by lack of re-prescription (O'Donovan et al., 2005). As mentioned it is fascinating therefore that none of the activity versus fitness studies seemed to have honed in on perceived exertion during habitual PA when correlating PA and CV-fitness measures.

The rest of this chapter is a discussion of studies that have reported on the relationships of both CV-fitness and intensity of physical training with measures of health.

2.4 Intensity of training, physical fitness and health

This section is a discussion of the studies summarized in Table 2.1. Six experimental and four cross-sectional studies explored the intensity fitness relationship with various measures of health/coronary risk which are listed in Table 2.1.

Of the six experimental studies two studies compared high intensity interval training with continuous training using similar methodology. Both studies (Conraads et al., 2014; Wisløff et al., 2007) studies compared 12 weeks of aerobic interval training (4 minute periods at 90 ï 95% of peak heart rate (HR) for a total of 38 minutes) against continuous training (70-75% of peak HR for 47 minutes). Conraads et al. (2014) studied 200 CAD patients with outcome measures of peripheral endothelial function, CVD risk factors and Quality of life. Wisloff et al. (2007) studied the same effects on 27 post infarction heart failure patients with an ejection fraction lower than 40%. The outcome measures were left ventricular remodelling, aerobic capacity, endothelial function and quality of life. Their results concluded that interval training was superior to continuous training on all outcomes measures. In contrast Conraads et al. (2014) reported no statistical significant difference between interval and continuous training. No effect was shown with regards to respective effects on VO_{2peak}, peripheral endothelial function, quality of life and some CVD risk factors. One of the contributing factors was that 4 minutes of high intensity interval cycle ergometer was not sustainable in their CVD clients. Therefore, this was not a feasible intervention for these patients. Wisloff et al. (2007) reported no problems with regard to the sustainment of the 4-minute treadmill intervals in his respondents. The heart failure patients did exhibit larger increases in VO_{2peak} after the interval training (in comparison to the continuous training) which may be explained by the comparative lower initial baseline values for the subject pool.

Four studies investigated the effect of vigorous (interval) and moderate (continuous training) on markers of metabolic syndrome and CVD risk factors such as blood lipids and BP. These studies show more or less similar results.

Martin et al. (2013) investigated the effect of a 12-week cardiac rehabilitation training programme on men and women (18 + years) with CVD. A peak graded exercise test (GXT) on a treadmill was used to determine peak METs and patients were split into low fitness (<5 METs) moderate fitness (5-8 METs) and high fitness (>8METs) categories. Supervised exercise sessions were performed twice weekly with 2-3 days encouraged self-training and one resistance training day. After completion of the 12-week program, all the subgroups evidenced significant improvement in CV-capacity measures. Those starting in the low fit category (1.41 METs/39% improvement) showed the largest improvement with lesser improvements in the moderate fit (0.01/15% METs) and high fit (0.80/8.6%) patients (P<.0.001). Relative to the low fit group, patients classified as moderately fit and highly fit had progressively lower overall mortality risk. The low fit category had the highest prevalence of comorbid illnesses, including diabetes, hypertension, heart failure, and peripheral vascular disease. Overall the participants showed a 13% reduction in mortality with each 1 MET improvement in CV-fitness over 12-weeks. This result was not dependent on starting levels of fitness as those who started in the low fitness group showed the largest (30% per 1 MET improvement in fitness) reduction in overall mortality. The authors emphasized that this finding signified that the low fit group did not need to attain the same level of fitness as the high fit group to secure reduced mortality risk.

Katzmarzyk, Church, and Blair (2004) studied the relationships between cardiorespiratory capacity/fitness and coronary risk in healthy white men (aged 20 ï 83 years) with and without the metabolic syndrome. A max treadmill test (Balke protocol) was used to determine cardiorespiratory fitness calculated in METs. Men in the middle and lower fitness groups had a higher risk of all-cause-mortality and higher risk of CVD mortality than those with high fitness. Fit men within each metabolic syndrome category had a better metabolic fitness profile (significantly lower waist circumference, lower triglycerides and plasma glucose levels, and higher HDL-C levels) than unfit men. Those with metabolic syndrome were 1.29 times more likely to die of any cause and 1.89 times more likely to die of CVD than healthy men. The general findings were that higher levels of CV-fitness reduced the over-all death rates in men with a high metabolic syndrome risk score. A clear dose-response relationship was shown between CV-fitness and mortality in men with the metabolic syndrome.

Cornelissen et al. (2009) conducted a study on healthy sedentary men and women (55 years +) with some CV risk factors like hypertension. The study consisted of a randomized cross-over design comprising of two 10-week training periods with a 10-week wash-out period in the middle. Group 1 started with 10-weeks low intensity training and then did 10 weeks high intensity training after the 10-week wash-out period. Group 2 did it the other way around (high intensity training followed low intensity training). The outcome measures were changes in BP, HR and risk factors such as blood lipids (total cholesterol, HDL, Low density lipoprotein (LDL) and total cholesterol/HDL ratio), anthropometric measurements (weight, body mass index (BMI), percentage body fat and waist circumference) and CV-fitness. Low intensity training was set at 33% of heart rate reserve and higher intensity at 66% of heart rate reserve. Participants exercised three times a week under supervision for 60 minutes with activities that could be incorporated into daily life. Activities included stationary cycling, stepping and walking/jogging on the treadmill. In terms of BP, the study found similar reductions in systolic blood pressure (SBP) and HR at both intensities with diastolic blood pressure (DBP) changes being dependent on high intensity training. Significant changes in body composition (BMI and body fat) as well the blood lipids were very much dependent on high intensity training. Both intensities (low and high) resulted significant improvements in cardiorespiratory fitness but higher intensity training manifested a 38% larger improvement.

A study by Kim, Oberman, Fletcher, and Lee (2001) measured the effects of high intensity training compared to low intensity training on blood lipids in men with CHD. Participants were men (age 30 ï 67 years) who had angiographic evidence of stenosis of 70% or higher in a major coronary vessel, diagnostic increases in blood enzyme activity, coronary artery bypass grafting, or percutaneous transluminal coronary angioplasty. A symptom or sign-limited maximal exercise test (Bruce protocol) was used to assess CV-capacity. Participants were randomly assigned to training groups of low intensity (50% of VO_{2max}) or high intensity (85% of VO_{2max}). All exercise sessions were medically supervised and consisted of 1 hour sessions 3 days per week consisting of 35 minutes of activity of walking/or jogging with 15 minutesôstationary biking and 5 minutes of warm up and cool down. Participants attended the study for 6 ï 12 months; high intensity and low intensity training had similar effects on blood lipids. Triglyceride levels decreased in both groups, but were only statistically significant ($p<0.05$) in the high intensity training group at the 12-month mark. Training attendance was highly and significantly related to decreasing LDL-to-HDL cholesterol and total-to-HDL cholesterol ratios over the 6 month to 12-month period. Training attendance rates also impacted significantly on HDL cholesterol which increased from baseline at 6 and 12 months. An important note was that participants in the low intensity group exercised above the recommended 50% and the high intensity group struggled to train at 85% of VO_{2max}.

Four cross-sectional studies investigated the intensity of PA (Low, Moderate Vigorous) on the Metabolic Syndrome and Overall Mortality.

Sassen et al. (2009) separated the individual components (intensity, duration and volume) of PA and investigated their respective inter-relationship with CV-capacity and metabolic syndrome. Subjects consisted of police employeeės (ages 18 ï 64 years) and the Adult Treatment Panel III (ATP III) definition was used to risk stratify their metabolic syndrome risk level. Physical fitness was assessed via direct method using cycle ergometers (20 watt increases until volitional exhaustion) to obtain VO_{2peak}. Physical activity was measured in METs using the IPAQ short Questionnaire. Clients were then placed into PA categories, low MET-hours (<4 METs), mod MET hours (4ï 6 METs) and high MET hours (>6 METs). Results revealed that participants with more than 3 CVD risk factors had a significantly lower intensity and less overall high intensity hours in comparison with individuals with only one CVD risk factors. VO_{2peak} showed an inverse relationship (positive for HDL-cholesterol) with the total CVD risk score and with each of the individual risk factors, except fasting glucose. Both PA and PF also showed a significant inverse association with the clustering of risk factors associated with metabolic syndrome. VO_{2peak} explained 78ï 93% of the total variance in high intensity PA and consequently made a large contribution to the relationships between PA and the overall risk score. The authors concluded that although PA and PF both had a risk factors lowering effect, PF was more important than PA.

Janssen and Ross (2012) compared moderate and vigorous intensity PA in USA adultės (ages 18 ï 62 years) with the metabolic syndrome. Physical activity was measured directly with accelerometers that were worn for 7 consecutive days. Metabolic equivalents were then calculated in the respondents who were placed in PA groups based on the intensity thresholds from the WHO guidelines. Results indicated that the odds of having metabolic syndrome where significantly lower in the very active groups as compared to the inactive groups. Both moderate and vigorous PA were independently associated with the metabolic syndrome risk. Achieving 150 min/week of moderate PA or 75 min/week of vigorous PA significantly reduced chronic disease risk. Vigorous PA (75 min/week) was associated with a 2.4-fold lower prevalence of metabolic syndrome risk. In essence shorter workout periods at a high intensity produced superior reduction of health risk.

Myers et al. (2004) compared contributions of fitness and PA levels on All-cause Mortality of men (aged 59 $\pm$ 11 years). They found that individuals with both a higher exercise capacity (<5

METs vs >5 METs) and higher PA level (PA no activity reported vs >2000 kcal/wk) had a larger (above 50%) survival rate. Those reporting no participation in PA in comparison with the relatively fit subjects ī had a 55% higher mortality risk. No deaths occurred amongst subjects who were both physically active (>150 kcal/wk) and fit (>10 METs). A 72% reduction was observed between the most and least fit subjects. Exercise capacity was a stronger predictor of mortality than habitual PA.

Hu et al. (2015) researched the effects of low, moderate and high PA intensities on the metabolic syndrome from 2009 ï 2011 in the middle-aged (40 -60 years) Chinese population. The IPAQ questionnaire was used to place participants into low, moderate or high intensity categories. A total of 8,750 participants were included in the study with 30.4% of subjects having metabolic syndrome and 11.3% of subjects having low PA in both the metabolic syndrome and non-metabolic syndrome groups. Risk factors (Age, BMI, SBP, DBP, fasting plasma glucose, and triglycerides) were higher in metabolic syndrome clients as compared to non-metabolic syndrome clients. The average weekly expenditure was 2,700 METs for non-metabolic syndrome clients and 2,529 for metabolic syndrome clients. Metabolic syndrome risk was 18.3% lower in the moderate and vigorous PA groups but no protective benefits were shown with moderate activity alone. Vigorous activity however reduced the risk of metabolic syndrome by approximately 11%.

2.5 Summary

The relative importance of CV-fitness and PA as protectors or intervention modalities against CV-risk seems to be well established. The aim of most studies were generally to investigate the protective value of exercise. Very few studies were specifically designed to contrast/compare the relative protective effect of high intensity exercise with that of CV-fitness. High intensity exercise and CV-fitness are still often discussed and treated as synonymous concepts. However, an increasing number of studies are starting to reflect, as part of statistical analysis of data, on the individual importance of the components of fitness and CV-fitness as markers of health. The interrelationships between high intensity physical exercise and CV-fitness does complicate the issue. The consensus seems to be that high intensity training is important with regards to both improving exercise capacity and lowering CV-risk. Cardiovascular fitness however outperformed high intensity training as an indicator of CV-risk in the majority of studies summarized in Table 2.1.

Table 2.1. Summary of studies investigating the relationships of physical activity and cardiorespiratory fitness with mortality, cardiovascular risk and markers of metabolic syndrome

Author	Year	Type	Respondents	Dependent Variables	Independent Variables	Results
Conraads, Pattyn, De Maeyer, Beckers, Coeckelberghs etc	2014	Experimental Study	Age: 40 ï 75 years Males & Females 200 CAD patients referred for cardiac rehabilitation 180 males, 20 female	Peak VO_{2max} GXT 20w + 20 w/min 10w + 10 w/min bicycle Peripheral endothelial function, CVD risk factors QoL (SF-12)	HIIT 90-95% peak HR Moderate intensity training 70 ï 75% peak heart rate 3 x week for 12-week bicycle, 4 minute intervals	12-week intervention equally improved peak VO_{2peak}, peripheral endothelial function, quality of life and some CVD risk factors,
Cornelissen, Arnout, Holowoet, Fagard	2009	Experimental study	Age 55 ï 71 years Males & Females 39 total clients with, normal, high normal or grade 1 hypertension	CVD risk factors Blood pressure Resting office BP, SBP 120mmHg or DBP 80mmHg no inclusion of high to very high CVD risk	3 x 10-week period w/sedentary period in between: Low ï sed. ï high intensity Or High-sed.-low intensity: Training 3 x week 60min per session. Daily activities ï Walking/jogging on treadmill, stationary cycling and stepping. Lower intensity 33% or higher 66% of heart rate reserve or of	Both low and high intensity reduced office and exercise SBP to a similar extent but DBP was slightly more noticeable with higher intensity. Low intensity increased fitness levels but was less effective when compared with high intensity training.
Hu, Liu, Wang, Yin, Yu, Zhang, Wu, Chen, Zheng, Feng	2015	Cross-sectional (2009 ï 2011)	Age 40 - 60 years Males and Females 8,750 Chinese population	Metabolic syndrome: BMI height, weight, waist, hip circumference, HR, BP, anthropometric measures, Blood samples, The International Diabetes Federation 2005 was used to define metabolic syndrome: central obesity (WC >90 cm for Asia males or >80 cm for Asia females) combined >2 risk factors: serum TG of >1665mmol/L; HDL <1.04mmol/L in males or <1.3mmol/L in females; BP of >130/85 mmHg; or serum glucose of >5.6mmol/L.	Face to face interviews (respondentôs health and lifestyle) IPAQ questionnaire (domestic & gardening activities, transport related activities, leisure time PA & work related PA measured in METs). Categories were used to classify PA (low, moderate or high intensity)	Metabolic syndrome associated with PA was lower with vigorous PA than with moderate PA. Protective effects of moderate PA on MS were not found. Vigorous PA has a beneficial effect on metabolic syndrome in the middle-aged Chinese population, and reduced the risk of metabolic syndrome by approximately 11%.

Jassen, Ross	2012	Cross-sectional (2003 ï 2006)	Age 20-64 1841 Males & Females U.S adultôs participants	Metabolic syndrome (2009 Joint interim Societies definition). Risk Factors that increases CVD, diabetes and all-cause mortality risk. > 3 risk factor: high waist circumference (men >94cm, female >80cm) high TGs (1.7mmol/l) low HDL (men <1.0mmol/l, female (<1.3mmol/l) elevated BP (SBP >130mmHg, DBP >85mmHg) & elevated glucose (>5.6mmol/L).	Accelerometers worn for 7 days. Moderate PA 150 min/week ï 3.0-5.99 METS, Vigorous PA 75 min/week ï >6.0 METS Four groups for MVPA. Inactive 0-249 MET min/week, somewhat active 250-499 MET min/week, Active 500-999 MET min/week, very active >1000 MET min/week (cut-points based on their equivalence to PA guidelines)	Vigorous PA was independently related to all components of the metabolic syndrome with the exception of high glucose. The odds of having metabolic syndrome decreased when moving from inactive through to very active. Vigorous PA (75 min/week) was more effective than 150 min/week of moderate PA on the metabolic syndrome.
Katzmarzyk, Church, Blair	2004	Experimental Study	Age 20 ï 83 years 19 223 males (well-educated professional non-Hispanic whites, clinical evaluation 1979 ï 1995) Healthy Men and Men with Metabolic Syndrome	Metabolic syndrome: ATP III definition, >3 more risk factors: High BP, (SBP >130 mmHg, DBP >85mmHG), central obesity (WC >102cm), high triglyceride levels (>1.69mmol/L) low HDL (<1.04mmol/L); and high fasting plasma glucose level (>6.1mmol/L) Mortality: determined by death or December 31, 1996 for survivors. Medical history questionnaire	Cardiorespiratory fitness: Max treadmill exercise test w/modified Bruce protocol to exhaustion. VO2max measured in METs from Bruce protocol. Age adjusted maximum METs were used to determine Unfit group ï bottom 20% Fit group ï upper 80%	A doseï response relationship was shown between cardiorespiratory fitness and mortality in men with metabolic syndrome. Fit men had a better metabolic fitness profile than unfit men. Metabolic syndrome death rates were greatly reduced by cardiovascular fitness.
Kim, Oberman, Fletcher, Lee	2001	Experimental study 6 ï 12 months	Age 30 ï 67 Men 185 participants predominantly middle aged white men.	Coronary Heart disease Fasting blood lipids, total cholesterol, HDL cholesterol, TGs levels	Maximal exercise test (symptom/sign-limited Bruce protocol to determine VO_{2max}) Supervised 1 hour sessions 3 x week. Low intensity 50% $VO_{2max.}$ Duration increased from 40 ï 60 mins over 2 weeks. High-intensity (85% of VO_{2max}) Duration increased from 40 ï 60 mins over 3-week period.	LDL & HDL levels increased slightly for both groups at 6 & 12 months after intervention. Triglyceride levels decreased for both groups but the only significant decrease was at 12 months in high intensity ($p<0.05$). Exercise frequency seemed more important than intensity for favourably influencing cholesterol levels.

