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EFFECTS OF PHYSICAL ACTIVITY AND FITNESS ON THE PSYCHOLOGICAL WELLBEING OF YOUNG MEN AND WORKING ADULTS: ASSOCIATIONS WITH STRESS, MENTAL RESOURCES, OVERWEIGHT AND WORKABILITY

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ABSTRACT

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Effects of physical activity and fitness on the psychological wellbeing of young men and working adults: associations with stress, mental resources, overweight and workability

University of Turku, Faculty of Medicine, Department of Physical Activity and Health, Paavo Nurmi Center, University of Turku, Doctoral Programme of Clinical Investigion. Annales Universitas Turkuensis, Medica-Odontologica, Turku, Finland, 2015.

Background: A positive association has been suggested to exist between physical activity and psychological wellbeing. However, the association between physical fitness, especially muscle fitness and psychological wellbeing, has not yet been fully elucidated.

Aims: The objective of the present thesis was to assess the relationship between physical activity and physical fitness with stress symptoms, mental resources and workability among young men and working adults.

Subjects and methods: Volunteers of young men (n=831, mean age 25-y (±4.0)), underwent a cardiorespiratory (CRF) and muscle fitness (MFI) test and completed leisure time physical activity (LTPA) and Occupational Stress Questionnaires (OSQ). The participants were divided into tertiles according to LTPA, CRF and MFI. A 12-month exercise intervention evaluated 371 working adults (exercise group, n=338, mean age 45-y (±8.8)); control group, n=33, mean age 41-y (±6.9)).The exercise group underwent a 12-month exercise program followed by a 12-month follow-up. The OSQ, Workability Index (WAI) and CRF were evaluated at baseline and at 4, 8, 12 and 24 months.

Results: Physically inactive subjects reported more stress and less available mental resources than the subjects who reported high physical activity levels. Improved physical fitness was associated with less stress and more mental resources among normal weight men, but not in overweight men. After a 12-month exercise intervention, employees in the exercise group increased their physical activity, improved workability, decreased stress symptoms and improved their physical fitness and mental resources. After the follow-up year, workability and stress were improved compared to baseline.

Conclusions: In this thesis, good physical fitness was associated with improved psychological wellbeing among young men and working adults.

Key words: stress, mental resources, workability, physical activity, physical fitness

TIIVISTELMÄ

Oili Kettunen

Liikunta-aktiivisuuden ja fyysisen kunnon yhteys henkiseen hyvinvointiin nuorilla miehillä ja työikäisillä: yhteydet stressioireisiin, henkisiin voimavaroihin, ylipainoon ja työkykyyn

Turun yliopisto, Lääketieteellinen tiedekunta, Terveysliikunta, Paavo Nurmi keskus, Turun yliopiston kliininen tohtoriohjelma.

Tausta: Runsaalla liikunnan määrällä ja hyvällä kestävyyskunnolla on havaittu positiivinen yhteys fyysiseen ja henkiseen hyvinvointiin, mutta lihaskunnon merkitystä ei tunneta riittävän hyvin.

Tavoite: Tutkimuksen tavoite oli arvioida liikunta-aktiivisuuden ja mitatun fyysisen kunnon vaikutuksia henkiseen hyvinvointiin nuorilla miehillä sekä pien- ja keskisuurten yritysten työntekijöillä.

Menetelmä: 831 nuorta miestä, ikä 25v (±4) osallistuivat vapaaehtoisina Puolustusvoimien kertausharjoitusten yhteydessä toteutettuun tutkimukseen. Tutkimukseen osallistujille tehtiin maksimaalisen hapenottokyvyn sekä lihaskunnon testaus, ja he täyttivät laajan terveyskyselyn, jossa arvioitiin liikunta-aktiivisuutta ja henkistä hyvinvointia. 12 kuukauden mittaisessa liikuntainterventiossa 371 työntekijän (liikuntaryhmä n=338, keski-ikä 45-v (±8.8); kontrolliryhmä, n=33, keski-ikä 41-v (±6.9)) liikunta-aktiivisuutta arvioitiin liikuntakyselyllä sekä fyysistä kuntoa 12-min epäsuoralla polkupyöräergometritestillä; henkistä hyvinvointia arvioitiin Työstressikyselyn stressiä ja henkisiä voimavaroja mittaavilla oirekysymyksillä lähtötilanteessa, 4-kk, 8-kk, 12-kk ja 24-kk kohdalla. Liikuntainterventio koostui 2 päivän liikuntaleireistä Suomen Urheiluopistolla, Vierumäellä sekä ohjatusta ryhmäliikunnasta. Seurantavuoden avulla haluttiin arvioida tulosten pysyvyyttä ilman ohjattua ryhmäliikuntaa. Vertailuryhmä osallistui samoihin mittauksiin, mutta heillä ei ollut ohjattua liikuntaa.

Tulokset: Reserviläistutkimuksessa runsas liikunta ja hyvä fyysinen kunto olivat yhteydessä matalampaan stressitasoon ja korkeampiin henkisiin voimavaroihin. Liikuntainterventiossa liikuntaryhmään kuuluneet työntekijät lisäsivät liikunta-aktiivisuuttaan, paransivat kuntoaan, henkisiä voimavarojaan ja vähensivät stressioireitaan. Parantunut työkyky ja alentunut stressi olivat yhteydessä parantuneeseen kuntoon. Vertailuryhmässä vastaavia positiivisia tuloksia ei havaittu. Vuoden seurannan jälkeen liikuntaryhmään kuuluneiden työntekijöiden työkyky oli parempi ja stressioireet vähentyneet verrattuna lähtötilanteeseen, mikä osoitti tulosten pysyvyyttä.

Johtopäätökset: Tässä tutkimuksessa hyvä fyysinen kunto oli yhteydessä parempaan psyykkiseen hyvinvointiin nuorilla miehillä ja työikäisillä.

Avainsanat: stressi, henkiset voimavarat, työkyky, liikunta, fyysinen kunto

LIST OF ORIGINAL PUBLICATIONS

This academic dissertation is based on following original research papers. Referred papers are indicated by Roman numerals (I-IV):

I) Kettunen O, Kyröläinen H, Santtila M, Vasankari T. Physical fitness and volume of leisure time physical activity relate with low stress and high mental resources in young men. Journal of Sports Medicine and Physical Fitness, 2014; 54 (4):545-551.

II) Kettunen O, Kyröläinen H, Santtila M, Vuorimaa T, Vasankari T. Good cardiorespiratory and muscle fitness associate with low stress and high mental resources in normal weight men. Submitted.

III) Kettunen O, Vuorimaa T, Vasankari T. 12-mo exercise intervention decreased stress symptoms and increased mental resources among working adults-results perceived after 12-mo follow-up, International Journal of Occupational Medicine and Environmental Health 2015;28(2):00–00 http://dx.doi.org/10.2478/s13382-014-0350-0.

IV) Kettunen O, Vuorimaa T, Vasankari T. 12-mo intervention of physical exercise increased work ability – especially subjects with poor to moderate baseline work ability. International Journal of Environmental Research and Public Health, 2014; 4; 11(4):3859-69. doi: 10.3390/ijerph110403859.