Martin, Arena, Haykowsky, Hauer, Austford, Knudtson, Aggarwal, Stone	2013	Experimental study	Age: 18 + 5641 patients (4282 males, 1359 females) Diagnosed with Cardiovascular disease (CAD participants who underwent coronary angiography)	Metabolic syndrome (Harmonised definition) >3 more risk factors: elevated waist circumference, triglyceride levels >150mg/dL high-density lipoprotein men <40mg/dL, <50 mg/dL, women high cholesterol BP: SBP >130 mmHg DBP .85 mmHg HBA1c >6.0% or receiving treatment for any of the above All-Cause Mortality Follow up at 1 year	Peak GXT treadmill to determine peak METs before and after 12-week programme. Low fitness (<5 METs) Mod fitness (5-8 METs) High fitness (>8 METs) Supervised 12-week Cardiorespiratory programme 2 x week. Aerobic target HR ï associated MET level, 12 ï 14 on Borg scale. Stretching and resistance training 1 x week. Self-training 2 ï 3 x week	A strong association between fitness and the presence of the metabolic syndrome. Patients with moderate Fit and High Fit had a progressively lower overall mortality risk. Improvements in cardiorespiratory fitness during cardiorespiratory fitness were associated with significant reduced mortality. Increasing Low fit patientõs baseline levels increases functional capacity lowering mortality risk.
Myers, Kaykha, George, Abella, Zaheer, Lear, Yamazaki, Froelicher	2004	Cross-sectional (April 1987 ï July 2000)	Age 59 ± 11 years 6213, Males	All-cause mortality Clinical history, listings of medication & risk factors ï Computerized forms (standard definitions of clinical conditions and exercise response).	Self-administered PA Questionnaire (Harvard Alumni studies of Paffenbarger and colleagues). Symptom-limited treadmill test with standardized graded or individualized ramp protocol 8 ï 12 minutes of maximal exercise	Fitness was a stronger predictor of mortality than activity patterns and exercise capacity was a stronger predictor of mortality than measures of adulthood habitual PA. A strong gradient was shown for the reduction in mortality as PA increased. Approximately 40% of the reduction in total mortality occurred between the least fit or least active groups

Sassen, Cornelissen, Kiers, Wittink, Kok, Vanhees	2009	Cross-sectional 2003-2004 and 2005-2006 U.S National Health and Nutrition Examination Survey	Ages 18 ï 62 years - 1298 police employees (874 male and 424 female)	Cardiovascular disease CVD Risk Factors, metabolic syndrome: ATP III definition >3 Risk factors: central obesity (men: WC >102cm; female: >88cm); high BP (SBP >130mmHg, DBP >85mmHg); low HDL (HDL, men <1.03mmol/l; females <1.30mmol/l); high triglycerides (>1.70mmol/l) high blood glucose (>6.1mmol/l) Drug treatment for any of the above	PF, peak oxygen uptake (VO_2 peak) 20w + 20 w/min PA, Short QUestionnaire to Assess Health-enhancing PA calculated via METs PA MET-hours low (<4 METs), PA MET hours moderate (4ï 6 METs), PA MET-hours high (>6 METs).	In comparison with PA, PF had an important significant inverse association with the overall CVD risk score and with each of its individual components, except glucose. Although PA and PF both have a CVD RF lowering effect, PF seems more important in the relationship compared with PA. This proposes that PA should preferably increase VO_{2peak} to maximally influence CVD risk factors.
Wisloff Stoylen, Lonnechen, Buvold, Rognmo, Haram, Tjonna, Helgerud, Slordahl, Lee, Videm, Bye, Smith, Najjar, Ellingsen, Skjaerpe	2007	Experimental Study	Age 75.5 ï 11.1 years 27 Norway patients	Post infarction heart failure ejection fraction <40% VO_2 peak individualized treadmill ramp protocol. Quality of life self-administered McNew Questionnaire	Interval high intensity 38min 4 mins 90 ï 95% peak HR with 3 min active recovery. Continuous moderate 47 mins 70 ï 75% peak HR Treadmill 2 x supervised 1 individual training session Control group supervised 1 x every 3 weeks	High intensity was superior to moderate intensity in patients with post infarction heart failure in regards to reversal of left ventricular remodelling, aerobic capacity, endothelial function and quality of life.

Chapter 3. Literature Review
Physical activity, physical fitness and mental health

3.1 Introduction

The major aim of this study is to explore the relationships of PA and PF with physical and mental health. This section of the literature review focuses on mental health with specific emphasis with how it relates with PA and fitness. This section starts consequently with a brief description of mental health and mental illness. This is followed with a short discussion of measuring issues in metal health studies. Recent studies that explored/investigated the mental health, PA and PF relationships were then summarized in a Table 3.1 and discussed.

3.2 Definitions of mental health

3.2.1 Mental Health Definition

The WHO defined mental health as a state of well-being in which the individual realises his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community (Kohl & Murray, 2012; WHO, 2004). Mental wellbeing is regarded as synonymous with positive mental health. Mental health has been increasingly recognised as an important component of health (WHO, 2011) and has a central place in global public health according to Herrman and Jané-Llopis (2012).

3.2.2 Mental Illness Definition

Mental illness encompasses a variety of disorders and diseases including the severe and enduring mental illnesses like bipolar disorder and schizophrenia, the common mental illnesses - depression and anxiety, and disorders of functioning like personality disorder, autism and, in old, age dementia (Kohl & Murray, 2012). These problems represent a significant disease burden in the community with one in six New Zealand adults (16%) having been diagnosed with both severe and common mental disorders. Mental illness is the third-leading cause of health loss (11.1%) for New Zealanders (Mental Health Foundation, 2014).

There are strong interconnections between mental and physical health and behaviour (Herrman & Jané-Llopis, 2012). In the New Zealandös Sovereign Wellbeing Index study small increases in PA coincided with better mental health. Those who engaged in high levels of exercise had a 9.1% higher mean mental health score compared with those reporting low levels of physical exercise (Mental Health Foundation, 2014). Mental health is therefore a national public concern and PA may have positive effect on mental health according to Biddle and Mutrie (2008). There is evidence that regular PA and exercise can lower the risk for depression, distress and lack of well-being, and dementia by at least 20 to 30% (Kohl & Murray, 2012). The exact dose of exercise to impact on mental health however has not been determined (Stathopoulou et al., 2006; Teychenne et al., 2008).

3.3 Measurement of mental health

Interpreting mental health studies is sometimes challenging due to the wide variety of mental health disorders ī different conditions may react differently to diverse stimuli of PA and/or intensity ī and the number of mental health scales in practice. A review by Stults-Kolehmainen, Tuit, and Sinha (2014) indicated an inverse relationship between psychological stress and PA. The authors indicated that the majority of literature computed that the experience of psychological stress impairs efforts to be physically active. It is unclear whether mental health would result in an avoidance of high intensity exercise specifically.

Stanton and Reaburn (2014) researched the effects of exercise on the treatment of depression. They concluded that 30 to 40 minutes of supervised exercise of low to moderate intensity three times a week was beneficial in the treatment of depression. The exercise consisted of indoor or outdoor walking, stationary cycling or cross trainer exercise. However, due to the considerable variation in exercise intensity across the various studies the reviewers were unable to construe a definitive conclusion regarding the optimal exercise intensity for improving depression. Helgadђttir, Forsell, and Ekblom (2015) found no difference between exercise patterns for those with anxiety and depression. They found that those with depressive and/or anxiety disorders spent a large amount of time being sedentary and were less likely to meet PA guidelines. Instead of focusing on high intensity exercise, they suggested that for treating depressive and anxiety disorders, it would be better to reduce sedentary time and increase light PA. Yet a recent study (Wu, Lee, Hsu, Chang, & Chen, 2015) found that high intensity interval training improved both physical and mental health in those with chronic schizophrenia. Hegberg and Tone (2015) found that individuals with high trait anxiety benefited psychologically and physiologically from PA but the desired dose was not stated.

Some articles also focused on the benefits of PF rather than intensity itself. Clennin et al. (2014) found better vitality and physical dimension quality of life with higher levels of CV-fitness in women. Gerber, Lindwall, Lindegard, B˜rjesson, and Jonsdottir (2013) stated that better CV-fitness seemed to be associated with decreased symptoms of psychological burnout and an improved capacity to cope with stress. There is some consensus among researchers (Barbour, Edenfield, & Blumenthal, 2007; Hegberg & Tone, 2015; Stanton & Happell, 2014; Str˜hle, 2009) that more research is needed to determine optimal dose (type, frequency, duration, intensity) of PA to optimize mental health.

3.4 Relationship constructs of mental health with physical health

There can be no health without mental health according to the WHO (2011). Mental well-being is particularly important for the prevention and management of CV-disease, but it also has important implications for the prevention and management of other chronic diseases such as diabetes, osteoporosis, hypertension, obesity, cancer and depression (Warburton et al., 2006).

Psychological distress as a precursor of cardiac risk, CV disease and CV reactivity has also received much attention. The general conclusion is that psychological distress is a health concern of utmost importance (Bergh et al., 2015; Biddle & Mutrie, 2008; Cezaretto et al., 2015). Theory is that chronic psychological distress leads to higher allostatic load and the clustering of the traditional coronary risk factors such as BP, waist hip ratio, and percentage body fat, total cholesterol/HDL ratio and glucose intolerance. Psychological distress in particular is linked to abdominal obesity and insulin resistance (metabolic syndrome) which both seems to be instrumental with regard to the clustering of risk factors (Dishman, 1994).

Mental health is an essential part of overall well-being, and mental disorders or problems can limit people's ability to obtain or maintain functional health. The number and types of mental disorders are numerous and their prevalence seems to increases as people age. Mental disorders are risk factors for the development of communicable and non-communicable disease, and contribute to accidental and non-accidental injuries according to Prince et al. (2007). Richards et al. (2015) also state that mental health disorders are major contributors to the global burden of disease and their inverse relationship with PA is widely accepted.

3.5 Relationship of mental health with physical activity

The optimal intensity and amount of exercise necessary for reduction of risk factors is largely unknown and differs from one risk factor to the next. Finding the optimal exercise prescription dose is complicated by the fact that the various risk factors respond differently on diverse training permutations. Some require high intensity exercise while other responds well on longer duration and low intensity exercise. Constructs of psychological health for instance respond positively on moderate amounts of exercise and seem to impact on health independent from level of fitness or participation in PA. The potential impact of psychological health on the intricate fitness/PA/health-relationships has not been thoroughly investigated.

Little information is available on the relationships between psychological health, fitness and cardiac risk profiles of the general workforce in New Zealand. Further, there is scarcity of scientific studies on the intricate relationship between psychological health, certain morphological variables such as abdominal obesity, and markers of psychological distress and coronary risk. The optimal dose and relative importance of intensity of exercise required for reduction of risk factors in the presence of psychological distress is largely unknown. Little research has actually examined habitual physical exercise and PF as moderators of the stress-illness and or the stress-coronary-heart-disease-risk relations.

Carmack et al. (1999) found that participation in leisure PA- as opposed to level of fitness-provides a stress-illness buffering effect. Both moderate and high intensity exercise show a clear illness buffering effect- with high intensity being significantly better than low intensity- against stress (measured as major and minor events) but not against depression. Dreyer et al. (2012) reduced the CV risks profiles of College staff with psychological burnout, multiple coronary risk factors and elevated waist-hip ratio with high intensity exercise within 10-weeks. The researchers concluded that the results had much to do with the careful/close monitoring of training sessions to ensure consistent high intensity training over the 10-weeks. It is unclear whether similar results can be obtained with self-managed habitual physical exercise. The impact of psychological resourcefulness on the relationships between physical exercise, PF, morphological variables and the traditional coronary risk factors has also not really been investigated. Kobasa (1979) found that psychologically resourceful people flourish on stress and that their psychological constitution provides the same buffering affect against illness as regular physical exercise. It is unclear whether that applies to the coronary risk factors and whether level of PF and intensity of physical training will negate or strengthen the buffering value of psychological resourcefulness. For more clarity on the issue of exercise intensity, CV-fitness, mental health-illness relationships eight studies were tabled (Table 3.1) and will be discussed in the next section.

3.6 Impact of physical activity and fitness on the mental health/coronary risk relationships

Five of the studies in Table 3.1 are cross-sectional studies and three are experimental studies. The cross-sectional studies are discussed first.

Anokye, Trueman, Green, Pavey, and Taylor (2012) took data from the England Health Survey 2008, to research the association of PA with health-related quality of life (HRQoL). The EuroQoL-5 Dimensions (EQ-5D) scale was used to measure HRQoL in participants aged 40 ï 60 years. The EQ-5D has five dimensions or subscales (mobility, self-care, usual activities, pain/discomfort, and anxiety/depression) with each dimension having three levels (no problems, some/moderate problems, and severe/extreme problems). Physical activity was measured with accelerometers and questionnaires. Being physically active meant a minimum of 90 minutes of at least moderate intensive (PA undertaken per week) or not being physically active at all. When compared with inactive individuals, being physically active via objective or subjective measures was related with higher HRQoL. This was consistent across different measures and types of PA as individuals who were physically active via sports, exercise or walking had better HRQoL than inactive individuals. They also found better associations between HRQoL and objective measures of PA than with subjective PA measures.

Table 3.1: Summary of physical activity mental health studies

Author	Year	Type	Respondents	Dependent Variables Mental health measures	Independent Variables PA or Fitness	Results
Anokye, Trueman, Green, Pavey, Taylor	2012	Cross-sectional study	Age 40 ï 60 years 5,537 participants Females and Males Health Survey for England 2008	Health related quality of life ï summary measure of health state utility value derived from the EuroQoL-5 Dimensions (EQ-5D)	Subjective PA - Validated Questionnaire (walking, housework, occupational activity, and sports and exercise). Objective PA: accelerometers worn for 7 consecutive days:	Higher levels of PA were associated with better health related quality of life. Objective measures of PA compared with subjective shows relatively better health related quality of life
Dunn, Madhukar, Trivedi, Kapmpert, Clark, Chambliss	2005	Cross-sectional study (July 1998 ï Oct 2001)	Age 20 ï 45 years 80 participants Females and Males	17-item Hamilton Rating Scale for Depression ($HRSD_{17}$). Structured clinical interview for depression	12-week individual supervised aerobic training sessions. Treadmill or stationary bike. ACSM exercise prescription Public Health Dose (PHD) 17.5kcal/kg/week or Low Dose (LD) 7kcal/kg/week Frequency of 3-5 days/week	Public health dose is an effective monotherapy for mild to moderate major depressive disorder
Gerber, Brand, Hermann, Colledge, Holsboer-Trachsler, Pühse	2014	Epidemiological study	Age 21.24 years 42 participants 22 Females, 20 Males Switzerland voluntary undergraduate students	Objective: Accelerometer worn 7 consecutive days (PA), Portable EEG-Sleep assessment Subjective: PSS, BDI Smatosensory Amplification Questionnaire and Insomnia Severity Index	ACSM recommendations Moderate physical activity intensity exercise (> 3 MET) Vigorous physical activity intensity exercise (> 6 MET)	ACSM vigorous PA was superior in improving overall mental health decreasing stress, pain, depressive symptoms and improving objective sleep patterns compared to those who met or exceeded the requirements for ACSM moderate PA.
Gerber, Lindwall, Lindegard, Börjesson, Jonsdottir,	2013	Epidemiological study	Age 39.2 years 197 participants Males and Females Health care workers	Shirom-Melamed Burnout Questionnaire (SMBQ:38). Twenty-two items with a Likert scale from 1 (almost never) to 7 (almost always). Seven item Depression Subscale of the Hospital Anxiety and Depression Scale (HAD-D)	Cardiorespiratory fitness was assessed via the Astrand indirect test for VO2max submaximal bicycle ergometer test.	High cardiorespiratory fitness was associated with lower levels of depression and burnout.

Hamer, Stamatakis	2010	Cross-sectional	Age 44.6 ± 15.0 years 921 participants Females and Males The Health Survey for England (HSE) 2008	Subjective: Mental Health 12 item version of the General Health Questionnaire Computer assisted personal interviewing (CAPI) Participants rated their health on a five-point scale (very good/ good/ fair/ poor/ very poor)	Objectively assessed: Accelerometers worn 7 consecutive days assessed Frequency, Duration, Intensity) PA levels Sedentary (<1.5 MET) Light (1.5 ï 3 MET), Moderate and Vigorous (>3 MET). Cardiorespiratory fitness Eight minutesôstep test	Participants reporting higher levels of fitness were significantly less likely to report psychological distress than those on lower end of the fitness spectrum for MVPA.
Helgadóttir, Forsell, Ekblom	2015	Cross-sectional (1st Feb 2011 ï 31st Jan 2013)	Age 18 ï 65 years 165 participants Females and Males Six Swedish Country Regions Mild to moderate depression/anxiety disorder symptoms	Participants diagnosed with psychiatric disorders. Patient Health Questionnaire (scoring >10) Mini International Neuropsychiatric Interview Montogomery-Asberg Depression Rating Scale (Symptom severity)	PA levels ï accelerometers worn for seven consecutive days. Sedentary activity (< 100 counts/min) light PA 100 ï 1951 counts/min) and MVPA (>1952 counts/min).	Participants had spent little time in MVPA so increasing low intensity PA levels and breaking up sedentary time seemed more beneficial alleviate symptoms of depressive and anxiety disorders.
Perales, Pozo-Cruz, Pozo-Cruz, Pozo-Cruz	2014	Cross-sectional study (2001 - 2011)	Age: 13,000 respondents Males and Females Australian Population	SF-36 Questionnaire Labour Dynamics in Australia Survey ï Self complete question.	MVPA: 150 to 300 minutesômoderate activity, 75 to 150 minutes of vigorous activity or a combination of both.	Frequency of MVPA and MVPA are positively associated with better Quality of Life.
Wu, Lee, Hsu, Chang, Chen	2015	Epidemiological study	Age 18 participants with Chronic schizophrenia	An interview process used the Positive and Negative Syndrome Scale. The Beck Depression Inventory and the Beck Anxiety Inventory were used every 2 weeks.	8-week HIIT programme 3 x week. Circuit training 3 minutes 45 secondsô bodyweight exercises. 25 minutesôtotal 5 min warm up, 15 minutes of HIIT, 5 minutesôcool down. Peak HR: 95% of maximum HR.	HIIT has positive effects on the mental and physical health of patients with chronic schizophrenia. Results showed a decrease in negative symptoms for both depression and anxiety.

Dunn, Trivedi, Kampert, Clark, and Chambliss (2005) researched the optimal exercise dose for treatment of depression. They used 80 normally sedentary participants aged 20 ï 45 years diagnosed with mild to moderate depression in a 12-week intervention study. They compared exercise defined as low intensity (7 kcal/kg/week) with high intensity (17.5 kcal/kg/week) at a frequency of 3 or 5 days a week. The 17-item Hamilton Rating Scale ($HRSD_{17}$) was the primary outcome, which measured severity of symptoms for depression. Two items (Response and Remission) were also utilised from the questionnaire. Response was defined as a 50% reduction in symptoms from individualsô baseline score. Remission of depressive symptoms was defined as an $HRSD_{17}$ score of <7. Exercising at an intensity of 17.5 kcal/kg/week 3-5days a week was more effective in reducing depression than exercising at 7 kcal/kg/week 3-5 days per week. No interaction was found between the effects of exercise frequency and energy expenditure. Interestingly, they found no difference between the low dose group and the physically inactive control group. They reported that higher intensity exercise had a superior effect on mild to moderate depression in comparison to low intensity exercise.

Hamer and Stamatakis (2010) objectively assessed PA, fitness and subjective wellbeing. Participants (n=921) were drawn from the Health Survey for England and were aged 16 ï 75 years. A five-point scale (very good/good/fair/poor/very poor) was used to rate health as a predictor of mortality and incidence of chronic and acute disease. Mental health or psychological stress was assessed with the 12-item version of the General Health Questionnaire. Objective measures required participants to wear an accelerometer for seven consecutive days during waking hours. Frequency, duration and intensity of PA was recorded via the accelerometer and then used to classify into sedentary (0.5 MET), light (1.5-3 MET), moderate and vigorous (> 3 METS). Cardiorespiratory fitness was determined with an 8-minute sub-maximal step stress test and expressed as an estimate VO_{2max}. Results show higher levels of moderate to vigorous PA in participants reporting very good health (6.7 adjusted mean difference = 43.2%) when compared to individuals reporting fair-poor health. Participants in the highest moderate to vigorous group had over a 50% lower risk of reporting poor health in comparison to those in the low levels of activity. Those in highest PA groups also reported significantly less psychological distress. A limitation of the study was that the physical active participants in the present analysis were younger and healthier than the overall group (reporting less limiting illness and better mental health) so findings could not be generalised to the overall community.

Helgadŋttir et al. (2015) studied the PA patterns of individuals with mild to moderate depression or anxiety disorders. Participants consisted of 18 ï 65 years old individuals who scored >10 on the Patient Health Questionnaire for diagnosing depressive disorders. The Mini International Neuropsychiatric Interview (MINI) scale was used to diagnose psychiatric disorders; categorized as either having a depressive disorder (major depressive episode, dysthymia) or anxiety disorder (panic disorder, social phobia, post-traumatic stress disorder, and generalised anxiety disorder). The Montgomery-Asberg Depression Rating Scale assessed severity of depressive symptoms. Participants wore instructed accelerometers for seven consecutive days and were classified into PA groups; sedentary (< 100 counts/min), light PA (100 ï 1951 counts/min) and moderate to vigorous (MVPA) (MVPA >1952 counts/min). Reaching public health guidelines meant more than 30 minutes of MVPA 5 days per week in bouts lasting longer than 10 minute at a time. Those categorized by the MINI as being depressed spent the lowest number of minutes in both low intensity PA and MVPA and reported the highest minutes of sedentary behaviour. Those with both depression and anxiety had less sedentary minutes and more minutes in MVPA than those with only depression or anxiety disorders. Participants with mild to moderate symptoms of depression and/or anxiety disorders spent the majority of their waking time (546 minutes or 9.1 hours) being sedentary per day. The participants as a group spent very small proportions of their overall time in MVPA and were in general mostly sedentary. It is hard to tell from this data whether they were inactive because they were depressed or whether the PA induce better mental health.

Perales, Pozo-Cruz, and Pozo-Cruz (2014) looked at the association between moderate to vigorous PA and quality of life. Key findings indicated that amongst the Australian population MVPA was positively and strongly associated with quality of life. The strongest associations occurred with the physical dimensions of the 36-Item Short Form Health Survey (SF-36). The most pronounced association with higher levels of HRQoL was more frequent MVPA. The recommended level of MVPA (150 to 300 minutesô moderate activity, 75 to 150 minutes of vigorous activity or a combination of both) was associated with better self-assessed general health satisfaction and with life overall. A clear positive dose-response relationship was observed between frequency of MVPA and all dimensions of the SF-36.

The three epidemiological studies report similar results. Gerber et al. (2014) researched associations between PA (vigorous-intensity and moderate PA), mental health and subjective sleep. Subjects were young undergraduate adults (mean age 21.24 years). The study focused on those meeting the ACSM's vigorous-intensity exercise guidelines (≥3 x 20 min of vigorous PA per week) and whether they exhibited mental health benefits in comparison with respondents not being vigorously active. Mental health was measured with the Perceived Stress Scale (PSS), Beck Depression Inventory (BDI), Smatosensory Amplification Questionnaire and the Insomnia Severity Index. Physical activity was assessed with an accelerometer device (respondents wearing it for 7 successive days); 20 of the 42 participants also completed an additional sleep-EEG assessment. This study found that those that did vigorous-intensity exercise (3 x 20 min per week) on top of moderate PA had additional mental health benefits. Participants who exceeded the ACSM moderate PA guidelines reported less perceived stress, less pain, fewer sleep complaints, and less depressive symptoms resulting in better overall mental health. Most importantly, this study emphasizes the additional mental health effects of vigorous or high intensity exercise for those that are already physically active. Vigorous PA coincided with better coping skills in times of high-perceived stress and less perceived stress in general. Vigorous exercise also impacted positively on quality of sleep and overall sleep time. Additionally, vigorous PA had a stress-buffering effect; vigorous exercisers with high levels of perceived stress had fewer psychological complaints. The additional stress-symptom-buffering effect that vigorous exercisers (as compared to moderate exercisers) seem to evidence might therefore be important as part of stress management.

Gerber, Lindwall, Lindegard, Börjesson & Jonsdottir (2013) examined CV-fitness and self-perceived stress with burnout and depression. Participants were recruited for an ongoing longitudinal cohort study conducted by the Institute of Stress Medicine, Gothenburg Sweden. Forty participants aged 25 – 50 years (20 men, 20 women) were included in this study and categorized into five stress groups. A single-item question was used to determine stress levels (A state where a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his/her mind is troubled all the time). This question has shown strong association with psychological and physical symptoms as well as mental resources in previous studies. Depression was also assessed with the Hospital Anxiety and Depression Scale Questionnaire. VO_{2max} was assessed with the 6-minute Astrand indirect submaximal test on a bicycle ergometer. Participants were placed in low, moderate or high cardiorespiratory fitness groups. The high fitness group had the lowest percentage of individuals with burnout scores that can be classed as either elevated or meeting criteria of clinical burnout. There were also no individuals with clinical levels of depression in the high fitness group. Additionally, individuals in the moderate and high fitness groups evidenced reduced presence of tension among those with high stress levels. This study seems to indicate that higher levels of CV-fitness coincide with lower presence of stress and with lower levels of psychological burnout and depression in those in stressful circumstances. Due to the cross-sectional nature of this study it is hard to conclude that fitness protects against stress; the possibility that stress impacts negatively on participation in vigorous activity needs to be considered as well. It is not only well documented but anyone who has worked with depressive clients knows how hard it is to get them to engage in PA (Chu, Buckworth, Kirby, & Emery, 2009; Kangas, Baldwin, Rosenfield, Smits, & Rethorst, 2015). An argument that the high fit respondents in this study represent a selection of vigorous active individuals (without depression) starts off with the misconception that a perfect relationship exists between fitness and vigorous PA. As has been illustrated in chapter 2 fitness has a strong genetic component and is not synonymous with participation in PA. The possibility that fitness has mental health benefits independent from PA therefore needs to be entertained as a possible explanation for the findings of this study.

Wu et al. (2015) examined the effect of high intensity interval training (HIIT) on the mental and physical health of patients with chronic schizophrenia. Participants included in the study were psychiatric patients (25 - 55 years old) with no contra-indications (hypertension, diabetes mellitus, history of brain injury, epilepsy, myocardial infarction, or recent musculoskeletal disease) for exercise and who were receiving outpatient day care treatment. Participants recruited attended an 8-week circuit format high intensity interval training program. This consisted of 25 minutesô total HIIT workout time 3 times a week utilizing bodyweight exercises. Physical health outcome measures were body weight, BMI, waist circumference, hip circumference, waist-hip ratio, BP, mean arterial pressure, pulse pressure and resting HR were recorded. A trained psychiatrist assessed mental health through an interview process using the Positive and Negative Syndrome Scale (PANSS). In addition, self-reported BDI and the Beck Anxiety Inventory (BAI) measures were recorded every two weeks until the end of the study. After 8-weeks of HITT training the PANSS, BDI and BAI scores decreased significantly. The authors found significant decreases (p=0.01) for the PANSS scores including the Total score (p=0.001), Negative Scale score (p=0.001), and General Psychopathology Scale score (p=0.001). These findings indicate that HITT had a positive effect on measures of mental health in schizophrenia patients. The training also had a positive impact on body weight, BMI, resting HR, pulse pressure and the BDI measures indicate a decrease in overall depressions and anxiety scores.

3.7 Conclusion

The current body of literature indicates that PA positively influences mental health. The dose of exercise remains unclear, however, with some research suggesting that lower intensity activity being more beneficial for mental health. In addition Perales et al. (2014) indicated that high frequency was a positive influence on mental health. Nonetheless, many of the articles provided evidence that performing high intensity PA was more effective in improving overall mental health than low intensity activity. There is still a large gap in the research with many of the articles combining moderate and vigorous activity with no clear distinction between the two. In conclusion, it is not a question of whether PA is beneficial to mental health, anymore, the major question now seems to centre on what prescription of intensity would be most beneficial for mental health.

Chapter 4: Methodology

4.1 Experimental design and participants

Data was collected as part of the iWorkWell project, which was conducted by Sport Manawatu on behalf of the Manawatu Mid-Central District Health Board. Participation was voluntary. Approval was obtained from the Central Regional Ethics Committee (CEN11/04/024). Following ethics approval, the project was advertised by contacting 20 companies in the Manawatu region. The number of subjects in the experimental group was determined by available amount of volunteers in the respective companies.

A total of 15 companies were contacted by Sports Manawatu. Twelve companies expressed interest and they were invited to an information evening. Eight companies decided to participate in the project. These include staff from regional, district and city councils in Palmerston North as well as workforce from pharmaceutical companies, health care linen providers, a regional sport support service, a child welfare and youth support service, work and income and the ministry of social development. Further information sessions were then scheduled at each individual company to inform staff about the project. A total of two hundred and thirty-seven (n=237) individuals were tested. The mean age of the sample was 39.5 years.

4.2 Procedures and data collection

All testing/data sampling was done at the Exercise Science Laboratory of the Universal College of Learning in Palmerston North, New Zealand.

4.2.1 Anthropometrical measures

Weight was recorded without shoes and as much other clothes removed as possible. Percentage body fat was obtained using the procedure of 6 skin folds (triceps, subscapula, supra-iliac, abdominal, thigh and medial calf), according to the guidelines of the International Society for the Advancement of Kinanthropometry (ISAK, 2001). A level III Anthropometrist conducted all the measurements.

4.2.2 Biochemical measures

Total cholesterol, LDL-cholesterol, HDL-cholesterol, triglycerides, glucose and the total cholesterol/HDL-ratio (total cholesterol/HDL-ratio) were collected from blood samples after overnight fasting. Participants were scheduled for blood tests between 8:00 am and 10:00 am at the Exercise Science Laboratory of the Universal College of Learning in Palmerston North two days before the physical assessments started. The blood samples were assessed at a registered biochemistry laboratory. Plasma glucose, total cholesterol and triglycerides were assayed by an automatic colorimetric method (DAX 96, Bayer Diagnostic, Milano, Italy). HDL-cholesterol was assayed by precipitation with phosphotungtic acid and magnesium, and LDL-cholesterol was calculated by the Friedwald formula. Non-HDL (total cholesterol-HDL), total cholesterol/HDL-ratio and triglyceride/HDL-ratio were calculated.

4.2.3 Physiological variables

The physiological variables that were measured included resting HR and resting BP. Resting HR and BP were taken after the client had been in a supine position for 5 minutes in a quiet room. Resting HR was measured with a stethoscope and a stopwatch for one minute and compared with the values the readings of a polar heart rate monitor. Resting BP was measured manually three times with a stethoscope and aneroid sphygmomanometer; with the lowest BP reading being recorded.

4.2.4 Coronary Risk Index

Coronary risk was assessed using a coronary risk index reflecting the 14 most common or typical risk factors for CAD and utilising a Likert-scale format based on levels of risk (Bjurstrom & Alexiou, 1978). The fourteen risk factors namely age, family history, body weight, exercise, tobacco smoking, total cholesterol, SBP, DBP, gender, perceived stress, CVD symptoms, personal history of CVD, diabetes mellitus, and gout.

4.2.5 Illness Rating Scale

Symptomatology was measured through the Seriousness of Illness Rating Scale (IRS) (Wyler, Masuda, & Holmes, 1968), a self-reported checklist of 126 commonly recognised physical and mental symptoms and diseases. In the development of this instrument, a general severity weight for each disorder was obtained by asking a large sample of physicians and laypersons to rate each of them. This carefully developed scale of seriousness of illness has served as a tool used frequently in stress and illness studies (Schroeder & Costa, 1984).

4.2.6 Metabolic syndrome score

The ATP III criteria for diagnosis of metabolic syndrome include waist circumference (males >102cm; females >88cm), triglycerides (Ó1.70mmol.l^{-1}), HDL-cholesterol (males <1.03mmol.l-1; females <1.30mmol.l-1), SBP (Ó130mmHg), DBP (Ó90mmHg) and fasting glucose (Ó6.0mmol.l-1) (Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004). For the purpose of this study the above-mentioned values exceeding the stipulated cut-offs were added into a cumulative metabolic syndrome score. Some sources (Grundy et al., 2004), also include elevated LDL-cholesterol as part of metabolic syndrome classification, but for the purpose of this study, the triglyceride/HDL-ratio was used as a separate marker of health because it provides an estimate of dense LDL molecules (Da Luz, Favarato, Faria-Neto, Lemos, & Chagas, 2008).