LIST OF ABBREVIATIONS

ACSM	American College of Sports Medicine
BMI	Body Mass Index
CRF	Cardiorespiratory Fitness
HR	Heart Rate
GAS	General Adaptation Syndrome
LTPA	Leisure Time Physical Activity
MET	Metabolic Equivalent
MFI	Muscle Fitness Index
MR	Mental Resources
MVPA	Moderate to Vigorous Physical Activity
OSQ	Occupational Stress Questionnaire
PA	Physical Activity
SS	Stress Symptoms
WAI	Workability Index
WHPI	Work Health Promotion Intervention
VO_2max	Maximal Oxygen Uptake
WRC	Work Research Centre

TABLE OF CONTENTS

1. INTRODUCTION

Mental health is a state of wellbeing that is characterized by sense of feeling well and having the ability to cope with normal stresses in life (Keyes et al. 2002). According to the World Health Organization (WHO 2014), mental health problems and disorders are common and nearly fifty percent of people suffer from a mental illness at some point of their lifetime (European Commission, 2010). Active efforts in mental health promotion and prevention are needed and they can significantly reduce an individual`s risk for developing a mental health disorder (European Commission, 2010). Mental health disorders and stress manifested by job stress or perceived overall stress cause a burden to individuals, workplaces, occupational and public health and a government's health and wellbeing costs (Page et al. 2014). Physical activity (PA) is an important tool used in public health to treat and prevent both physical and some mental diseases such as depressive and anxiety disorders (Peluso & de Andrad 2005, Gerber & Pühse 2009). Physical activity is also one option to increase workability (Nurminen et al. 2002). Recent findings in both cross-sectional and longitudinal studies as well as clinical trials suggest that exercise and physical activity interventions have beneficial effects on several physical and mental health outcomes, including a health-related quality of life, improved mood (Penedo & Dahn 2005, Häkkinen et al. 2010) and satisfaction with life (Arent et al. 2000, Rejeski & Mihalko 2001, Ekkekakis 2003, Netz et al. 2005, Penedo & Dahn 2005, Ekkekakis et al. 2011). The workplace represents an ideal place for the promotion of health and physical activity (Malik et al. 2014) and it is suggested that investment in employees' health may have positive effects on sickness absence and workability (Rongen et al. 2013). Although the evidence supporting that those who are physically active and exercise are healthier than none exercisers is strong, most adults do not perform enough physical activity to achieve health and wellbeing benefits (Troiano et al. 2008).

According to previous studies there is a lot of evidence supporting the positive effects of physical activity on overall wellbeing but whether the connection is caused by a high volume of physical activity itself or good physical fitness remains unclear. The main purpose of this thesis was to evaluate the relationship between physical activity and physical fitness on psychological wellbeing and workability of healthy adults. Also, we investigated how being overweight effects on the relationship between psychological wellbeing and physical fitness and activity.

2. THE REVIEW OF THE LITERATURE

2.1. The concept of wellbeing

The WHO (2014) defines mental health as follows: "Mental health can be understood as a state of wellbeing in which the individual realizes 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 own community." Currently, the concept of wellbeing is viewed as a more complex phenomenon (Roscoe 2009). Most theories include five similar components: emotional, intellectual, physical, social and spiritual aspects to wellbeing (Roscoe 2009). Some theories add also occupational and environmental (Renger et al. 2000) wellbeing to the model as well. The holistic model of wellbeing comprises five life tasks: spirituality, self-regulation, work, friendship and love (Witmer & Sweeney 1992, Myers et al. 2000). The Wheel of Wellness (WoW) by Myers et al. (2000) describes 12 subtasks belonging to wellness: sense of worth, sense of control, realistic beliefs, emotional awareness and coping, problem solving, creativity, sense of humor, nutrition, exercise, self-care, stress management, gender identity and cultural identity.

The hedonic tradition of wellbeing research defines wellbeing with happiness, a positive effect, a low negative effect, and satisfaction with life (Kahneman et al. 1999, Lyubomirsky & Lepper 1999, Diener 2000). The eudemonic tradition of wellbeing research highlights positive psychological functioning and human development (Ryff 1989a, 1989b; Waterman 1993). Nowadays most researchers believe that wellbeing is a multi-dimensional construct (Diener 2009, Stiglitz al. 2009). Dodge et al. (2012) suggests that the new definition of wellbeing should focus on three areas of wellbeing, the idea of a set point for wellbeing, the inevitability of equilibrium/homeostasis and the fluctuating state between challenges and resources. According to this new definition, wellbeing is seen as the balance between an individual`s resource pool and the challenges faced and this is described in Figure 1 (Dodge et al. 2012).

Figure 1. The Definition of Wellbeing (Dodge et al. 2012).

2.1.1. Physical wellbeing

Physical wellbeing is defined as a state where person maintains and improves cardiorespiratory fitness, flexibility and strength (Hettler 1980). The model also emphasizes the importance of maintaining a healthy diet and trying to keep bodily balance and harmony through awareness and monitoring of body feelings, internal states, physical signs, tension patterns and reactions (Hettler 1980). One`s attention to physical self-care, activity level, nutrition and use of medical services are important to individuals as well. To summarize, physical wellbeing is the active and continuous effort to maintain the optimum level of physical activity and nutrition as well as self-care and maintaining healthy life-style choices (use of preventative health measures, medical services, abstinence of drugs and excessive alcohol use and safe sex practices) (Roscoe 2009). Table 1 summarizes the content of theories of physical wellbeing.

Table 1. Content of physical wellbeing theories.

Study	Focus	Important	Goal
Hettler et al. 1980	Cardiorespiratory fitness, flexibility, strength	Healthy diet, bodily balance and harmony through awareness of monitoring the body feelings, internal states, physical signs, tension patterns and reactions	Attention to physical self-care, activity level, nutritional needs, use of medical services
Leafgren 1990	Cardiorespiratory strength, regular physical activity	Healthy nutritional choices, no use of drugs, alcohol and tobacco	Medical self-care, use of medical services
Crose et al. 1992	Body awareness/image, exercise, eating behavior	Attitudes towards physical fitness	Health care, medical history and medication
Adams et al. 1997	Subjective feeling of physical health	No measuring, feeling important	Subjective feeling of physical health
Durlak 2000	Muscle tone, cholesterol level, blood pressure, eating habits, exercise level	Exercise level, eating habits	Physical wellbeing

2.1.2. Emotional and psychological wellbeing

Emotional wellbeing and mental health concerns are major health issues and they affect physical health (Harvard Health Publications 2014). Decreased emotional wellbeing relates to negative mental health states such as: stress, depression and anxiety and they can contribute digestive disorders, sleep disturbance and lack of energy (Harvard Health Publications 2014). Emotional wellbeing is according to theories the ability to act autonomously and cope with stress, and the capacity to have fulfilling relationships with others, awareness and acceptance of feeling an individual`s sense of optimism, as well as positive attitude about life, oneself and the future (Hettler 1980, Adams et al. 1997, Renger 2000, Roscoe 2009). The literature uses also the term “psychological wellbeing” with the same meaning as “emotional wellbeing” (Renger et al. 2000).

2.1.3. Stress

Stress has been defined by many authors and many ways with reference to its sources, consequences and the resources to overcome the negative effects of it (Abbas et al. 2013). Stress is a normal physical response to events that make you feel threatened or that disturb your balance in some way. When you sense danger—whether it is real or imagined—the body's defenses kick into high gear in a rapid, automatic process known as the “fight-or-flight-or-freeze” reaction, also known as the stress response. The stress response is the body’s way of protecting you. The concept of stress was first defined by Hans Selye as a general, nonspecific response to any stressor and later he introduced also the descriptions “bad or negative stress” and good or positive so-called “eustress” (Abbas et al. 2013). The systemic stress theory by Selye (1976) is called the General Adaptation Syndrome (GAS) and it has influenced research into stress-related behavior (Krohne 2002). Selye’s theory consists of three stages. The first stage is an alarm reaction that comprises an initial shock phase (an increased adrenalin discharge and gastro-intestinal ulcerations). If a harmful situation continues, the second stage is resistance. The third stage is exhaustion where the individual’s capacity of adapting to the stressors is exhausted (Krohne 2002).

The psychological stress theory, by Lazarus (1991, 1993), is regarded as an individual’s evaluation of the significance of what is happening to their wellbeing and their ability to cope with demands (Krohne 2002). The Occupational Stress Questionnaire (OSQ), used in this thesis, is based on the psychological stress theory (Elo et al. 1992). Resource theories of stress concentrate on resources that preserve wellbeing in the face of stressful events (Krohne 2002). Several social and personal constructs have been proposed to affect wellbeing such as social support (Schwarzer & Leppin 1991), sense of coherence (Antonovsky 1979), hardiness (Kobasa 1979), self-efficacy (Bandura 1977) and optimism (Scheier et al. 1994). The conservation of resources theory (COR) by Hobfoll et al. (1996, Hobfoll 1998) assumes that stress occurs if one of three of the following context exists: experience of a loss of resources, when resources are threatened or when people invest their resources without subsequent gain (Krohne 2002). However stress is not always bad and there is a term, eustress, that is used for this positive stress (Selye 1974). Eustress is not defined by the stressor type, but rather seen as an opportunity to encounter the stressor as a challenge (Fevre et al. 2006) and the function of challenge is to motivate a person toward improvement and goal (Smith 1991).

2.1.4. Mental resources

Mental or psychological resources include some psychological beliefs such as optimism, personal control and a sense of meaning are known to be protective of mental health. The studies have revealed that even unrealistically optimistic beliefs about the future may be health protective (Taylor et al. 2000). The research suggests that psychological beliefs such as meaning, control and optimism act as resources, which may not only preserve mental health in the context of traumatic or life-threatening events but be protective of physical health as well (Taylor et al. 2000). In this thesis, mental resources are seen as being active, energetic, capable, confident and being able to manage one`s daily tasks well (Elo et al. 1992).

2.1.5. Measurement of psychological wellbeing

There is a considerable heterogeneity of measuring stress and psychological wellbeing (Gerber & Pühse, 2009). Measurements vary between standard questionnaires or single questions and laboratory tests. In some recent studies, physiological measurements parameters, such as heart rate variability (Boullosa et al. 2014, Teisala et al. 2014), blood pressure and adrenaline and noradrenaline levels have been used (Lucassen et al. 2014, Tulppo et al. 2014). Some of the questionnaires are listed below in Table 2.

Table 2. List of measuring psychological wellbeing.

Instrument	Dimension	Remarks
Cornell Medical Index, Brodman et al. (1951)	Physical and mental symptoms or stress	One of the oldest, yes/no simple questions
Beck Depression Inventory (BDI), Beck et al. (1961)	Self-reported depression symptoms	21 items
Zung Self-Rating Depression Scale, Zung (1965, 1966)	Depression	20 items
Occupational Stress questionnaire (OSQ) Elo et al. (1972)	Physical, somatical and mental symptoms of stress, mental resources	Short/long version, a single question of stress or parts of the questionnaire is used
Stress Diagnostic Survey (SDS) Ivancevich and Mateson`s (1976, 1989)	Type AB-pattern and type AB work environment;	Personal stressors (non work version) and the job related stressors (work version of SDS)
General Health Questionnaire (GHQ), Goldenberger (1978), Goldenberger & Williams (1988)	Anxiety and depression	Most widely used strain detector, available in short and long form
Satisfaction with Life Scale (SWLS), Diener, Emmons, Larsen, Griffin (1985)	To measure global cognitive judgments of satisfaction with one`s life	5 items
The Perceived Stress Scale (PSS) (1985)	The degree of which situations in one`s life are appraised as stressful	The stressfulness of situations and the effectiveness of stress-reducing interventions

Instrument	Dimension	Remarks
The Zimbardo Time Perspective Inventory (ZTPI), Zimbardo & Boyd, (1999)	How people project themselves in the time according to their orientation to past, present and future; and attitudes (positive, negative, fatalistic or hedonistic)	56 items
The General Nordic Questionnaire (GNQ), Lindström et al. (2000)	Job control, job demands, role expectations, leadership, organizational commitment, social interactions etc.	
The Cognitive Emotion Regulation Questionnaire, (CERQ) Garnefski & Kraaf (2002)	Coping strategies	36 (18) items
Four Dimension Health Questionnaire (4DSQ), Terluin et al. (2004)	General distress, depression, anxiety and somatization	
Health and Safety Executive (HSE) Indicator Tool Cousins et al. (2004)	Demands, control, relationships, managerial and peer support, role and change	
Swedish Demand-Control-Support Questionnaire (DCSQ), Sanne et al. (2005)	Psychological demands, social support, and decision latitude	Shorter and modified version of Karashek`s Job Content Questionnaire (JCQ, Karasek et al. 1998)
Copenhagen Psychosocial Questionnaire (COPSOQ II), Pejtersen et al. (2010)	Justice, trust, work family conflicts, social inclusiveness, stress, burnout, insomnia	
Stress in General Scale (SIG), Stanton et al. 2001 & (SIG-Revised version): Yankolewich et al. (2011)	Job threat stress and job pressure stress, anxiety, feeling of nervousness	

2.2. Physical activity, physical fitness and psychological wellbeing

2.2.1. Physical activity and physical fitness

Physical activity is any body movement that works your muscles and requires more energy than resting and generally refers to movement that enhances health (US Surgeon General 2008). Walking, running, dancing, swimming, yoga and gardening are a few examples of physical activity. Health- related physical activity consists of body composition, cardiovascular fitness, flexibility, muscular endurance and strength (Corbin et al. 2000). The relation between physical activity and fitness is very close, and physical fitness is mainly determined by physical activity patterns (Blair et al 2001). Genetic contributions to fitness are important; however physical activity seems to be the principal determinant for cardiorespiratory fitness (Blair et al. 2001). Increases in physical activity enhance physical fitness for most individuals, although the amount of adaptation in fitness to a standard exercise dose varies very much and is under genetic control (Haskell et al. 2007). However it is not possible to conclude whether physical activity or fitness is more important for health (Blair et al. 2001). Figure 2 describes the complex relationship among physical activity, physical fitness, health, wellness and other factors.