4.2.7 Composite of health

Composite of health was calculated on SPSS 22 for Windows (SPSS IBM, Chicago, IL) using the IRS, coronary risk index (CRI), Non-HDL, triglyceride/HDL-ratio and metabolic syndrome scores. The objective was to reduce the multiple health variables to 1 representative health variable. The inclusion of the metabolic syndrome score and the triglyceride/HDL-ratio into a composite of health also combine more modern understanding of illness and coronary risk pathology with the comprehensive, but dated, Illness rating and CRI scales. Composite scores are particularly convenient when numerous instruments are used to attain a more comprehensive estimation of a diverse construct, such as health. Reducing the data to a composite score make it more manageable especially if the aim is to compare the relationships of more than 1 independent variable with the numerous representative measures of the dependent variable. A new variable is essentially created, which is a mathematical function of all the related variables. The methodology described by Logio, Dowdall, Babbie, and Halley (2008), was used to calculate the composite score. Composite scores can be unit-weighted or regression-weighted. The Unit-weighted approach, used in this study, is to either add all items together or calculating the average of each item. The regression-weighted approach uses a factor analysis. The researchers opted for the unit-weighted approach.

4.2.8 Functional capacity

Functional capacity was measured using baseline physiological assessments of aerobic fitness using the YMCA cycle ergometer sub-maximal test protocol (ACSM, 2010). Heart rate was recorded with a polar heart rate FT1 monitor. Karvonen's formula (ACSM, 2010) was used to determine 80% of maximum HR (220 ï age ï resting HR × training percentage + resting HR). The testing protocol comprised of a 2-minute warm-up at 25 Watts followed by 3-minute stages with increments in power output, this was dependent on the subjectõs HR and BP exercise response. The aim was to push each individual to at least 70% of his/her age adjusted maximum HR but BP responses were used to determine symptom maximums on the odd occasion when BP responded poorly (systolic raising above 230 mmHg or diastolic increasing by more than 10 mmHg) during the exercise test. Heart rate was manually recorded every minute of each stage with a HR monitor, while exercise BP was manually recorded during the last minute of each stage. The ACSM (2010) metabolic and multistage equations were used to calculate each individual's relative predicted VO_{2max} and/or functional capacity in METs (VO_{2max} divided by 3.5).

4.2.9 Physical activity

Two measuring instruments were used to access participation in PA, namely the Baecke PA questionnaire (Baecke, Burema, & Frijters, 1982) and the index developed by Sharkey (1984).

By allocating the Borg scale numerical values to the practice requirements, intensity, duration and frequency, the Sharkey method (Sharkey, 1984) expresses participation in PA as an index by multiplying the values with each other. The Sharkey Index measures relative perceived intensity of training with a Likert-type scale where 1 equals light PA, such as fishing and walking, and 5 equals activity that incite sustained heavy breathing.

The Baecke questionnaire also utilises the Likert scale scores for intensity (1=never sweat doing PA to 5=always sweating), duration (1=less than 5 minutes to 5=>45 minutes) and frequency (1=never to 5=very often) to calculate absolute type scores for work, sport and leisure activity. The leisure index includes walking and cycling for transportation purposes (work, school and during shopping). Philippaerts and Lefevre (1998) studied the reliability and validity of the Baecke Index against Doubly Labelled Water (DLW) and found that it provided both reliable and valid PA data.

4.3 Psychological variables

Psychological health was assessed by means of reliable questionnaires validated by the respective designers through the use of random controlled samples and by correlating results with various other accepted and validated questionnaires measuring similar or opposite psychological constructs.

4.3.1 Perceived stress scale

The PSS (Cohen, Kamarck, & Mermelstein, 1983) was included as a measure of general life stress. The PSS measures the degree to which the subject perceives situations in her/his life as stressful. The PSS consists of 14 items that refer to the general frequency of feelings or thoughts about stress during the past month. Items are rated on a 5-point scale from "never" to "very often". The items are general in nature in order to assess a global level of perceived stress. Internal reliability ranged from .84 to .86 for a variety of populations (Cohen et al., 1983).

4.3.2 Affectometer

The Affectometer 2 (Happiness) is used to measure well-being and quality of life (Kammann & Flett, 1983). The Affectometer 2 is a 5-minute inventory of general happiness or sense of well-being based on measuring the balance of positive and negative feelings in recent experience. The scale consists of two parts in which the first part consists of 19 statements and the second part consists of 20 adjectives. It runs on a 5-point Likert scale ranging from 1 (*does* *not apply to me at all*) to 5 (*applies s to me all the time*). Scores can range from 39 to 195 with higher scores reflecting the experiences of higher psychological well-being and lower scores reflecting lower levels of psychological well-being of the individual (Kammann & Flett, 1983; Tennant, Joseph, & Stewart-Brown, 2007). Studies in the U.K studies and New Zealand reported similar responses showcasing a high level of internal validity and reliability and expected correlations with socio-demographic factors (Kammann & Flett, 1983; Tennant et al., 2007).

4.3.3 CES-D depressions scale

The 20-item Centre for Epidemiologic Studies Depression (CES-D) Scale was created by Radlof in 1977. It measures the frequency of occurrence of symptoms during the past week. A 0ï 3 Likert-type scale (ôrarely or none of the timeô to ômost or all of the timeö) is used, with total scores ranging from 0 to 60 (Radlof, 1977). Reliable and valid results for the CES-D as a measure of depressive symptoms have been reported in patients with systemic sclerosis (Thombs, Hudson, Schieir, Taillefer, & Baron, 2008) and patients with breast cancer (Hann, Winter, & Jacobsen, 1999).

4.3.4 Psychological burnout

Emotional exhaustion was measured by the Psychological Burnout questionnaire (Pines, Aronson, & Kafry, 1981). The burnout questionnaire is a valid and reliable research instrument that indicates the individualôs level of exhaustion, which is considered to be the element of the burnout syndrome (Schaufeli, Maslach, & Marek, 1993; Shirom, 1989). Pines and Aronson (1988) define burnout as ña state of physical, emotional and mental exhaustion caused by long-term involvement in situations that are emotionally demandingò. The burnout questionnaire consists of 21 items that express exhaustion and that are scored on a 7-point rating scale, ranging from ônever to ôalwaysô. The burnout questionnaire has consistence internal coefficients that range from .91 to .93 showcasing the questionnaire as a reliable instrument.

4.4 Statistical Analysis

The inter-relationships between the PA and CV-fitness variables were investigated with partial correlations as part of the first aim of the study. Control variables were age, gender and body weight, in both instances. The analysis provides information on the relative contributions of the various PA variables with CV-fitness. Partial correlations were also used to investigate the relationships between measures of psychological health and physical health as part of the second aim of the study.

The contributions of the PA variables and CV-fitness to health were assessed with a stepwise multiple regression analysis. The dependent variable was a composite of health. The independent variables were age, gender, body weight, MET, Sharkey dose, Baecke dose, work activity, sport activity, leisure activity, and intensity. This analysis was used to compare the relative contributions of intensity of training, PA dose and MET to the variance of the composite of health. The R^2 change values provide information on the amount of variance explained by each variable entered. This analysis offers information for the first and second aims.

Three Analysis of covariance (ANCOVA) were performed using the same control variables as in the partial correlations. The first ANCOVA was performed to assess the dependent and independent relationships of PA dose and intensity of training with all the health variables. Participants were placed into low, moderate and high intensity and PA dose groups based on the group distributions as determined with frequency tables. Those in the upper 30% of the group distribution were classed as high in terms of PA and intensity of training, while those in the bottom 30% were classed as low. The rest were placed in the moderate group. The cut-offs for intensity were 2.5 (n=104) and 4.6 (n=102) for the low and high groups, indicating a normal distribution since the number of respondents above and below the 30 and 70% percentiles were almost the same. The high and low grouping cut-offs for PA dose were 36.0 (n=86) and 63 (n=90) respectively, which also indicate a nearly normal distribution.

In the second ANCOVA, intensity of training and MET was used as independent variables and the composite of health as the dependent variable. The cut-off for the high and low MET groupings were <8.0 MET (n=76) and >9.99 (n=69) respectively. Eta^2 and Wilks Lambda scores were calculated to determine individual and combined contributions of the independent and control variables to the variances of the dependent variable. This analysis provides information relating to the third study aim.

The relationships of intensity of training and CV-capacity with psychological health were investigated with a third ANCOVA. The control variables were body mass, age, intensity of training and gender. For the binary logistical regressions participants were grouped for each of the variables used into relative “high” and “low” categories. Stress symptoms (1^{st} binary analysis) and composite of health (2^{nd} binary analysis) were split at the 60^{th} percentile. Grouping at the 60^{th} percentile are generally recommended for binary analysis because the aim is to distinguish predictability of either poor or good performers (Thomas, Silverman, & Nelson, 2015).

Log data transformation of the dependent variables was done to correct for slight positive skewness. The log transformed variables were checked again for normality and met skewness and standard error (SE) criteria of normality: CRI (skewness=0.343; SE=0.104); IRS (skewness= -0.531; SE=0.204); metabolic syndrome (skewness= -0.160; SE=0.054); Non-HDL (skewness= -0.262; SE=0.104); Trig/HDL-ratio (skewness=0.466; SE=0.204) and composite of health (skewness=0.231; SE=0.104).

Chapter 5: Results

5.1 Introduction

This study has two basics aims. The first aim relates to the relationship of physical activity and physical fitness with measures of health. The second aim investigates the impact of physical activity on the psychological health-illness interactions.

In this chapter the demographic data of males and females (Tables 5.1 to 5.4) are first reported. This is followed with a reporting of data relating to the first aim namely the relationships of PA and CV-capacity with each other (Table 4.5) and with measures of health (Tables 5.6 to 5.12).

The chapter then shifts focus to the reporting of data relating to the interrelations between psychological health, PA, CV-capacity and health (Tables 5.13 and 5.14). The chapter concludes with the results of the binary regression analysis (Table 5.17) that was utilized to predict physical health with CV-capacity, stress symptoms and intensity of training while controlling for gender and age.

5.2 Comparison of males and females

5.2.1 Anthropometric variables

The anthropometric data of males and females and the overall group are presented in Table 5.1. The only statistically significant difference between males and females was percentage body fat. The females present with a larger percentage body fat (27.4 versus 14.4; $p<0.001$). The mean BMI was 27.1 indicating that the group on average presented with a normal body weight. The mean age of the respondents was 39.5 years with females slightly older (40.2 versus 38.9) than males.

Table 5.1. ***Comparison of male and female participants for descriptive and anthropometric data***

Variables	**Total (n=237)**	**Women (n=142)**	**Men (n=95)**	**t-value**	**p-value**
	Mean ± SD	*Mean ± SD*	*Mean ± SD*		
Age (yrs)	39.50 ± 12.10	40.20 ± 12.00	38.90 ± 12.26	0.729	0.96
Weight (kg)	79.30 ± 18.90	73.20 ± 15.80	87.30 ± 19.90	5.589	0.21
Body Fat (%)	21.90 ± 9.80	27.40 ± 8.40	14.40 ± 6.10	11.87	0.001
BMI	27.20 ± 5.60	26.90 ± 5.50	27.50 ± 5.80	0.749	0.94

BMI=Body Mass Index

5.2.2. Health status

The health status data of males and females and of overall group are presented in Table 5.2. There were no statistically significant ($p>0.05$) differences between males and females.

Table 5.2. ***Comparison of male and female participants for health status***

Variables	**Total (n=237)**	**Women (n=142)**	**Men (n=95)**	**t-value**	**p-value**
	Mean ± SD	*Mean ± SD*	*Mean ± SD*		
IRS	258.70 ± 205.70	317.90 ± 218.30	253.50 ± 193.10	2.885	0.32
CRI	24.50 ± 7.20	23.50 ± 6.87	25.50 ± 7.30	2.077	0.94
MS-score	1.72 ± 1.10	1.57 ± 1.10	1.95 ± 1.13	1.979	0.81
Non-HDL	3.80 ± 0.95	3.76 ± 0.90	3.85 ± 0.95	0.563	0.64
Trig/HDL-ratio	0.88 ± 0.66	0.80 ± 0.60	1.01 ± 0.74	1.963	0.51

Note. IRS = Illness rating scale, CRI = Coronary risk Index, Metabolic syndrome score.

5.2.3 Physical activity and CV-capacity

The PA and CV-capacity data of males, females and the overall group are presented in Table 5.3. The mean VO_{2peak} of the participants was 31.4ml.kg^{-1} (8.97 MET x 3.5), which is a moderate level of CV-fitness. Of the group, 32.1% (n=76) had a functional capacity lower than 8.0 MET, while 29.1% (n=69) had functional capacities higher than 10.0 MET. A Sharkey PA dose value of 45 equates to more or less 1000kcal.week^{-}1 (Dreyer & Strydom, 1994). The group mean of 57.4, therefore, indicates a cohort of participants that was moderately physically active. A Sharkey dose value of 36.0 represents a kcal expenditure of 450kcal.week^{-1}, while 63.0 equates to about 1500kcal.week^{-1} (Dreyer & Strydom, 1994). A total 36.3% (n=86) of the participants were below the 450kcal.week^{-1} cut-off and 37.9% (n=90) above the 1500kcal.week^{-1} cut-off.

Table 5.3. ***Comparison of male and female participants for physical activity and CV-capacity***

Variables	Total (n=237) *Mean ± SD*	Women (n=142) *Mean ± SD*	Men (n=95) *Mean ± SD*	t-value	p-value
CV-capacity					
VO_{2peak}	31.38 ± 7.74	29.14 ± 7.16	34.42 ± 7.55	5.004	0.44
MET	8.97 ± 2.21	8.33 ± 2.05	9.83 ± 2.16	5.004	0.44
Physical activity					
Sharkey index	57.40 ± 47.29	53.50 ± 48.70	64.90 ± 44.70	1.806	0.40
Intensity	3.80 ± 2.78	3.39 ± 2.87	4.21 ± 2.68	2.545	0.83
Duration	6.54 ± 4.66	5.97 ± 4.98	7.11 ± 4.34	1.808	0.13
Frequency	5.62 ± 3.90	5.38 ± 4.39	5.87 ± 3.41	0.924	0.007
Baecke index	2.48 ± 0.58	2.35 ± 0.56	2.60 ± 0.59	3.264	0.31
Work activity	2.28 ± 0.40	2.30 ± 0.41	2.26 ± 0.39	0.765	0.57
Sport activity	3.02 ± 1.33	2.72 ± 1.31	3.32 ± 1.34	3.467	0.61
Leisure activity	2.14 ± 0.57	2.04 ± 0.55	2.23 ± 0.58	3.600	0.28

Note. VO_{2peak} = estimated peak VO_2 (ml/kg/min), CV capacity=Cardiovascular capacity

Apart from frequency of training none of the other variables showed any statistical significance between males and females. Males had a higher mean VO_{2peak}, as compared to females (34.42 vs 29.14). Both groups had reasonable levels of CV-fitness (>8.0 MET). The Sharkey index also demonstrate a fairly good level of participation in PA in both gender groups.

5.2.4 Psychological health

The psychological health data of males and females and the overall group are presented in Table 5.4.

There were no statistical differences between males and females in regards to the measured constructs of psychological health. The mean scores for all measures also indicated normal psychological health overall for both gender groups.

Table 5.4. ***Comparison of males and females for psychological health***

Variables	**Total (n=237)**	**Women (n=142)**	**Men (n=95)**	**t-value**	**p-value**
	Mean ± SD	*Mean ± SD*	*Mean ± SD*		
Burnout	2.88 ± 0.66	2.96 ± 0.62	2.78 ± 0.68	2.295	0.22
CES-D	15.52 ± 6.04	15.08 ± 5.26	16.25 ± 7.12	1.432	0.60
Affectometer	21.59 ± 10.94	21.10 ± 10.95	22.26 ± 10.90	0.788	0.96
Stress Symptoms	13.56 ± 7.30	14.64 ± 7.33	12.09 ± 7.02	2.637	0.45

Note. CES-D = Centre for Epidemiologic Studies Depression Scale, Burnout = psychological burnout.

5.3 Relationships between physical activity and cardiovascular fitness

Partial correlations were calculated to determine the relationships between the measures of PA and CV-fitness, while controlling for age, weight and gender (Table 5.5). The R^2, which provides information on shared variance and coefficient of determination, are indicated in brackets. The lowest R^2 was 0.8% (work activity with VO_{2peak}) and the highest 20.3% (Baecke PA dose and sport activity with VO_{2peak}). This shows that the effect of PA and the CV-fitness variables on health, as investigated in the ANCOVAs, are not confounded. It also provides information on which of the PA variables shows the most meaningful coefficient of determination to the variances of the CV-fitness variables.