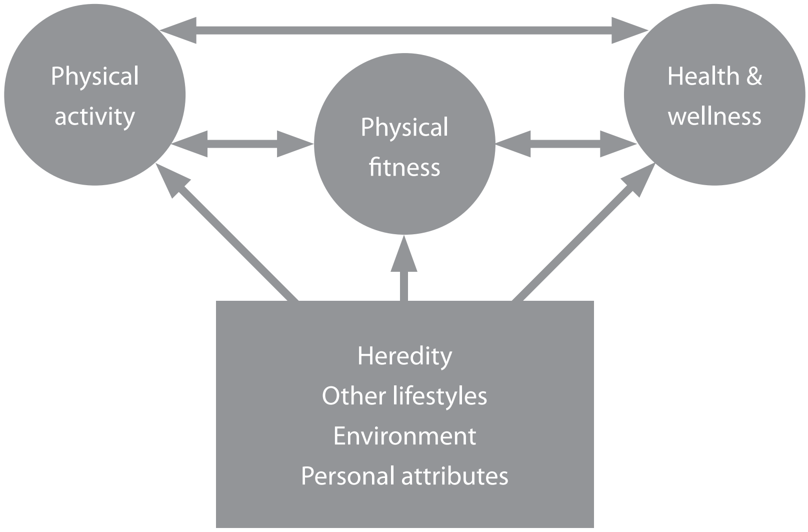

Figure 2. Complex relationships among physical activity, physical fitness, health, wellness and other factors (Corbin et al. 2000, adapted from Bouchard et al. [1990]).

The latest standards for exercise training for promoting and maintaining health, recommend endurance training at least five days a week for 30 to 60 minutes at time, depending of the intensity of the exercise and resistance training for the main muscle groups for two to three times a week, 30 to 40 minutes (Fletcher et al. 2013). Combinations of moderate and vigorous intensity activity can be performed to meet this recommendation. Because of the dose-response relation between physical activity and health, persons who wish to further improve their personal fitness, reduce their risk for chronic diseases and disabilities or prevent unhealthy weight gain may benefit by exceeding the minimum recommended amounts of physical activity (US Surgeon General 2008, Fletcher et al. 2013). These recommendations seem to be relevant recommendation for both physical and mental health (Johnsdottir et al. 2010).

2.2.2. Physical activity, physical fitness and coping with stress

By improving physical wellbeing we may also improve psychological wellbeing and physical activity may have positive effect on mood and anxiety (Ströhle 2009). Physical activity is seen as one of the factors that protect against stress (Gerber & Pühse 2009). In a study among the European Union countries, physical activity in everyday life was associated with both self-rated health in general (Abu-Omar et al. 2004b) and also mental health (Abu-Omar et al. 2004a). Figure 3 illustrates the most important pathways of how exercise may affect the interplay among stress, resources, health and wellbeing.

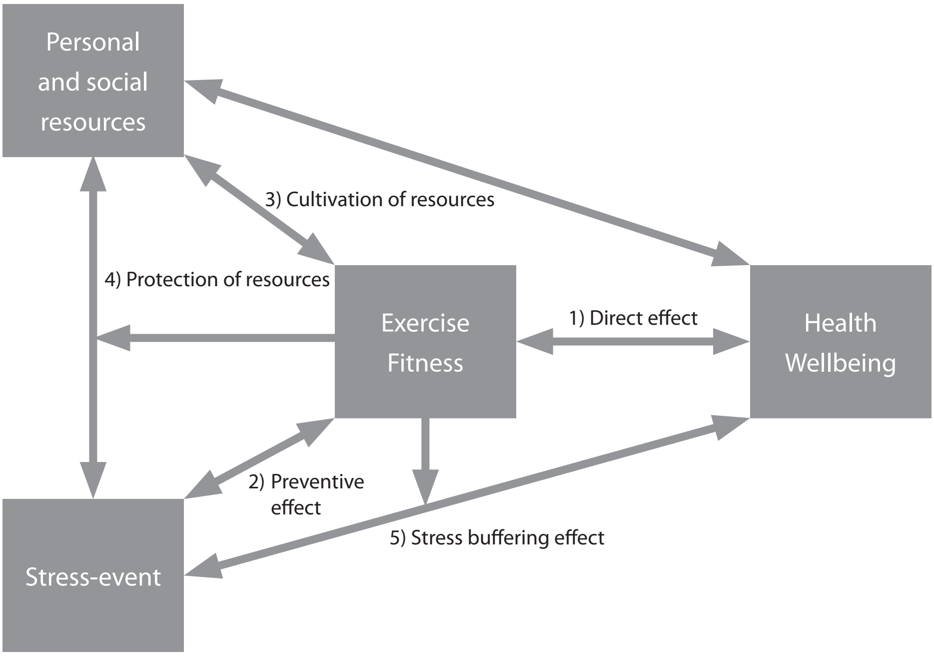

Figure 3. Potential influence of exercise on the interplay among stress, resources, health and wellbeing. Modified according to Gerber & Pühse 2009 [Fuchs et al. 1992]). Numbers indicate the potential pathways described in detail in the text.

The direct relationship between exercise and health is well-established for coronary heart disease, diabetes, bone mineral density, colon cancer, life-satisfaction or depression (path 1) (US Surgeon General 2008). However these effects occur independent of the amount of stress the person feels. A preventive effect (path 2) of exercise exists whenever exercise contributes to a lower feeling of stress (Gerber & Pühse 2009). Aldana et al. (1996) reported lower levels of stress among physically active individuals compared to inactive ones. A causal link between exercise and stress was found by Schnohr et al. (2005) in the Copenhagen Heart Study, where increased exercise was followed by decreased stress among participants. Exercise may also strengthen other personal resources, like self-esteem or social support, which in turn may influence to the stress-health relationship (path 3) (Gerber & Pühse 2009). Adopting a new lifestyle or experiencing motor competence may lead to feelings of mastery and confidence in overcoming problems and challenges (Fox 1999, Ekeland et al. 2005). Exercise may also protect against stress-induced losses of personal and social resources (path 4) (Gerber & Pühse 2009), however there is yet limited evidence supporting this relationship. Exercise may offer a protective effect, the so-called "stress buffering" effect during times of heightened stress (path 5) (Gerber & Pühse 2009). Exercise is generally effective for stress reduction and exercising after a stressful event returns blood pressure closer to baseline (i.e., facilitates cardiovascular recovery) more quickly (Chafin et al. 2008). In other words, going for a walk after a stressful meeting or a conflict situation at work can limit the duration of a stress response.

The hypotheses concerning the association between physical fitness and stress process contains three major components: stressors, resources and distress. In Figure 4, the paths between physical fitness and stress are described (Ensel & Lin 2004).

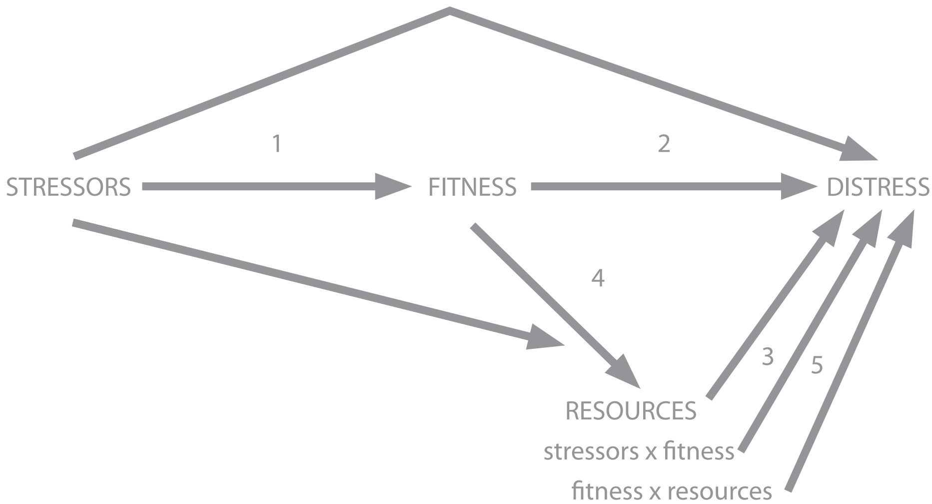

Figure 4. Conceptual model of the association between fitness and the stress and resources process (Ensel & Lin 2004). Numbers indicate the potential pathways described in detail in the text.

In Figure 4, the first hypothesis suggests that fitness has a deterring effect on distress (path 2). In the model, the distress deterring effects of fitness are posed to remain even after other major stress-model variables (stressors and resources) are controlled for in the model. The second hypothesis suggests that fitness moderates (buffers) the effect of stressors on distress (path 3). The third hypothesis explains that fitness mediates the effects of stressors on distress (path 1 and path 2). The fourth hypothesis suggests that fitness is indirectly related to distress. Meaning that, higher levels of fitness are associated with lower levels of distress (paths 4 and 5). Another explanation is that psychosocial resources have the potential to mediate the effect of fitness on distress (Ensel & Lin 2004).

2.2.3. Associations among physical activity, physical fitness and psychological wellbeing

The association between physical activity and psychological wellbeing has been studied from the perspectives of treatment and prevention of mental disorders and mental illness as well as improvement of physical and psychological wellbeing among the general population and patients with mental disorders or diagnosis (Fox 1999).

Previous studies indicate that in the general population physical activity may be inversely associated with psychiatric morbidity and psychosomatic function including depression and emotional wellbeing (Dunn et al. 2001, Brown et al. 2003, Goodwin 2003). Several studies have shown that engaging in regular physical activity can reduce symptoms of depression and anxiety and improve mood and stress management (Fox 1999, Paluska & Schwenk 2000, Blake et al. 2009). A number of cross-sectional and prospective studies have found an association between lower depressive symptoms and high amount of physical activity among women and men (Allgöwer et al. 2001). Strong evidence exists that physical activity is associated with a better psychological wellbeing.

In a review of meta-analyses focusing on the relationship between cardiorespiratory fitness and stress reactivity, Holmes et al. (2010) found three studies. Firstly, Jakson & Dishman (2006) found that a reduction in reactivity was a favorable stress response among 73 studies. Response patterns of specific components of integrated stress responses, and their recovery after stress, might indicate a healthier response pattern (Jackson & Dishman 2006). Secondly, Forcier et al. (2006) found in a meta-analysis of 33 studies that cardiorespiratory fitness (CRF) was associated with a faster heart rate recovery, but not systolic or diastolic blood pressure recovery. Thirdly, Hamer et al. (2006) reported as a result of 15 studies that aerobic exercise might produce benefits by placing individuals frequently within the post-exercise window, during which the attenuation of stress responses occurs. Fourth, Boullosa et al. 2014 evaluated three review articles, one opinion article and one hypothesis and theory article, including both human and animal models for evaluating the understanding of cardiovascular responses to stress. However the evidence of the association between CRF and psychological wellbeing is inconclusive and more research is needed.

Musculoskeletal fitness is associated with many physical health benefits, such as reduced coronary risk factors, increased bone mineral density (reduced risk of osteoporosis), increased flexibility, improved glucose tolerance and greater success in completion of activities of daily living (Kell et al. 2001). There is some evidence of the association between strength training and psychological wellbeing (O`Connor et al. 2010), however, to our knowledge there were no previous studies evaluating the association between objectively measured muscular fitness and stress or psychological wellbeing.

2.3. Overweight

Being overweight and obesity are major public health concerns worldwide (Miller et al. 2001, Ogden et al. 2006, WHO 2013). Obesity is an independent risk factor for many chronic physical diseases such as diabetes, hypertension, coronary heart disease (Doll et al. 2000) and some mental disease, such as depression (Stunkard et al. 2003), and it is also associated with high health care costs (Doll et al. 2000). The body weight categories are described generally according to the body mass index (BMI) categories: normal weight (18.50-24.99 kg/m2), overweight (25.00-29.99 kg/m2) and obese (≥30.00 kg/m2) (WHO 2013).

2.3.1. Overweight, physical activity, physical fitness and psychological wellbeing

There is some evidence of the association between obesity, overweight, depression and anxiety (Jorm et al. 2003). The association among obesity, depression, anxiety and a lower wellbeing was found among a large sample of Australian women but not in men (Jorm et al. 2003). Zhao et al. (2009) found an association with stress among both underweight and obese men and women among US adults. There are two studies that have evaluated whether physical activity moderates the relationship between stress and obesity or other components of the metabolic syndrome among youths aged 8 to 12 years (Yin et al. 2005, Holmes et al. 2010). Yin et al (2005) found that personal stress was associated with BMI but not with self-reported physical activity among 303 individuals aged 12 to 24 years. A small (n=38) sample of boys between 8 to 18 years were divided into high and low PA groups and none of the stress variables were associated with metabolic risk score in the group that reported high physical activity (Holmes et al. 2010). However there is limited evidence of the association between overweight, physical fitness and psychological wellbeing in healthy adults.

2.4. Workability

The concept of workability was developed by the researchers of the Finnish Institute of Occupational Health (Tuomi 1997, Ilmarinen et al. 1997). The workability can be defined as the balance between the work demands and the individual resources (Ilmarinen & Rantanen 1999, Arvidson 2013). Workability Index (WAI) is a questionnaire-based method assessing perceived workability (Tuomi et al. 1997). WAI consists of seven indicators that help answer the question of how well or healthy the employees are currently and in the near future. In addition, WAI aims to assess how able they are to do their work with respect to their work demands, health and mental resources. WAI is recommended for use in occupational health care and research related to work (Ilmarinen et al. 1997, Feldt et al. 2009). The test-retest reliability of the WAI questionnaire was evaluated by Zwart et al. (2002) and the internal quality of WAI was tested by Eskelinen et al. (1991) and Nygård et al. (1991). WAI is by far the most used and well-accepted instrument to measure workability worldwide (Van den Berg et al. 2009).