PA dose, as measured with the Baecke questionnaire, correlates slightly better (r=0.45 versus r=0.37) with CV-capacity (VO_{2peak}), than relative perceived intensity of exercise (Table 5.5).

Table 5.5. ***Partial correlations# of physical activity with cardiovascular fitness***

Physical activity measures	**VO_{2peak}**	
Sharkey PAI	0.39*	(15.2%)
Intensity	0.37*	(13.7%)
Overall Baecke Physical activity questionnaire	0.45*	(20.3%)
Work physical activity	0.09	(00.8%)
Sport physical activity	0.45*	(20.3%)
Leisure physical activity	0.28*	(07.8%)

Note. Values in brackets: R^2 x 100; *=p<0.05; # = Controlling for age, weight, gender

The Baecke sport activities subscale (R^2 x 100= 20.3%), and the Sharkey intensity of training scale (R^2 x 100=13.7%) are markedly better contributors to the variance of VO_{2peak} than the other 2 Baecke subscales (work activity=0.8% and leisure activity=7.8%).

The individual and combined relationships of intensity of training and an overall PA score to CV-fitness (METs) was investigated with an ANCOVA. The covariates were age, gender and body weight.

The F-ratio, p-values and Eta^2 values of each of the two independent variables (PA dose and intensity of training), the combined variables and the control variables are presented in Table 5.6.

Intensity of training contributed more to the variance of CV-capacity (8.5% versus 2.5%) than the overall activity score (Table 5.6). The contribution of intensity was statistically significant (p=0.000) while the 2.5% contribution of the overall PA dose was not statistically significant.

Table 5.6. *Relationships of overall activity and intensity of training with measures of CV-capacity and health: ANCOVA analysis*

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
CV-capacity	Gender	31.160	0.000	0.145	53.6%
	Age	16.106	0.000	0.081	
	Body weight	15.558	0.000	0.078	
	Intensity level	8.530	0.000	0.085	
	PA dose	2.350	0.098	0.025	
	Combined	1.577	0.182	0.033	
	Overall model	14.388	0.000	0.464	

5.4 Relationship of PA and CV-capacity variables with measures of physical health

The correlations of Intensity of training and CV-capacity (VO_{2peak}) with measures of health are reported in Table 5.7. This table relates to the first aim which compares the relationships of intensity of training and VO_{2peak} with measures of health.

Of the two variables VO_{2peak} generally correlates better with most of the health variables. The best R^2 values was VO_{2peak} with CRI (R^2 = 8.1%) and composite of health (R^2 = 4.5%)

Table 5.7. ***Partial correlations of Intensity of training and CV -capacity with measures of health***

Health Variables	**Intensity**	VO_{2peak}
IRS	0.043 (0.2%)	0.079 (0.6%)
CRI	-0.156 (2.4%)	-0.285 (8.1%)
Non-HDL	-0.099 (0.1%)	-0.144 (2.1%)
Trig/HDL ratio	0.004 (0.001%)	-0.103 (1.1%)
Metabolic syndrome	-0.115 (1.3%)	-0.177 (3.1%)
Composite of health	-0.091 (0.8%)	0.213 (4.5%)

Note. IRS = Illness rating scale, CRI = Coronary risk Index, Metabolic syndrome score

Table 5.8. ***Relationships of overall physical activity and intensity of training with measures of coronary risk: ANCOVA analysis***

Dependent variables	**ANCOVA variables**	**F-ratio**	**p-Values**	**Eta^2**	**Wilks Lambda**
CRI	Gender	0.001	0.970	0.000	56.7%
	Age	42.349	0.000	0.188	
	Body weight	48.782	0.000	0.210	
	Intensity level	1.516	0.222	0.016	
	PA dose	0.676	0.510	0.007	
	Combined	0.301	0.877	0.007	
	Overall model	12.705	0.000	0.433	
Non-HDL	Gender	0.463	0.498	0.004	82.6%
	Age	7.793	0.006	0.057	
	Body weight	8.253	0.005	0.061	
	Intensity level	1.218	0.299	0.019	
	PA dose	0.115	0.892	0.002	
	Combined	0.857	0.492	0.026	
	Overall model	2.455	0.008	0.174	
Trig/HDL-ratio	Gender	0.048	0.827	0.000	80.9%
	Age	6.175	0.014	0.046	
	Body weight	18.322	0.000	0.125	
	Intensity level	0.569	0.568	0.009	
	PA dose	0.717	0.490	0.011	
	Combined	0.491	0.742	0.015	
	Overall model	2.750	0.003	0.191	

The dependent and independent relationships of intensity of training and PA dose with measures of coronary risk are presented in Table 5.8. Intensity of training contributed more to the variance CRI (1.6% versus 0.7%), Non-HDL (1.9% versus 0.2%) than the overall activity dose score (Table 5.8). None of these contributions were statistically significant (p>0.05). PA dose showed a marginally higher contribution to the variance of triglyceride/HDL-ratio (1.1% versus 0.9%) than intensity of training.

In Table 5.9 PA dose contributes marginally more (2.4% versus 1.2%) to the variance of a measure of metabolic syndrome than intensity of training.

Table 5.9. *Relationships of overall activity and intensity of training with measures of metabolic syndrome: ANCOVA analysis*

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
Metabolic syndrome score	Gender	0.175	0.677	0.001	67.1%
	Age	23.537	0.000	0.155	
	Body weight	19.658	0.000	0.133	
	Intensity level	0.770	0.465	0.012	
	PA dose	1.542	0.218	0.024	
	Combined	0.180	0.948	0.006	
	Overall model	5.693	0.000	0.329	

In Table 5.10 intensity of training contributed more to the variance of IRS (2.2% versus 1.1%) and the composite health score (1.7% versus 0.4%) than the overall activity score. The contributions (of both intensity and PA dose) was however not statistically significant (p>0.05).

The moderating effect of intensity of training on the fitness-health relationship can be seen in Table 5.11. In this ANCOVA PA dose was replaced with CV-capacity as one of the independent variables.

Table 5.10. *Relationships of overall activity and intensity of training with measures of overall health: ANCOVA analysis*

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta²	Wilks Lambda
IRS	Gender	15.193	0.000	0.077	86.8%
	Age	0.046	0.831	0.000	
	Body weight	8.884	0.003	0.046	
	Intensity level	2.029	0.134	0.022	
	PA dose	1.008	0.367	0.011	
	Combined	0.818	0.515	0.018	
	Overall model	2.528	0.005	0.132	
Composite health score	Gender	0.455	0.501	0.004	56.8%
	Age	32.549	0.000	0.203	
	Body weight	49.242	0.000	0.278	
	Intensity level	1.135	0.325	0.017	
	PA dose	0.228	0.797	0.004	
	Combined	0.106	0.980	0.003	
	Overall model	8.833	0.000	0.432	

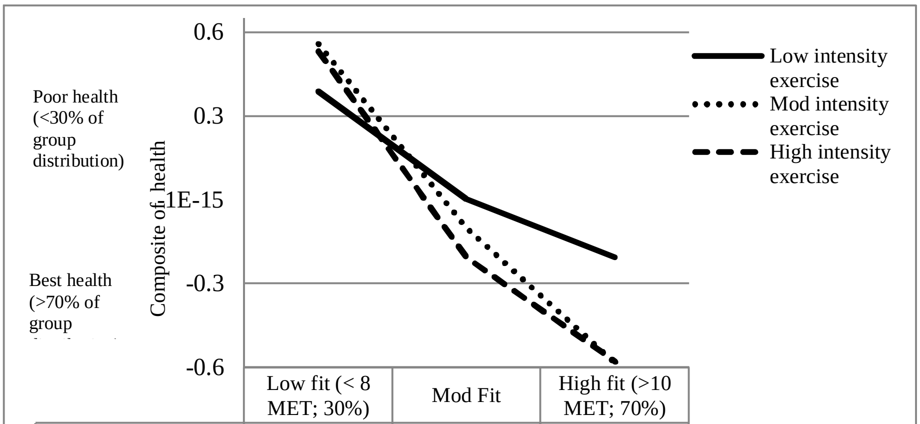
The control variables were age, gender and body weight. Body weight (F=23.301; p=0.000) and CV-capacity (F=6.752; p=0.002) were the only statistically significant contributors to the variance of the composite health score in this analysis. CV-capacity (VO_{2peak}) contributed 9.5% (p=0.002) to the variance of the composite health score in comparison to the non-significant (p=0.470) 1.2% contribution of intensity of training.

The results of the ANCOVA reported in Table 5.11 are illustrated schematically in Figure 5.1. It reveals that moderate and high perceived intensity of training did not coincide with better health in the low fitness group (<8 MET).

Those classified as low fit had mean composite health scores in the bottom 30% of the group distribution irrespective of level of participation in PA. In contrast, a downward trend can be observed in the low, moderate and high intensity groups in correspondence with level of CV-fitness. As fitness increases the composite health score decreases, which indicates better health. The fitness-health improvements are nevertheless markedly steeper in the moderate and high perceived intensity cohorts (109.8% and 104.8%) as compared to the low intensity cohort (52.8%).

Table 5.11. ***Relationships of CV-capacity and intensity of training with a composite health score: ANCOVA analysis***

Dependent variable	**ANCOVA Variables**	**F-ratio**	**p-Values**	**Eta^2**	**Wilks Lambda**
Composite of health	Gender	2.265	0.135	0.017	64.0%
	Age	0.048	0.827	0.000	
	Body weight	23.301	0.000	0.154	
	Intensity level	0.765	0.470	0.012	
	CV-Capacity	6.753	0.002	0.095	
	Combined	0.346	0.847	0.011	
	Overall model	6.559	0.000	0.360	



	Low fit (< 8 MET; 30%)	Mod Fit	High fit (>10 MET; 70%)
Low intensity exercise	0.388	0.003	-0.205
Mod intensity exercise	0.559	-0.099	-0.583
High intensity exercise	0.533	-0.204	-0.577

Figure 5.1 Association **between perceived intensity of training and composite of health stratified by functional capacity**

5.5 Physical activity and cardiovascular fitness as predictors of health

A stepwise multiple regression analysis was performed to compare the contributions of intensity of training and the other PA variables, as well as CV-fitness, to the variance of the composite of health. This analysis provides information on the overall theme of the study, namely the moderating effect of intensity of training on the relationships of PA dose and CV-fitness to health. A total of 10 independent variables (age, gender, body weight, MET, Sharkey dose, Baecke dose, work activity, sport activity, leisure activity and the Sharkey intensity scale), were used in this analysis. Only 6 of the variables (body weight, MET, Sharkey dose, intensity, work activity and leisure activity), were listed as contributors to the composite of health in the stepwise regression output. The major contributor was body weight (F=37.5; R^2=0.214; p=0.000).

The other significant contributors were MET (F=23.9; R^2=0.117; p=0.000), relative intensity of training (F=4.99; R^2=0.023; p=0.027) and Sharkey dose (F=4.04; R^2=0.019; p=0.046).

Work activity and leisure activity were listed as non-significant contributors. In terms of the aims of the study, the important information gained from this analysis is that the relative intensity scale contributed slightly more (2.3%) to the variance of the composite of health than PA dose (1.9%), but markedly less than MET (11.7%). The 6 independent variables in Table 5.12 contributed as a group 38.7% to the variance of the composite of health.

Table 5.12. ***Stepwise multiple regression analysis to predict a composite of health***

Predictor variables	Multiple R	Multiple R^2	R^2 change	F-value	p-Value
Body weight	0.463	0.214	0.214	37.60	0.000
MET	0.575	0.331	0.117	23.90	0.000
Sharkey dose	0.592	0.350	0.019	4.04	0.046
Intensity	0.611	0.373	0.023	4.99	0.027
Work activity	0.616	0.379	0.006	1.39	0.239
Leisure activity	0.622	0.387	0.007	1.45	0.231

Note: No control variables were used in this analysis.

5.6 Relationship of psychological constructs with measures of physical activity and CV-capacity

The relationship of psychological health with measures of PA and CV-capacity was investigated with partial correlations (Table 5.13) while statistically controlling for age, weight and gender.

The R^2-values are generally very low (highest being 3.0%) which indicate that the Psychological constructs and measures of PA/fitness contributes very little to each other's variance. The best correlations were stress symptoms with work activity (r = 0.151) and the Affectometer with the Sharkey PA index (R = 0.163) and intensity of training (R = 0.174). Sport activity also evidence a comparatively higher r value with psychological burnout (R = 0.103).

The correlations are generally negative which means as PA and fitness goes up psychological profiles improves. The exception is stress symptoms which seems to indicate that higher levels of PA coincided with higher levels of stress symptoms. The correlations are however so small that not much can be made of it.

Table 5.13. ***Partial correlations# of physical activity and CV-capacity with constructs of psychological health***

Measures of PA and CV-capacity	Stress symptoms	Affectometer	Psych burnout	CES-D
Sharkey PAI	0.013 (0.01%)	0.163 (2.7%)	-0.067 (0.4%)	-0.062 (0.4%)
Intensity	0.061 (0.4%)	0.174 (3.0%)	-0.067 (0.4%)	-0.047 (0.2%)
Overall Beacke	0.019 (0.04%)	0.088 (0.7%)	-0.089 (0.8%)	-0.071 (0.5%)
Work activity	0.151 (2.3%)	-0.053 (0.3%)	0.068 (0.5%)	-0.025 (0.06%)
Sport activity	0.005 (0.003%)	0.101 (1.0%)	-0.103 (1.1%)	-0.088 (0.8%)
Leisure activity	-0.056 (0.3%)	0.073 (0.5%)	-0.080 (0.6%)	0.003 (0%)
CV-capacity	0.030 (0.09%)	0.072 (0.5%)	-0.074 (0.5%)	-0.058 (0.3%)

Note. Values in brackets: R^2 x 100; # = Controlling for age, weight, gender

5.7 Relationship of psychological variables with measures of physical health

Partial correlations were done to investigate the relationships of the psychological constructs with measures of health. Results of this analysis are presented in Table 5.14.

Table 5.14. ***Partial correlations# of constructs of psychological health with measures of physical health***

Health Variables	Stress symptoms	Affectometer	Psych burnout	CES-D
IRS	0.446 (19.9%)	-0.251 (6.3%)	0.360 (13.0%)	0.258 (6.7%)
CRI	0.429 (18.4%)	-0.187 (3.5%)	0.281 (7.9%)	0.249 (6.2%)
Non-HDL	0.071 (0.5%)	-0.007 (0.005%)	0.000 (0%)	0.096 (0.9%)
Trig/HDL ratio	0.202 (4.1%)	-0.114 (1.3%)	0.131 (1.7%)	0.163 (2.7%)
Metabolic syndrome	0.075 (0.6%)	-0.156 (2.4%)	0.109 (0.2%)	0.024 (0.06%)
Composite of health	0.433 (18.7%)	-0.202 (4.1%)	0.275 (7.6%)	0.277 (7.7%)

Note. IRS = Illness rating scale, CRI = Coronary risk Index, Metabolic syndrome score

The two psychological constructs that show the best relationship with variables of health are stress symptoms and psychological burnout. Of these two, stress symptoms contribute ultimately the most to the variances of IRS, CRI and the composite of health.

5.8 Prediction of measures of psychological health with CV-capacity and intensity of training

The individual and combined relationships of CV-capacity and intensity of training to constructs of psychological health was investigated with an ANCOVA. The covariates were age, gender and body weight.

The F-ratio, p-values and Eta^2 values of each of the two independent variables (CV-capacity and intensity of training), the combined variables and the control variables are presented in Table 5.15.

Gender (F=4.505; p=0.035), CV-capacity (F=3.447; p=0.034) and the overall model (F=2.133; p=0.02) were statistically significant contributors to the variance of stress symptoms. The Eta^2 values indicate that CV-capacity contributed only slightly more to the variance of stress symptoms than intensity of training (3.6 versus 3.0%).

Neither the independent variables (CV-capacity and intensity of training) nor the control variables (gender, age and body weight) contributed individually or in combination statistically significantly (p>0.05) to the variances of psychological burnout and the depression scale (CES-D).

In the case the Affectometer only intensity of training (F=3.194; p=0.043) proved to be a statistically significant contributor. As was the case with the stress symptoms scale the Eta^2 value indicates a relatively small individual contribution of only 3.4%. In comparison CV-capacity contributed only 1.1% to the variance of the Affectometer.

The Wilks Lambda indicate that the independent and control variables failed to explain 77.5% to 89.5% of the dependent variables.

Table 5.15. *Relationships of intensity of training and CV-capacity with measures of psychological health: ANCOVA analysis*

Dependent variables	ANCOVA variables	F-ratio	p-Values	Eta^2	Wilks Lambda
Stress symptoms	Gender	4.505	0.035	0.024	77.5%
	Age	0.452	0.502	0.002	
	Body weight	0.244	0.622	0.001	
	Intensity level	2.823	0.062	0.030	
	CV-capacity	3.447	0.034	0.036	
	Combined	0.855	0.492	0.018	
	Overall model	2.133	0.020	0.114	
CES-D	Gender	1.015	0.315	0.006	89.5%
	Age	0.012	0.914	0.000	
	Body weight	0.551	0.459	0.003	
	Intensity level	1.029	0.359	0.011	
	CV-capacity	1.707	0.184	0.018	
	Combined	1.031	0.393	0.022	
	Overall model	0.786	0.654	0.045	
Psych burnout	Gender	2.000	0.159	0.011	87.8%
	Age	0.666	0.416	0.004	
	Body weight	0.007	0.936	0.000	
	Intensity level	0.256	0.774	0.003	
	CV-capacity	1.926	0.149	0.021	
	Combined	0.596	0.666	0.013	
	Overall Model	1.254	0.255	0.070	
Affectometer	Gender	0.380	0.538	0.002	82.4%
	Age	1.067	0.303	0.006	
	Body weight	1.503	0.222	0.008	
	Intensity level	3.194	0.043	0.034	
	CV-capacity	0.999	0.370	0.011	
	Combined	1.099	0.359	0.023	
	Overall Model	1.686	0.079	0.092	

A binary logistic regression analysis was conducted to predict psychological health (Stress Symptom category) with CV-capacity, intensity of training, age and gender (Table 5.16).

Table 5.16. ***Binary logistic regression analysis to predict the stress symptom score categories with CV-capacity, intensity of training, gender and age.***

				Stress Symptom Category				
Variables	-2 Log likelihood	R^2	B	S.E	Wald	OR	(95% CI)	*p*-value
Gender	245.8	0.109	-.921	.339	7.381	.398	.205-.774	.007
Age			-.009	.014	.464	.991	.965-1.017	.496
CV-capacity			-.135	.090	2.243	.874	.732-1.043	.134
Intensity level			.065	.045	2.086	1.067	.9771-.166	.149

A test of the full model against the constant only model was statistically significant indicating that the predictor variables distinguishes with statistical significance between low and high stress symptoms scores (chi square = 14.92, p=0.005). The Nagelkerke R^2 value indicates that the predictor variables contribute only 10.9% to the variance of the stress symptoms categories. The model was able to predict stress symptom categories with 61% accuracy.

The only statistically significant contributor in the model was gender (Table 5.16). An odds of 1 indicate no relationship, a value greater than 1 indicates a positive relationship, and a value less than 1 indicate a negative relationship. The odds statistic can be interpreted in terms of percentage change by subtracting 1 and multiplying by 100. The odds ratios indicate that one unit rise in CV-capacity will results in a 12.6% [100(.874 ï 1)] decrease odds of being in the high stress symptom group. The comparative value for intensity of training is 6.7%.

5.9 Prediction of health with measures of health, CV-capacity and intensity of training

A binary logistic regression analysis was also conducted to predict health (Composite of health category) with stress symptoms, CV-capacity, intensity of training, age and gender (Table 5.17).

Table 5.17. ***Binary logistic regression analysis to predict the composite of health risk category with stress symptoms, CV-capacity, intensity of training, gender and age.***

Composite of Health Category								
Variables	-2 Log likelihood	R^2	B	S.E	Wald	OR	(95% CI)	*p*-value
CV-capacity	135.174	0.304	.369	.132	7.877	1.447	1.118-1.872	.005
Stress symptoms			-.074	.031	5.586	.929	.873-.987	.018
Intensity			.009	.068	.016	1.009	.883-1.152	.900
Gender			-1.62	.519	9.719	.198	.072-.548	.002
Age			-.049	.018	7.322	.952	.919-.987	.007

A test of the full model against the constant only model indicates that the predictor variables distinguishes with statistical significance between low and high levels of health (chi square = 33.4, p=0.000). The Nagelkerke R^2 value indicates that the predictor variables contribute 30.4% to the variance of the composite of health score. The model was able to predict 74.8% of the health categories.

As indicated in Table 5.17 the variables that contributed statistically significantly to the model was CV-capacity (p=0.005), stress symptoms (p=0.018), gender (p=0.002) and age (p=0.007). CV-capacity evidenced the highest odds ratio indicating that it was the best predictor variable in the model.

Individuals with a high CV-capacity were 1.447 more likely to present with good health. This odds ratio mean that for every 1 unit increase in CV-capacity the odds of being in the good health group increase by 44.7%. In contrast every unit increase in stress symptoms will decrease in the odds to be in the good health group by 7.1%. The unit decrease to be in the good health category for age is 4.8%. Males were 80.2% less likely to be in the good health category than females.

Chapter 6. Discussion

6.1 Introduction

The discussion of the results is provided in five major parts or sections. The first and second sections relate to the first and second aims, respectively. These are followed by sections covering the study conclusions, practical implications and recommendations for future research.

6.2 Discussion of results relating to the first aim of the study

Figure 6.1 provides an illustration or model of the interactions between PA, fitness and health that is under scrutiny in this study in terms of the first aim. The model indicates that A (PA) leads to B (PF) and that both A and B leads to C (Health). The model also positions that A and B do not necessarily influence each other's relationships with C.

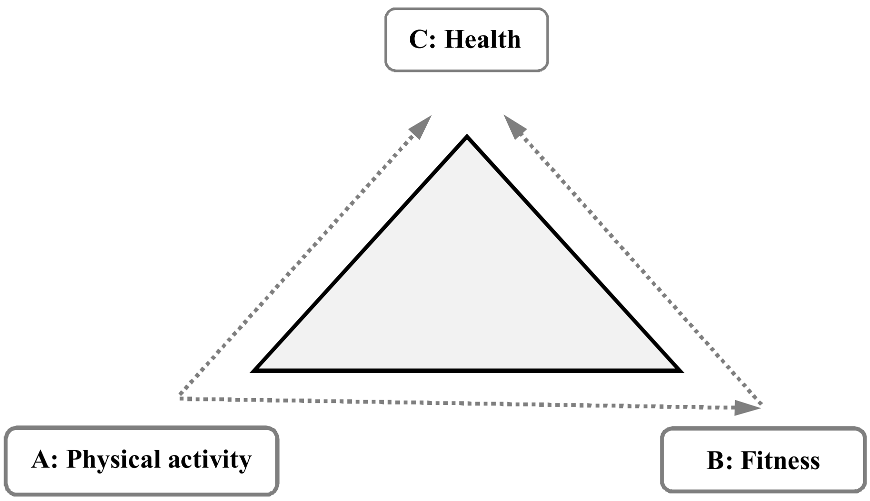


***Figure 6.1*. Model of physical activity, fitness and health inter-relationships**

The scientific angle of the present study is that it is more appropriate to test the interactions between fitness, PA and health with a relative measure of perceived intensity as opposed to an absolute measure of PA. In short, the moderating impact of a relative measure of perceived intensity of training on the AB, AC and BC relationships in an apparently healthy population were investigated.

More specifically, the first aim of this study was to determine whether relative perceived intensity of training moderates the PA-health (AC-line in Figure 6.1), PA-fitness (AB-line) and fitness-health (BC-line) relationships. The results indicate that perceived intensity of training had marginal moderating effects on the PA-health (AC) and the PA-fitness (AB) relationships. Perceived intensity of training had no moderating effect on the CV fitness-health (BC) relationship in the low fitness group and small moderating effects in the moderate and high fitness groups. The contribution of the measures of PA condenses to negligently small units in the presence of moderate and high levels of CV-fitness.

6.2.1 Intensity as moderator of the physical activity-health (AC) relationship

As explained in chapter 1 defining exercise intensity using an absolute scale in METs like the IPAQ may be limited because it neglects variations in PF.

In terms of the aims of the current study, the IPAQ were consequently considered 'contaminated' by fitness level, as well as by duration and frequency of training. What was needed for this study was a measure of relative perceived intensity and not an absolute PA score. Consequently, a relative intensity index developed by Sharkey (1984) was utilised, which has a Likert-like format, like the Borg RPE Scale.

The Borg RPE Scale (Borg, 1998) is commonly used during exercise stress testing. Good correlations exist between ratings on this scale and HR (r=0.80 to 0.90), during graded exercise testing (Borg, 1998; Lee et al., 2003). Lee et al. (2003) used the Borg scale to rate exertion level of habitual physical exercise of 7337 men. Participants were asked, "When you are exercising in your usual fashion, how would you rate your level of exertion (degree of effort)?" Men responded using a scale ranging from 0 ("nothing at all") to 10 ("maximal"). They found a dose-response relation with greater decrements in CHD rates at higher relative perceived intensities. This applied even to men not fulfilling current recommendations for PA. On the other hand, the absolute intensity of PA did not perform as well in distinguishing CHD risk groups (Lee et al., 2003).

Relative perceived intensity of training contributes more to the variances of virtually all the measures of health (IRS, CRI, Non-HDL and a composite of health) than the absolute PA scores (Table 4). The exceptions were the metabolic syndrome score (2.4% versus 1.2%) and the triglyceride/HDL-ratio (1.1% versus 0.9%).

6.2.2 Intensity as moderator of the physical activity dose-fitness (AB) relationship

A marginal tendency seems to exist in the data that perceived intensity moderates the PA dose-fitness (AB) relationship. The largest coefficient of determination (R^2) value is 20.3% (Table 5.5), indicating that, in this population, CV-capacity (MET) is not an exclusive product of participation in physical exercise. Research on genetic determination of CV-fitness indicates that genes account for 40-50% of individual variation in (Bouchard et al., 1999). CV-fitness is clearly not an exclusive product of PA. Therefore, it is unrealistic to expect close to perfect correlations between measures of PA and CV-fitness. A high CV-fitness is an indication of a highly integrated and well-functioning oxygen transport system free of pathological conditions. Genetics, underlying pathology, body composition, type of training/fitness testing can all influence how well PA patterns reflect CV status. The current data supports the idea that fitness and PA (even if it is high intensity) are separate entities that should be treated as separate risk factors. Maybe fitness status assessment should play an integral part in the CV risk paradigm.

In terms of measuring/assessing PA, the Sharkey intensity index did not excel as an outstanding predictor of fitness in this study. This was a slightly different outcome from what was expected and might be because the Sharkey relative intensity scale (stretching from 1 for light to 5 for sustained heavy breathing), has a ceiling effect. The intensity choices provided might not be broad enough to distinguish with apt exactitude between levels of intensity.

Paffenbarger, Blair, Lee, and Hyde (1993) compared the average weekly exercise records of 107 women and 457 men over six months before they completed a maximal exercise test on a treadmill. They found correlations between activity and fitness ranging from r=0.66 to r=0.83 across different age groups and both sexes. Dreyer et al. (2012) reported a correlation of r=0.65 between intensity of physical training and change in VO_{2peak} in clients that completed a 10-week exercise intervention program. Both these studies scored activity with the Cooper Clinic point system that corrects for intensity in the sense that the overall score is adjusted according to the time it takes to complete set workouts. The Cooper system adjustment for time is different from the IPAQ adjustments. The IPAQ multiply the vigorous days with activity minutes. The consequence is that it adjusts negatively for speed whereby a higher score is attained if the perceived 'vigorous' run is slower. In contrast, the Cooper points system adjusts positively for speed by achieving a higher score if it takes fewer minutes to complete a set task/run/distance.

The above findings support the idea that a more precise assessment of intensity might increase the fitness predictive qualities of PA questionnaires.

Helmerhorst et al. (2012) did a systematic review of reliability and objective criterion-related validity of PA questionnaires. They concluded that the validity of PA questionnaires was moderate at best. They emphasise the importance of accurate assessment of intensity levels as part of improving the validity of PA questionnaires. Strath et al. (2013) published a guide to the assessment of PA and stated that there is no single best instrument appropriate for every situation. It was against this backdrop that the Sharkey intensity index was trailed in the current study. The results of this study indicate that it lacks precision as a predictor of fitness, but not more so than the Baecke questionnaire, which is one of the better PA questionnaires, according to Helmerhorst et al. (2012).

6.2.3 Intensity as moderator of the fitness-health (BC) relationship

Intensity of training faded as a contributor to the composite health score when CV-fitness (expressed as MET), was included as a predictor variable. The same applied to duration, frequency, work, sport and leisure activity measures. Therefore, physical exercise (whether of perceived high intensity and of long duration and/or at high frequency), did not equate to better health in the presence of low CV-fitness in this analysis (Table 5.12).

The fact that the composite of health dropped by 52.8% across the fitness groups in the low-intensity group (Figure 5.1) indicates that fitness has health benefits independent of perceived intensity of exercise. A steeper downward trend across the fitness groups in the moderate and high perceived exercise intensity groups (109.8% and 104.3% respectively, versus 52.8% in the low-intensity group), exist. It suggests that perceived intensity of training has a positive effect on the CV fitness-health (BC) relationship. Similarly, Williams (2001) reported a 60% decline in risk for CVD from the least-fit to the most-fit, in contrast to a 30% decline in risk from the least-active to most-active.

That high-intensity exercise leads to greater fitness benefits (as compared to low and moderate intensity exercise), is not a new concept. What is new is the increasing awareness of how important intensity of training is in the case of health and rehabilitation. Kemi and Wisloff (2010) suggest that a threshold of intensity may exist for improving the heart's mechanical efficiency. In a multivariable meta-regression analysis, Uddin et al. (2015) found only exercise intervention intensity to be significantly associated with VO_{2max} ($p = 0.04$) in patients with CHD and heart failure.

6.3 Discussion of results relating to the second aim of the study

The second aim investigated the impact of intensity of physical training and CV-capacity on the psychological health-illness interactions. The psychological constructs correlated relatively poor with measures of PA and CV-capacity (R^2 averaging between 0% and 3%) and only slightly better with measures of health (R^2 averaging between 0.06% and 19.9%). CV-capacity proved to be a markedly better indicator/predictor of physical health than psychological constructs and intensity of training.

6.3.1 Relationship of psychological variables with health

The group means for the four psychological constructs used in this study are reported in Table 5.4 and indicate fairly good levels of psychological health in the cohort. The mean for stress symptoms was 13.56 ± 7.30 indicating low levels of stress (Cohen et al., 1983). The psychological burnout mean was 2.88 ± 0.66 indicating very low level of psychological burnout (Pines & Aronson, 1988). The mean score for the CES-D scale was 15.52 ± 6.04 indicating a normal score (Radloff, 1977). The group mean for the Affectometer happiness scale was 21.59 ± 10.94 indicating a good level of psycho-emotional wellness or happiness (Kammann & Flett, 1983).

These four psychological or mental health constructs were correlated with 5 measures of health (IRS, CRI, Non-HDL, triglyceride/HDL-ratio, metabolic syndrome and the composite of health). None of the instruments correlated statistically significantly ($p>0.05$) with the measures of health. The stress symptoms instrument was the only psychological construct that correlated moderately with both the IRS ($r=0.446$), CRI ($r=0.429$) and the composite of health ($r=0.433$). This resulted in R^2 values of respectively 19.9%, 18.4% and 18.7%. The constructs of psychological health utilized in this study, therefore, contributed poorly to the variances of measures of health. One possible reason for this might be the fact that the group means values as indicated in Table 5.4 indicate fairly good levels of psychological health.

6.3.2 Intensity as moderator of the VO_{2peak} psychological health relationship

Both CV-capacity and intensity of training contributed poorly to the variances of constructs of psychological health. The correlations varied between 0.2% and 3.0% in the case of intensity of training and 0.09% and 0.5% in the case of CV-capacity (Table 5.13). This indicates that the Psychological constructs and measures of PA/fitness contributes very little to each other's variance. The psychological construct that evidenced the best relationship with the independent variables (CV-capacity and intensity of training) was stress symptoms (Table 5.15). CV-capacity contributed slightly more than intensity of training (3.6 versus 3.0%) to the variance of stress symptoms. CV-capacity was also the better predictor (as opposed to intensity of training) of high stress in the binary logistic regression analysis (Table 5.16).

Measures of PA and CV-capacity showed relatively poor relationships with psychological health in this study. Probable influences on the strength of the relationships could be the fact that the mean scores for the psychological constructs was in the normal bracket as well as the relatively high mean levels of PA/CV-capacity in the cohort. As indicated in Chapter 3 moderate to high intensity exercise as well as higher levels of CV-fitness seems to coincide with better levels of psychological health. The type of constructs/questionnaires used to assess psychological health in exercise studies also seems to impact on results. In this study a questionnaire used to assess stress symptoms showed superior relationships with measures of CV-capacity and PA as compared to measures of happiness, depression and psychological burnout. The relationships between psychological health and PA and CV-capacity are generally poor in this study. It is therefore difficult to make a conclusive statement regarding whether intensity moderates the CV-capacity psychological relationship. However, CV-capacity generally contributes more to the variances of almost all the constructs of psychological health in the ANCOVA (Table 5.15) than intensity of training. In the first binary logistic regression analysis (Table 5.16) CV-capacity emerged as a markedly better predictor of psychological distress than intensity of training (12.6% versus 6.7%).