2.4.1. Physical activity, physical fitness and workability

Within the concept of workability, physical activity is one means by which to promote individual resources, although perceived workability depends on other individual characteristics and work-related factors as well (Ilmarinen & Rantanen 1999). Since the mid-1970`s, exercise programs at the worksite have been carried out in many countries (Shephard 1996) with the hope to enhance health and functional capacity of employees. There is strong evidence that physical activity is related to better workability (Tuomi et al. 1997, Tuomi et al. 2001, Kaleta et al. 2006, Kuoppala et al. 2008), but the relationship between increased exercise and improved fitness related on perceived workability remains inconsistent (Smolander et al. 2000, Sörensen et al. 2008). The factors associated with poor workability are a lack of leisure time vigorous physical activity, poor musculoskeletal capacity, older age, obesity, high mental work demands, lack of autonomy, poor physical work environment and high physical workload (Tuomi et al. 1997).

2.4.2. Effects of physical activity interventions on psychological wellbeing and workability

During the past 30 to 40 years, companies have implemented physical activity interventions or Workplace Health Promoting Programs (WHPP), which aim to improve employee’s lifestyle, improve health, workability and work productivity (Dishman et al. 1998, Rongen et al. 2013). There is a great variety of these interventions concerning their duration, measurements and study populations (Proper et al. 2002, Conn et al. 2009, Rongen et al. 2013, Malik et al. 2014). However, the lack of studies with better methodological quality makes the evidence of the effectiveness of the interventions inconclusive (Engbergs et al. 2005, Dishman et al. 2009, Groeneveld et al. 2010, Maes et al. 2012, Rongen et al. 2013, Malik et al. 2014). The duration of the programs varies from two weeks to two years and with occasional follow-ups (Proper et al. 2002). The WHPPs include either exercise (aerobic, strength, stretching, social games), health education (dietary, sleep, smoking), counselling (face-to face, group, telephone or internet) (Proper et al. 2002, Malik et al. 2013). WPPPs may improve overall health (Hutchinson et al. 2012), increase physical activity (Proper et al. 2003, Conn et al. 2009), promote workability (Kuoppala et al. 2008), lead to small improvements in weight status (Anderson et al. 2009) and dietary behavior (Ni Mhurchu et al. 2010, Maes et al. 2012). WHPPs may also decrease work absences due to sickness (Proper et al. 2002, Kuoppala et al. 2008, Conn et al. 2009) and even have some promising effects on work productivity (Brown et al. 2011, Cancelliere et al. 2011).

2.4.3. Mechanisms of explaining the association between exercise and psychological wellbeing

Several biochemical, physiological and psychological mechanisms have been suggested to explain the relationship between exercise and mental health (Carless & Faulkner 2003), but the relationship remains open (Biddle & Mutrie 2001, Gerber & Pühse, 2009). First, it can be assumed that exercise results in reduced arousal (i.e., mood enhancement due to cognitive distraction and biochemical changes) or more positive health behaviors during times of high stress. Second, exercise may bring improved fitness and as an indirect consequence, a more positive physiological stress regulation (i.e., reduced secretion of hormones, lowered blood pressure) or enhanced recovery process (Gerber & Pühse 2009). The “mastery hypothesis” by Gauvin & Brawley (1993) explains that exercise provides individuals with an opportunity to conquer challenges and increase feelings of competency as they learn and master a new skill (Thorne et al. 2000). The “cross-stressor” adaptation theory suggest that regular PA and good fitness lead to adaptations in response to both exercise and psychological stressors (Forcier et al. 2006).

The distraction hypothesis proposes that diversion from unpleasant stimuli leads to an improved mood during and after exercise (Morgan 1985). In the self-efficacy hypothesis, exercise is seen as a challenging activity and the ability to get involved in it regularly might lead to improved mood and self-confidence (North et al. 1990). The social interaction hypothesis suggests that social relationships as well as mutual support among individuals involved in exercise play an important role in the effects on mental health (Ransford 1982). The physiological hypothesis emphasizes hormones to explain the association with PA and wellbeing, monoamines and endorphins are the most studied hormones in this association (Peluso & de Andrad 2005). The monoamines hypothesis suggests that physical activity increases the synaptic transmission of monoamines (Ransford 1982, Morgan 1985), which supposedly function similarly as antidepressive drugs (Dunn & Dishman 1991, Nicoloff & Schwenk 1995). The endorphin hypothesis proposes that physical activity causes the release of endogenous opioids, basically beta-endorphin (Ransford 1982, Morgan 1985, Nicoloff & Schwenk 1995). It is supposed that the inhibitory effects of these substances on the central nervous system are responsible for the sensation of calm and improved mood after exercise (Allen 2000), but this has yet to be confirmed (Peluso & de Andrad 2005). Therefore highly physically active individuals report increased irritability, restlessness, nervousness, and feelings of frustration when they cannot exercise for some reason (Morris et al. 1990, Allen 2000). There is no consensus yet concerning the above mentioned hypothesis and a psychobiological model combining all of them is the most probable (Paluska & Schwenk 2000).

According to the literature, there is strong evidence supporting that physical activity is associated with improved psychological wellbeing. However, the association between physical fitness, especially muscle fitness and psychological wellbeing, has not yet been fully elucidated.

3. OBJECTIVE OF THE PRESENT STUDY

The aim of the present study was to evaluate how physical fitness and volume of leisure time physical activity associate with stress symptoms, mental resources and workability. The enquiry was conducted in four studies. The specific aims were:

I) To determine if leisure time physical activity and physical fitness effect on stress symptoms and mental resources in healthy young men (Study I)

II) To assess if being overweight alters the relationship between stress symptoms / mental resources and physical fitness / leisure time physical activity in young men (Study II)

III) To examine the effects of the 12-month exercise intervention and the 12-months follow-up on stress symptoms and mental resources in working adults (Study III)

IV) To ascertain the impact of a 12-month exercise intervention and 12-months follow-up on workability of working adults (Study IV)

4. MATERIALS AND METHODS

4.1. Subjects

4.1.1. Characteristics of the subjects in the cross-sectional study (Study I-II)

The study group of studies I-II was enrolled from April 2008 to November 2008 during eight refresher courses organized around Finland. Overall 1155 reservists were invited, out of whom 922 participated in the courses and 831 volunteered for study I and 824 for study II. 66 participants were excluded from the study because they had missed some of the physical fitness tests due to the medical reasons. Thus, 831/824 men, aged between 20-45 years volunteered for the present study. Most of the subjects had undergone their military service within 10 years. Because of the compulsory military service, the study population consisted of reservists, who have underwent their military service, and is a geographically representative sample of healthy Finnish young men. Participants signed a written consent form indicating that they were aware of risks and the benefits of study. The mean (±SD) age of the study group was 25 (±5) years, height 180 (±6) cm, weight 80 (±13) kg and body mass index (BMI) 25 (±3.8), and 38% of the participants were smokers (Table 3). For Study II, the study population was divided into two groups according to the body mass index (BMI). The BMI cut-off points for normal (18.50-24.99) (n=486) and (overweight ≥25.00) (n=338) groups were selected according to the WHO standards (WHO 2013). The amount of obese participants (BMI ≥30.00, n=74) was included to the overweight group. The weight, body mass (kg) and height (cm) of the participants were measured using lightweight clothing.