As has been illustrated in Chapter 2, fitness has a strong genetic component and is not synonymous with participation in PA. The possibility that CV fitness has mental health benefits independent from PA, therefore, needs to be entertained as a possible explanation for the findings of this study.

6.3.3 CV-capacity as moderator of the stress health relationship

CV-capacity proved to be a markedly better predictor (44.4% versus 7.1%) of health (as measured with the composite of health) than stress symptoms in the binary logistic regression analysis reported in Table 5.17. Intensity of training evidenced an odds ratio of 0.009% which means it contributed almost nothing as a predictor of health in the presence of CV-capacity, psychological health (stress symptoms), age and body weight. CV-capacity consequently emerged as a better indicator or predictor of illness/health than stress symptoms and intensity of training. Stress symptoms as predictor of health proved to be comparatively better than chronological age (7.1% versus 4.8%).

The second aim of the present study was to determine whether the association between psychological health and measures of health are moderated or mediated by CV-fitness and intensity of physical training. There seems to be a lack of studies that investigated the potential impact of psychological health on the intricate fitness/PA/health-relationships. One of the major contributions of this thesis to current knowledge is, therefore, that it investigates the effect of a relative measure of perceived intensity on the interactions between stress, illness and CV-capacity.

CV-capacity computed as the superior predictor -in comparison to psychological distress (stress symptoms) and intensity of training- in the binary logistical regression analysis procedures conducted in this study. This should be considered in relation to the data presented in Tables 5.7 and 5.14. In Table 5.7 CV-capacity contributed 4.5% to the variance of the composite of health. In Table 5.14 stress symptoms contributed 18.7% to the variance of the composite of health. Stress symptoms therefore contributed more to the variance of health than CV-capacity in the two mentioned partial correlation analyses. However, when they were both included in the same analysis -such as in the binary logistic regression analysis CV-capacity become amplified as a predictor of health while stress symptoms declined as predictor. In terms of the second aim this seems to indicate a CV-capacity moderating effect on the association between the utilized measure of psychological health and the composite health score. This is rather unique information as no other study could be found that investigated the moderating effect of CV-capacity on the stress/illness relationship.

In contrast, the contribution of intensity of training to health seems to disappear in the presence of CV-capacity and psychological distress. A potential explanation for this may be that high intensity exercise might be counterproductive in the presence of low CV-capacity and elevated levels of psychological stress.

According to Leidy's framework, functional status includes four dimensions: functional capacity, functional performance, functional capacity utilization, and functional reserve (Leidy, 1994). Functional capacity is defined as one's maximal capacity to perform a specific task in the physical, social, psychological or cognitive domains. For example, functional capacity might be one's maximal ability in strength and endurance or in aptitude or memory. The second dimension, functional performance, refers to activities that one performs on a day-to-day basis. Functional performance could be assessed by the level of physical activity and energy expended to complete any particular task. Functional performance also could be influenced by functional capacity, as in cases when reduced capacity limits performance of day-to-day activities. The third dimension, capacity utilization, refers to the percentage of functional capacity that is used day to day. The fourth dimension, functional reserve, refers to the difference between capacity utilization and functional capacity. People generally do not function at 100% of their capacity on a day-to-day basis, and people with high capacity might use only a small percentage of their capacity daily. When functional capacity declines, a person might be required to use a higher percentage of capacity or to cut back on daily activities. High intensity exercise might according to this model exceed functional reserve and hence impact negatively on post exercise recovery in those with low functional capacity and high levels of stress.

6.4 Limitations

While the findings of this thesis provide novel insights into the contributions of CV-capacity and measures of mental health to physical health, it is acknowledged that there are some limitations to the present study that may impact on the reliability of the results and their interpretations. The cross-sectional design of the present study averts cause and effect conclusions, in the first instance. The other primarily limitations include the CV-capacity and PA measurement, tools and the characteristics of the study population.

6.4.1 Exercise capacity measurement

In the present study, only an indirect sub-maximal cycle ergometry method was used to estimate VO_{2peak}. Direct gas exchange measures were not used in this study due to inaccessibility and time required to do direct gas exchange measurement on the entire study population. It was simply not logistically viable but it is acknowledged that cardiopulmonary exercise testing would have improved the accuracy of peak oxygen uptake measurement. However, medical supervision would have been required to perform maximal exercise testing on some high-risk participants and this was not feasible for this study. In defence, the extrapolation method used to predict VO_{2peak} from the YMCA submaximal leg ergometer test has been shown to provide accurate predictions values (Beekley et al., 2004). However, Garatachea, Cavalcanti, García-López, González-Gallego, and de Paz (2007) reported that predicted VO_{2max} was overestimated in healthy adults by 5.4% for men, and 11.8% for women for the YMCA protocol. Per implication it might be possible that direct measured VO_{2peak} measures would correlate better with measures of PA and intensity of training as was reported in Chapter 5.

6.4.2 Physical activity measures

Two measuring instruments were used to access participation in PA, namely the Baecke PA questionnaire (Baecke et al., 1982) and the index developed by Sharkey (1984). These questionnaires were selected purposefully because it utilizes relative scales to measure intensity, duration and frequency of training as opposed to absolute scales. Pitta et al. (2006) stated that care must be taken when using subjective methods of measuring PA, as they rely on patient memory and report. Accelerometers are a more reliable method to accurately quantify PA levels; however, they can only accurately measure lower body activity. Measurement of hand/arm movements involving the carrying or lifting of objects cannot be tracked accurately. In addition, accelerometers need to be worn for at least a couple of days to provide accurate PA profile data. Logistically this poses a major problem with large study populations.

Questionnaires are inexpensive and easy to apply and provide subjective insights of the patientǒs views of their own PA levels; however, patients may underestimate sedentary activities or overestimate their true level of PA by 300% (Klesges et al., 1990). However, to enhance the reliability of the PA measurements the PA questionnaire was completed under supervision of the researchers, and careful interviewing of the participants was applied when recalling their PA of their last typical week in an attempt to avoid any under or overestimation of weekly PA.

As mentioned before (in this Chapter) the Sharkey relative intensity scale (stretching from 1 for light to 5 for sustained heavy breathing), might have had a ceiling effect. This resulted in an inability to measure high intensity with the amount of exactness that was required.

6.4.3 Characteristics of the study population

Two hundred and thirty-seven (N=237) participants from 8 different companies were tested. The majority (59.9%) were female. The female sample size in itself was too small to use alone for the type of statistical procedures utilized. The result was that the cohort consisted of an unequal number of males and females. As counter, statistical control measures were employed for almost all statistical procedures. This is acceptable practice but it is not impossible that the findings could differ in a cohort consisting of exclusively males or females.

The group mean for participation in PA and CV-capacity were above average indicating a fairly physically active and physically fit cohort. The mean psychological health scores in contrast were fairly low indicating cohort with low numbers of individuals in psychological distress. This could potentially have impacted on the results.

6.5 Future research

The present thesis aimed to determine the moderating effect of intensity of training on the interactions PA, CV-capacity, physical and mental health. The study cohort presents a relatively healthy group of adults Ó20 years of age. A similar study on individuals with co-morbidities is required. Future research could also benefit from using broader relative intensity scales and accelerometers.

Optimal exercise rehabilitation strategies need to be investigated to enhance the effectiveness of exercise training. It is apparent that high intensity exercise could potentially be counterproductive in those with high levels of psychological distress. Exercise training programmes may need to be individualised to match the functional capacity and the level of psychological distress to gain insight on the exercise dose required to optimize health benefits. This might enhance the understanding of how to gain maximum benefits from exercise in those with either low functional capacities, high levels of distress and chronic disease. In short studies that provide more clarity on the relationship between stress and PA in those suffering with established psychological stress are required.

Alternative testing methods to determine psychological health, CV-capacity and physical health are needed as part of a similar investigation into the importance of intensity of training. In addition, the importance of CV-capacity as part of risk stratification and/or as independent indicator of mental and physical health needs more exploration. Future research should focus on the establishment of CV-capacity and PA parameter norms that lead to optimal health outcomes.

6.6 Practical implications

The practical implications of the findings of this study are that PA and CV-fitness should be considered partly distinct components of health. Poor fitness and physical inactivity should be considered separate and inter-related risk factors. The findings leave the impression that the use of relative measures of intensity of training might positively affect the predictive (health and fitness) accuracy of PA questionnaires. Data from the current study and the literature quoted confirm that exercise of higher perceived intensity equates with better health outcomes. However, high-intensity exercise did not parallel with better health in the absence of moderate and high levels of fitness. Therefore, the data could also indicate that exercise for health needs to be of sufficient intensity to improve levels of CV-fitness (Defina et al., 2015; Franklin, 2007; Kemi & Wisloff, 2010; Tjønna et al., 2013; Williams, 2001). Rhen et al. (2013) states in this regard: "The question today is not whether physical activity per se has beneficial effects. The question is how to attain a sufficient level of high-intensity physical activity in all strata of the population."

6.7 Conclusions

Ultimately, CV-fitness emerged as a potent marker of physical health if not mental health in this study. Physical exercise on the other hand did not equate with better health in the absence of at least reasonable levels of fitness in this cross-sectional study of a selection of the workforce in the Manawatu region in New Zealand.

Chapter 7. Reference List

ACSM. (2010). *American College of Sports Medicine, ACSM's health-related physical fitness assessment manual.*: Philadelphia, PA: Lippincott Williams & Wilkins.

ACSM. (2013). *American College of Sports Medicine health-related physical fitness assessment manual*: Lippincott Williams & Wilkins.

Anokye, N., K,, Trueman, P., Green, C., Pavey, T., G,, & Taylor, R., S,. (2012). Physical Activity and Health Related Quality of Life. *BMC Public Health 12*(624).

Baecke, J. A., Burema, J., & Frijters, J. E. (1982). A short questionnaire for the measurement of habitual physical activity in epidemiological studies. *American Journal for Clinical Nutrition, 36*(5), 936-942.

Barbour, K. A., Edenfield, T. M., & Blumenthal, J. A. (2007). Exercise as a treatment for depression and other psychiatric disorders. *Journal of Cardiopulmonary Rehabilitation and Prevention, 27*, 359-367.

Beekley, M. D., Brechue, W. F., Dehoyos, D. V., Garzarella, L., Werber-Zion, G., & Pollock, M. L. (2004). Cross-validation of the YMCA submaximal cycle ergometer test to predict VO2max. *Research Quarterly for Exercise and Sport, 75*(3), 337-342.

Bergh, C., Udumyan, R., Fall, K., Almroth, H., & Montgomery, S. (2015). Stress resilience and physical fitness in adolescence and risk of coronary heart disease in middle age. *Heart, 101*(8), 623-629.

Biddle, S., JH, Fox, K., & Boutcher, S. (2003). *Physical activity and psychological well-being*: Routledge.

Biddle, S., JH, & Mutrie, N. (2008). *Psychology of physical activity: Determinants, well-being and interventions* (2nd ed.). Oxon: Routledge

Bjurstrom, L. A., & Alexiou, N. G. (1978). A program of heart disease intervention for public employees: A five year report. *Journal of Occupational Medicine, 20*(8), 521-531.

Blair, S., N, Kohl, H., W, Paffenbarger, R., S, Clark, D., G, Cooper, K., H, & Gibbons, L., W. (1989). Changes in physical fitness and all-cause mortality: A prospective study of healthy men and women. *Journal of the American Medical Association, 262*, 2395-2401.

Borg, G. (1998). *"Borg's perceived exertion and pain scales"* Human Kinetics. Retrieved from http://books.google.co.nz/books?id=qgUKnwEACAAJ

Bouchard, C., An, P., Rice, T., Skinner, J. S., Wilmore, J. H., Gagnon, J., . . . Rao, D. (1999). Familial aggregation of V02max response to exercise training: Results from the HERITAGE family study. *Journal of Applied Physiology, 87*(3), 1003-1008.

Bouchard, C., Blair, S., N, & Haskell, W., L. (2012). *Physical Activity and Health* (2nd ed.). Champaign IL: Human Kinetics

Carmack, C. L., Boudreaux, E., Amaral-Melendez, M., Brantley, P. J., & de Moor, C. (1999). Aerobic fitness and leisure physical activity as moderators of the stress-illness relation. *Annals of Behavioural Medicine, 21*(3), 251-257.

Caspersen, C., J, Powell, K., E, & Christenson, G., M. (1985). Physical activity, exercise and physical fitness: Definitions and distinctions for health-related research *Public Health Reports, 100*(2), 126-131.

Cezaretto, A., Pakseresht, M., Sharma, S., Kolahdooz, F., Siqueira-Catania, A., de Barros, C. R., & Ferreira, S. R. G. (2015). Influence of depression on cardiometabolic responses to a lifestyle intervention in at-risk individuals. *Journal of Affective Disorders, 174*, 516-521.

Chu, I. H., Buckworth, J., Kirby, T. E., & Emery, C. F. (2009). Effect of exercise intensity on depressive symptoms in women. *Mental Health and Physical Activity, 2*(1), 37-43. doi:10.1016/j.mhpa.2009.01.001

Clennin, M. N., Payne, J. P. W., Rienzi, E. G., Lavie, C. J., Blair, S. N., Pate, R. R., & Sui, X. (2014). Association between cardiorespiratory fitness and health-related quality of life among patients at risk for cardiovascular disease in Uruguay. *PLoS One, 10*(4). doi:10.1371/journal.pone.0123989

Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress *Journal of Health and Social Behavior* 385-396.

Committee, P. A. G. A. (2008). *Physical activity guidelines advisory committee report, 2008*.

Conraads, V. M., Pattyn, N., De Maeyer, C., Beckers, P. J., Coeckelberghs, E., Cornelissen, V. A., . . . Vanhees, L. (2014). Aerobic interval training and continuous training equally improve aerobic exercise capacity in patients with coronary artery disease: the SAINTEX-CAD study. *International Journal of Cardiology, 179*, 203-210. doi:10.1016/j.ijcard.2014.10.155

Cornelissen, V. A., Arnout, J., Holvoet, P., & Fagard, R. H. (2009). Influence of exercise at lower and higher intensity on blood pressure and cardiovascular risk factors at older age. *Journal of Hypertension, 27*(4), 753-762. doi:10.1097/HJH.0b013e328322cf60

Da Luz, P. L., Favarato, D., Faria-Neto, J. R., Lemos, P., & Chagas, A. C. P. (2008). High ratio of triglycerides to HDL-cholesterol predicts extensive coronary disease. *Clinics, 63*(4), 427-432.

Defina, L. F., Haskell, W. L., Willis, B. L., Barlow, C. E., Finley, C. E., Levine, B. D., & Cooper, K. H. (2015). Physical activity versus cardiorespiratory fitness: Two (partly) distinct components of cardiovascular health? *Progress in Cardiovascular Disease, , 57*(4), 324-329.

Dishman, R., K. (1994). *Advances in exercise adherence*: Human Kinetics Publishers.

Dreyer, L., Dreyer, S., & Rankin, D. (2012). Effects of a 10-week high-intensity exercise intervention on college staff with psychological burnout and multiple risk factors. *Journal of Research, 7*(1).

Dreyer, L. I., & Strydom, G. L. (1994). Physical activity and some morphological, physiological and biochemical parameters among executives. *South African Journal for Research in Sport, Physical Education and Recreation, 17*(1), 1-14.

Dunn, A. L., Trivedi, M. H., Kampert, J. B., Clark, C. G., & Chambliss, H. O. (2005). Exercise treatment for depression, efficacy and dose response. *American Journal of Medicine, 28*(1), 1-8. doi:10.1016/j.amepre.2004.09.003

Epel, E. S., McEwen, B., Seeman, T., Matthews, K., Castellazzo, G., Brownell, K. D., . . . Ickovics, J. R. (2000). Stress and body shape: stress-induced cortisol secretion is consistently greater among women with central fat. *Psychosomatic Medicine, 62*(5), 623-632.

Fletcher, G. F., Balady, G., Blair, S. N., Blumenthal, J., Caspersen, C., Chaitman, B., . . . Pollock, M. L. (1996). Statement on exercise: Benefits and recommendations for physical activity programs for all Americans: A statement for health professionals by the committee on exercise and cardiac rehabilitation of the council on clinical cardiology. *Circulation, 94*(4), 857-862.

Franklin, B. A. (2007). Fitness: The ultimate marker for risk stratification and health outcomes?. *Preventive Cardiology, 10*(1), 42-45; quiz 46.