Table 3. Participant characteristics (Study I, n=831 and Study II, n=824).

Character	Mean (±SD)
Age (years)	25 (4)
Height (cm)	180 (6)
Weight (kg)	80 (13)
Body Mass Index (kg/cm^2)	25 (4)
*VO_2max (ml·kg^{-1}·min^{-1})	40 (8)
Muscle fitness (points)	12 (9)

*VO_2max (oxygen consumption, milliliters of oxygen per kilogram of body mass per minute)

4.1.2. Characteristics of the subjects in the exercise intervention study (Study III-IV)

The study group of studies III-IV comprised 371 employees whom were recruited from small and medium-sized companies (less than 100 employees per company) in Southern Finland. The inclusion criteria were: healthy, no permanent medication, aged 20-60, and no contraindications to walking exercise. The subjects were divided into an exercise and control group, so that about 10 percent of subjects would comprise the control group. The control subjects were from same companies that were the intervention subjects, but they came from a different workplace / department, so that they were not involved in any part of the intervention. Participants in the control group were selected such that there would be approximately as many men as women and an even difference in white collar and blue collar workers. They were a similar age as the exercise group and that their leisure time physical activity (LTPA) at baseline did not differ from that of exercise group. The exercise group consisted of 338 participants (85 blue- and 253 white collar workers; 212 women and 126 men) and the control group with 33 participants (19 blue and 14 white collar workers; 17 women and 16 men). Blue collar work was kitchen-, cleaning- and construction work. White collar work was teaching, journalism, banking, and insurance work. Because this was a real working life intervention we decided not to use randomization. In this study, we decided to use the protocol of “real-life” setting (work life). It was very clear that a randomized controlled design would not be the most realistic design. Only 10% of the participants were allocated to the control group. Also, the subjects in the control group were collected from different working places than the subjects in the intervention group. At baseline, the age, height, weight, BMI, use of alcohol, physical activity level and smoking status did not differ between the control and intervention groups. However, aerobic fitness at baseline was somewhat higher in the control group. Furthermore in order to diminish the bias, we used: A) a high number of participants from several companies, B) several sampling points (4 time points of measurements) during the intervention, C) one year follow-up, and D) different methods to evaluate the physical activity (questionnaire, exercise diary, fitness tests 5 times) (Table 4).

Table 4. Subject characteristics of the exercise group (n=338) and control group (n=33). Mean (±SD) or %.

	Exercise group mean (±SD), n=338	**Control group mean (±SD), n=33**	**P-value exercise vs. control**
Women /men	212 / 126	17 / 18	
Age (y)	45 (8.8)	41 (6.9)	0.357
Weight (kg)	76 (15.3)	81 (12.6)	0.104
Height (cm)	170 (8.7)	169 (8.3)	0.403
BMI (kg/m^2)	26.1 (4.4)	27.4 (4.0)	0.693
*MET / h /week	8.2 (8.7)	7.7 (11.5)	0.398
Use of alcohol /doses per week	7.7 (10.5)	8.7 (11.0)	0.565
Current smoker (%)	21.0	12.0	0.816

*Metabolic Equivalent (one MET represents the approximate rate of VO_2 consumption of a seated individual at rest, which is 3.5 mL O_2/kg/min)

4.2. Study design

4.2.1. Study design of the reservists study (Studies I-II)

The reservists were informed of the study in a call up letter about the refresher course. All the measurements were performed during the eight refresher courses. A health examination and the presentation of measurements were done at the beginning of the refresher course. The participants completed the questionnaires including health, use of alcohol and tobacco products, leisure time physical activity, stress symptoms and mental resources. For the fitness tests, the participants were divided into groups of ten men. The body height and weight were measured while participants wore light sport clothing. After a light breakfast, muscle fitness was measured by four consecutive tests: grip strength, push-ups, sit-ups and repeated squats, followed by the test of maximal aerobic capacity (VO_2max).

4.2.2. Study design of the exercise intervention study (Studies III-IV)

The exercise group underwent a 12-month long exercise program including two-day training camps at the Sport Institute of Finland (at baseline, 4, 8, 12 and 24months). The training camps contained physical fitness tests, supervised group exercise, questionnaires and lessons concerning health-related issues. The employees in the exercise group formed groups of 15-20 persons within the same company. Each group was coached with a physiotherapist or exercise instructor. The same coach guided the particular group during the whole intervention. Between training camps, the exercise program contained 1-2 supervised group exercise sessions per month (mainly by walking, skiing and biking). Every subject had an individualized exercise program based on estimated oxygen uptake (VO_2max) according to the fitness tests. Exercise intensity was monitored with Polar heart rate microcomputers (Polar Electro, Kempele, Finland). Exercise amount and intensity between training camps were recorded with personal web-based exercise diaries. The 12-month supervised exercise program was followed by a 12-month follow-up without any supervised exercise. The employees of the control group participated in all measurements during the same time points (baseline, 4-, 8- , 12- and 24-month), however they did not get any supervised exercise or coaching.

4.3. Physical fitness tests

4.3.1. Cardiorespiratory fitness (VO_2max)

VO_2 max was measured indirectly using a bicycle ergometer test (Ergoline 800 S, Ergoselect 100 K or 200 K, Bitz Germany). The handlebars and seats were individually adjusted. After a 5-min warm up, the test began with a power output of 75 W, which was increased by 25 W after every other minute. A pedaling rate of 60 rpm was maintained throughout the test. Heart rate (HR) was recorded continuously (Polar

Vantage NV or S610, S710 or 810, Kempele, Finland). The test was terminated at volitional exhaustion, including a decrease in the pedaling rate to below 50.rpm. Predicted VO_2 max was determined from the HR and power (Fitware, Mikkeli, Finland) as follows: VO_2 max- (ml · kg^{-1} · min^{-1}) = 12.35*Pmax·kg^{-1}+ 3.5, where Pmax · kg^{-1} represents the highest work rate (power) achieved during the test as watts and body mass as kilograms. The intraclass correlation has been reported to be high with this method (ICC r = 0.82–0.94) for men (Santtila et al. 2013). In the exercise intervention study, maximal oxygen uptake was extrapolated indirectly on the basis of an electrically braked bicycle ergometer (Ergoline 800S, Ergoline, Berlin, Germany) test (pedal rate, 60 rpm) using three submaximal loads. The lowest submaximal load was calculated to produce a heart rate of approximately 120 beats per minute and the highest submaximal load approximately 85% of age-adjusted maximal heart rate. The age-adjusted maximal heart rate was derived from the reference values of Seliger & Bartunek (1976), and maximal oxygen uptake was extrapolated from the maximal heart rate. The same individual workloads that were used at the baseline test were used during the follow-up tests. Lower heart rates at the highest load prompted the additional fourth work load to increase the heart rates to the expected levels.