Garatachea, N., Cavalcanti, E., García-López, D., González-Gallego, J., & de Paz, J. A. (2007). Estimation of energy expenditure in healthy adults from the YMCA submaximal cycle ergometer test. *Evaluation & the Health Professions, 30*(2), 138-149.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I.-M., . . . Swain, D. P. (2011). American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: Guidance for prescribing exercise. *Medicine and Science in Sports and Exercise, 43*(7), 1334-1359.

Gerber, M., Brand, S., Herrmann, C., Colledge, E., Holsboer-Trachsler, E., & Pühse, U. (2014). Increased objectively assessed vigorous-intensity exercise is associated with reduced stress, increased mental health and good objective and subjective sleep in young adults *Physiology and Behviour, 135*, 17-24. doi:10.1016/j.physbeh.2014.05.047

Gerber, M., Lindwall, M., Lindegard, A., B˜rjesson, M., & Jonsdottir, I. H. (2013). Cardiorespiratory fitness protects against stress-related symptoms of burnout and depression. *Patient Education and Counseling, 93*(1), 146-152. doi:10.1016/j.pec.2013.03.021

Gibala, M. J., Little, J. P., MacDonald, M. J., & Hawley, J. A. (2012). Physiological adaptations to low-volume, high-intensity interval training in health and disease. *The Journal of Physiology, 590*(5), 1077-1084.

Grundy, S. M., Brewer, H. B., Cleeman, J. I., Smith, S. C., & Lenfant, C. (2004). Definition of metabolic syndrome. report of the national heart, lung and blood institute/american heart association conference on scientific issues related to definition. *Circulation, 109*(3), 433-438.

Hamer, M., & Stamatakis, E. (2010). Objectively assessed physical activity, fitness and subjective wellbeing. *Mental Health and Physical Activity, 3*(2), 67-71. doi:10.1016/j.mhpa.2010.09.001

Hann, D., Winter, K., & Jacobsen, P. (1999). Measurement of depressive symptoms in cancer patients: Evaluation of the center for epidemiological studies depression scale (CES-D). *Journal of Psychosomatic Research, 46*(5), 437-443.

Health, P. A. a. (1996). *Physical activity and health: A report of the surgeon general*. United States. Department of Health Human Services: diane Publishing.

Hegberg, N. J., & Tone, E. B. (2015). Physical activity and stress resilience: considering those at-risk for developing mental health problems. *Mental Health and Physical Activity, 8*, 1-7. doi:10.1016/j.mhpa.2014.10.001

Helgadђttir, B., Forsell, Y., & Ekblom, ̀ . (2015). Physical activity patterns of people affected by depressive and anxiety disorders as measured by accelerometers: A cross-sectional study. *PLoS One, 10*(1). doi:10.1371/journal.pone.0115894

Helmerhorst, H., JF, Brage, S., Warren, J., Besson, H., & Ekelund, U. (2012). A systematic review of reliability and objective criterion-related validity of physical activity questionnaires. *International Journal of Behavioral Nutrition and Physical Activity, 9*(103).

Herrman, H., & Jané-Llopis, E. (2012). The status of mental health promotion. *Public Health Reviews, 34*(2).

Hu, B., Liu, X., Wang, C., Yin, S., Yu, L., Zhang, T., . . . Feng, F. (2015). Vigorous-intensity physical activity is associated with metabolic syndrome among the Chinese middle-aged population: A cross-sectional study. *International Journal of Sport Nutrition Exercise Metabolism, 25*(2), 119-127. doi:10.1123/ijsnem.2013-0231

IPAQ Research Commitee. (2005). *Guidelines for data processing and analysis of the international physical activity questionnaire (IPAQ): Short and long forms*. Retrieved 12 March 2015, from http://www.ipaq.ki.se/scoring.pdf

ISAK. (2001). *International Society for the Advancement of Kinanthropometry International standards for anthropometric assessment*. Underdale, Adelaide, South Australia: National Library of Australia.

Janssen, I., & Ross, R. (2012). Vigorous intensity physical activity is related to the metabolic syndrome independent of the physical activity dose. *Inernational Journal of Epidemiology, 41*(4), 1132-1140. doi:10.1093/ije/dys038

Kammann, R., & Flett, R. (1983). Affectometer 2: A scale to measure current level of general happiness. *Australian Journal of Psychology, 35*(2), 259-265.

Kangas, J. L., Baldwin, A. S., Rosenfield, D., Smits, J. A., & Rethorst, C. D. (2015). Examining the moderating effect of depressive symptoms on the relation between exercise and self-efficacy during the initiation of regular exercise. *Health Psychology, 34*(5), 556-565.

Katzmarzyk, P. T., Church, T. S., & Blair, S. N. (2004). Cardiorespiratory fitness attenuates the effects of the metabolic syndrome on all-cause and cardiovascular disease mortality in men. *American Medical Association 164*, 1092-1097.

Kemi, O. J., & Wisloff, U. (2010). High-intensity aerobic exercise training improves the heart in health and disease. *Journal of Cardiopulmonary Rehabilitation and Prevention, 30*(1), 2-11.

Kim, J., Oberman, A., Fletcher, G. F., & Lee, J. Y. (2001). Effect of exercise intensity and frequency on lipid levels in men with coronary heart disease: Training level comparison trial. *American Journal of Cardiology 87*.

Kinder, L. S., Carnethon, M. R., Palaniappan, L. P., King, A. C., & Fortmann, S. P. (2004). Depression and the metabolic syndrome in young adults: Findings from the Third

National Health and Nutrition Examination Survey. *Psychosomatic Medicine, 66*(3), 316-322.

Klesges, R. C., Eck, L. H., Mellon, M. W., Fulliton, W., Somes, G. W., & Hanson, C. L. (1990). The accuracy of self-reports of physical activity. *Medicince and Science in Sports and Exercise, 22*(5), 690-697.

Kobasa, S. C. (1979). Stressful life events, personality, and health: an inquiry into hardiness. *Journal of Personality and Social Psychology, 37*(1), 1.

Kohl, H. W., 3rd, & Murray, T. D. (2012). *Foundations of physical activity and public health*: Human Kinetics

Lee, I. M., Sesso, H. D., Oguma, Y., & Paffenbarger, R. S., Jr. (2003). Relative intensity of physical activity and risk of coronary heart disease. *Circulation, 107*(8), 1110-1116.

Leidy, N. K. (1994). Functional status and the forward progress of merry-go-rounds: Toward a coherent analytical framework. *Nursing Research, 43*(4), 196-202.

Logio, K. A., Dowdall, G. W., Babbie, E. R., & Halley, F. S. (2008). *Adventures in criminal justice research.* Retrieved 24 June 2015 from http://dx.doi.org/10.4135/9781412990318

Martin, B., Arena, R., Haykowsky, M., Hauer, T., Austford, L. D., Knudtson, M., . . . Stone, J. A. (2013). Cardiovascular fitness and mortality after contemporary cardiac rehabilitation. *Medical Education and Research 88*(5), 455-463.

Mental Health Foundation. (2014). *New Zealand quick facts and stats: mental disorders*. Retrieved from https://www.mentalhealth.org.nz/assets/Uploads/MHF-Quick-facts-and-stats-FINAL.pdf

Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., . . . Froelicher, V. (2004). Fitness versus physical activity patterns in predicting mortality in men. *American Journal of Medicine, 117*(12), 912-918. doi:10.1016/j.amjmed.2004.06.047

Myers, J., McAuley, P., Lavie, C. J., Despres, J.-P., Arena, R., & Kokkinos, P. (2015). Physical activity and cardiorespiratory fitness as major markers of cardiovascular risk: Their independent and interwoven importance to health status. *Progress in Cardiovascular Diseases, 57*(4), 306-314.

O'Donovan, G., Owen, A., Bird, S., R, Kearney, E., M, Nevill, A., M, Jones, D., W, & Woolf-May, K. (2005). Changes in cardiorespiratory fitness and coronary heart disease risk factors following 24 wk of moderate-or high intensity exercise of equal energy cost. *Journal of Applied Physiology, 98*, 1619-1625.

Paffenbarger, R. S., Blair, S. N., Lee, I. M., & Hyde, R. T. (1993). Measurement of physical activity to assess health effects in free-living populations. *Journal of Medicine and Science in Sports and Exercise, 25*(1), 60-70.

Patte, R., R. (1988). The evolving definition of physical fitness. *QUEST, 40*, 174-179.

Perales, F., Pozo-Cruz, J. d., & Pozo-Cruz, B. d. (2014). Impact of physical activity on psychological distress: A prospective analysis of an Australian national sample. *American Journal of Public Health, 104*(12), 91-97.

Philippaerts, R. M., & Lefevre, J. (1998). Reliability and validity of three physical activity questionnaires in Flemish males. *American Journal of Epidemiology, 147*(10), 982-990.

Pines, A., & Aronson, E. (1988). *Career burnout: Causes and cures*. New York: The Free Press.

Pines, A., Aronson, E., & Kafry, D. (1981). *Burnout: From tedium to personal growth* (Vol. The Free Press): New York.

Pitta, F., Troosters, T., Probst, V., Spruit, M., Decramer, M., & Gosselink, R. (2006). Quantifying physical activity in daily life with questionnaires and motion sensors in COPD. *European Respiratory Journal, 27*(5), 1040-1055.

Prince, M., Patel, V., Saxena, S., Maj, M., Maselko, J., Phillips, M. R., & Rahman, A. (2007). No health without mental health. *The Lancet, 370*(9590), 859-877. doi:10.1016/s0140-6736(07)61238-0

Radloff, L. S. (1977). The CES-D scale a self-report depression scale for research in the general population. *Applied Psychological Measurement, 1*(3), 385-401.

Ramos, J. S., Dalleck, L. C., Tjønna, A. E., Beetham, K. S., & Coombes, J. S. (2015). The impact of high-intensity interval training versus moderate-intensity continuous training on vascular function: A systematic review and meta-analysis. *Sports Medicine, 45*(5), 679-692.

Rhen, T. A., Winett, R. A., Wisloff, U., & Rognmo, O. (2013). Increasing physical activity of high intensity to reduce the prevalence of chronic diseases and improve public health. *Open Cardiovascular Medicine Journal, 7*(1), 1-8.

Richards, J., Jiang, X., Kelly, P., Chau, J., Bauman, A., & Ding, D. (2015). Don't worry, be happy: Cross-sectional associations between physical activity and happiness in 15 European countries. *BMC Public Health, 15*, 53. doi:10.1186/s12889-015-1391-4

Sassen, B., Cornelissen, V. A., Kiers, H., Wittink, H., Kok, G., & Vanhees, L. (2009). Physical fitness matters more than physical activity in controlling cardiovascular disease risk factors. *European Journal of Cardiovascular Prevention Rehabilitation, 16*(6), 677-683. doi:10.1097/HJR.0b013e3283312e94

Schaufeli, W. B., Maslach, C., & Marek, T. (1993). *Professional burnout. Recent developments in theory and research*. Washington, D. C.: Taylor & Francis.

Schroeder, D. H., & Costa, P. T. (1984). Influence of life event stress on physical illness: Substantive effects or methodological flaws. *Journal of Personality and Social Psychology, 46*(4), 853-863.

Sharkey, R. J. (1984). Physiology of fitness. Champaign IL: Human Kinetics

Shephard, R. J. (2002). Limits to the measurement of habitual physical activity by questionnaires. *Journal of Sports Medicine, 37*(3), 197-206.

Shephard, R. J., & Bouchard, C. (1994). Population evaluations of health related fitness from perceptions of physical activity and fitness. *Canadian Journal of Applied Physiology, 19*(2), 151-173.

Shirom, A. (1989). *A Burnout in work organizations In C. L. Cooper, & I. T. Robertson (Eds), International review of industrial and organizational psychology* New York Wiley

Stanton, R., & Happell, B. (2014). Exercise for mental illness: A systematic review of inpatient studies. *International Journal of Mental Health Nursing, 23*(3), 232-242. doi:10.1111/inm.12045

Stanton, R., & Reaburn, P. (2014). Exercise and the treatment of depression: A review of the exercise program variables. *Journal of Science and Medicine in Sport, 17*(2), 177-182. doi:10.1016/j.jsams.2013.03.010

Stathopoulou, G., Powers, M. B., Berry, A. C., Smits, J. A., & Otto, M. W. (2006). Exercise interventions for mental health: a quantitative and qualitative review. *Clinical Psychology: Science and Practice, 13*(2), 179-193.

Strath, J. S., Kaminsky, L. A., Ainsworth, B. E., Ekelund, U., Freedson, P. S., Gary, R. A., . . . Swartz, A. M. (2013). Guide to the assessment of physical activity, clinical and research applications: A scientific statement from the American Heart Association. *American Heart Association. Circulation, 128*(20), 2259-2279.

Str˜hle, A. (2009). Physical activity, exercise, depression and anxiety disorders. *Journal of Neural Transmission (Vienna), 116*(6), 777-784. doi:10.1007/s00702-008-0092-x

Stults-Kolehmainen, M. A., Tuit, K., & Sinha, R. (2014). Lower cumulative stress is associated with better health for physically active adults in the community. *The International Journal on the Biology of Stress, 17*(2), 157-168. doi:10.3109/10253890.2013.878329

Swain, D. P. (2005). Moderate or vigorous intensity exercise: which is better for improving aerobic fitness? . *Preventive Cardiology, 8*(1), 55-58.

Tennant, R., Joseph, S., & Stewart-Brown, S. (2007). The Affectometer 2: A measure of positive mental health in UK populations. *Quality of Life Research, 16*(4), 687-695.

Teychenne, M., Ball, K., & Salmon, J. (2008). Physical activity and likelihood of depression in adults: A review. *Preventive Medicine, 46*(5), 397-411.

Thomas, J., R, Silverman, S., & Nelson, J. (2015). *Research Methods in Physical Activity, 7E*: Human kinetics.

Thombs, B. D., Hudson, M., Schieir, O., Taillefer, S. S., & Baron, M. (2008). Reliability and validity of the Center for Epidemiologic Studies Depression Scale in patients with systemic sclerosis. *Arthritis Care and Research, 59*(3), 438-443.

Tjønna, A. E., Leinan, I. M., Bartnes, A. T., Jenssen, B. M., Gibala, M. J., Winett, R. A., & Wisløff, U. (2013). Low- and high-volume of intensive endurance training significantly improves maximal oxygen uptake after 10-weeks of training in healthy men. *PLoS ONE, 8*(5), 8-14. doi:10.1371/journal.pone.0065382

Uddin, J., Zwisler, A. D., Lewinter, C., Moniruzzaman, M., Lund, K., Tang, L. H., & Taylor, R. S. (2015). Predictors of exercise capacity following exercise-based rehabilitation in patients with coronary heart disease and heart failure: A meta-regression analysis. *European Journal of Preventive Cardiology*.

Vanhees, L., Lefevre, J., Philippaerts, R., Martens, M., Huygens, W., Troosters, T., & Beunen, G. (2005). How to assess physical activity? How assess physical fitness? *European Journal of Cardiovascular Prevention and Rehabilitation, 12*, 102-114.

Warburton, D. E., Nicol, C. W., & Bredin, S. S. (2006). Health benefits of physical activity: The evidence. *Canadian Medical Association Journal, 174*(6), 801-809.

Warren, J. M., Ekelund, U., Besson, H., Mezzani, A., Geladas, N., & Vanhees, L. (2010). Assessment of physical activity - a review of methodologies with reference to epidemiological research: A report of the exercise physiology section of the European association of cardiovascular prevention and rehabilitation. *European Journal of Cardiovascular Prevention and Rehabilitation, 17*(2), 127-139.

WHO. (1968). World Health Organization exercise tests in relation to cardiovascular function: Report of a WHO meeting [held in Geneva from 25 to 30 September 1967].

WHO. (2004). *World Health Organisation: Promoting mental health, concepts, emerging evidence, practice*. Retrieved from http://www.who.int/mental_health/evidence/en/promoting_mhh.pdf

WHO. (2011). *World Health Organisation: No health without mental health*. Retrieved from https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213761/dh_124058.pdf

Williams, P. T. (2001). Physical fitness and activity as seperate heart disease risk factors: a meta-analysis. *Journal of the American College of Sport Medicine*.

Wisløff, U., Støylen, A., Loennechen, J. P., Bruvold, M., Rognmo, Ø., Haram, P. M., . . . Skjaerpe, T. (2007). Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: A randomized study. *Journal of the American Heart Association, 115*(24), 3086-3094. doi:10.1161/CIRCULATIONAHA.106.675041

Wu, M. H., Lee, C. P., Hsu, S. C., Chang, C. M., & Chen, C. Y. (2015). Effectiveness of high-intensity interval training on the mental and physical health of people with chronic schizophrenia. *Neuropsychiatric Disease and Treatment, 11*, 1255-1263. doi:10.2147/NDT.S81482

Wyler, A. R., Masuda, M., & Holmes, T. H. (1968). Seriousness of illness rating scale. *Journal of Psychosomatic Research, 11*(4), 363-374.