4.3.2. Muscular fitness

For muscular fitness, muscle fitness index (MFI) was calculated using the result of each muscle test according to the standards of the Finnish Defense Forces (Pihlainen et al. 2009) among the reservists (Study 1-II). The order of the tests was: 1) grip strength (antebrachial muscles), 2) push-ups (arm and shoulder extensors, pectoralis major), 3) sit-ups (abdominal muscles and hip flexors) and 4) repeated squats (glutei and quadriceps femoris muscles). Both cardiorespiratory and muscular fitness tests have age specific reference values that have been used in the Finnish Defense Forces since 2000, and they are based on data of 3635 civilians (Pihlainen et al. 2009). The result of the push-ups, sit-ups and repeated squats were expressed as the number of correctly performed repetitions within 60 seconds, while the grip strength was measured during a single maximal isometric contraction. Grip-strength was determined three times from both hands and the final score was the average of the highest scores of both hands (sitting, elbow at 90 degrees, Saehan Corporation, Masan, South Korea) (Fogelholm et al. 2006a, Kyröläinen et al. 2008). In the start position of sit-up test, the subject was lying supine on the floor with knees flexed at a 90 degree angle and hands behind the neck. The ankles were fixed to the floor by an assistant, and a repetition was counted after the participant's elbows touched the flexed knees (Viljanen et al. 1991). To execute one repetition of push-ups, the participant had a shoulder-wide stance and fingers pointing forward. From this start position, elbows were flexed at a 90 degree angle with the torso touching the floor. Then the upper extremities were fully extended, while the upper body was straight and fully extended (ACSM 2000). Repeated squat movement started while standing straight and lowering of the upper body until the thighs were at a horizontal level. After this, the subject flexed his lower extremities in order to stand straight again (Viljanen et al. 1991). MFI was calculated as the results of four tests. Before the tests, supervisors demonstrated the correct technique of each test and, thereafter, they controlled each performance (Häkkinen et al. 2010).

4.4. Psychological wellbeing questionnaires

4.4.1. Stress symptoms (SS)

The stress level and mental resources were measured by questions derived from the OSQ (Elo et al 1992). Stress symptoms were calculated from a sum of four questions with five categories as follows: A) Stress means the situation when a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his mind is troubled all the time. Do you feel that kind of stress these days? (1) not at all, (2) only a little, (3) to some extent, (4) rather much, (5) very much. B) What is your health state compared to that of other people your age? (1) very good, (2) rather good, (3) average, (4) rather poor, (5) very poor. C) How satisfied are you with your present work? (1) very satisfied, (2) rather satisfied, (3) neither satisfied nor dissatisfied, (4) rather dissatisfied, (5) very dissatisfied (5). D) How satisfied are you with your present life? (1) very satisfied, (2) rather satisfied, (3) neither satisfied nor dissatisfied, (4) rather dissatisfied, (5) very dissatisfied. A high sum scale was classified as experiencing high level of stress and low sum scale was categorized as experiencing a low level of stress (Elo et al. 1992).

4.4.2. Mental resources (MR)

Mental resources in this study mean how active, energetic, capable and confident people feel with themselves in daily activities (Elo et al. 1992). Mental resources were calculated using a sum of three questions with five categories: A) Have you been active and energetic lately? (1) constantly, (2) rather often, (3) now and then, (4) rather seldom, (5) not at all. B) Do you feel capable and confident? (1) constantly, (2) rather often, (3) now and then, (4) rather seldom, (5) never. C) Do you think you have done your daily chores well lately? (1) constantly, (2) rather often, (3) now and then, (4) rather seldom, (5) not at all (Elo et al.1992). A low sum scale was classified as experiencing high mental resources and high sum scale was classified as experiencing low mental resources (Elo et al. 1992).

4.4.3. Leisure time physical activity (LTPA)

In the reservist study the weekly LTPA frequency and intensity was determined from responses to a single question (SIVAQ) with six categories: (1) no physical activity at all, (2) some physical activity without feeling out of breath or sweating, (3) physical activity without feeling out of breath or sweating, (4) physical activity with feeling out of breath or sweating twice a week, (5) physical activity with feeling out of breath or sweating three times a week, and (6) physical activity with out of breath or sweating at least four times a week (Fogelholm et al. 2006b). In the analysis, the subjects were placed in three groups according to their physical activity level: low (combination of LTPA categories 1 and 2), moderate (categories 3 and 4) or high (categories 5 and 6).

4.4.4. Lifestyle questionnaire

In the exercise intervention study use of alcohol, tobacco and LTPA were asked at baseline and after 12-month with a questionnaire. The exercise amount and intensity between training camps were evaluated with personal exercise diaries via internet. The weekly LTPA was determined using three questions concerning frequency, duration and intensity of the exercise (Vasankari et al. 1998). According to the answers, we calculated the metabolic equivalent (MET) h/week values (LTPA times per week x duration x intensity) (Table 4). One MET represents the approximate rate of VO_2 consumption of a seated individual at rest, which is 3.5 mL O_2/kg/min (ACSM 2000, Sjögren et al. 2006). The distance and the method of travelling to work were also asked.

4.4.5. Workability

In the intervention study workability was measured with the WAI questionnaire (Tuomi et al. 1997). The sum score forms the Workability Index, which has been classified into the following four categories of workability: 1. poor (values 7-27), 2. moderate (values 28-36), 3. good (values 37-43) and 4. excellent workability (values 44-49) (Feldt et al. 2009). At baseline, participants were categorized into four workability classes according to the workability index and for the statistical analysis the two lowest WAI groups were combined: the WAI score 7-36 (n=43) poor/moderate, the WAI score 37-43 (n=168) good and WAI 44-49 (n=127) excellent.

4.5. Exercise intervention

The exercise program contained 1-2 supervised group exercise sessions per month, between training camps and 3-5 unsupervised exercise sessions weekly (mainly by walking, nordic walking, skiing and biking). Every participant of the exercise group was given an individualized exercise program based on the estimated VO_2max. During the exercise, the mean heart rate was mainly at the moderate level, mainly 60-80% of estimated maximal heart rate. Exercise intensity was monitored with Polar heart rate microcomputers (Polar Electro, Kempele, Finland). The amount and intensity of exercise between training camps were recorded with personal web-based exercise diaries. The content of exercise diaries were commented twice a month by coaches and there was a possibility to get detailed information concerning the exercise program of the following weeks if needed. During the 12-month follow-up, there was no exercise program, no lessons or group exercise and no support from the coach. The participants only completed the exercise diaries. The exercise intervention is described below in Figure 5.

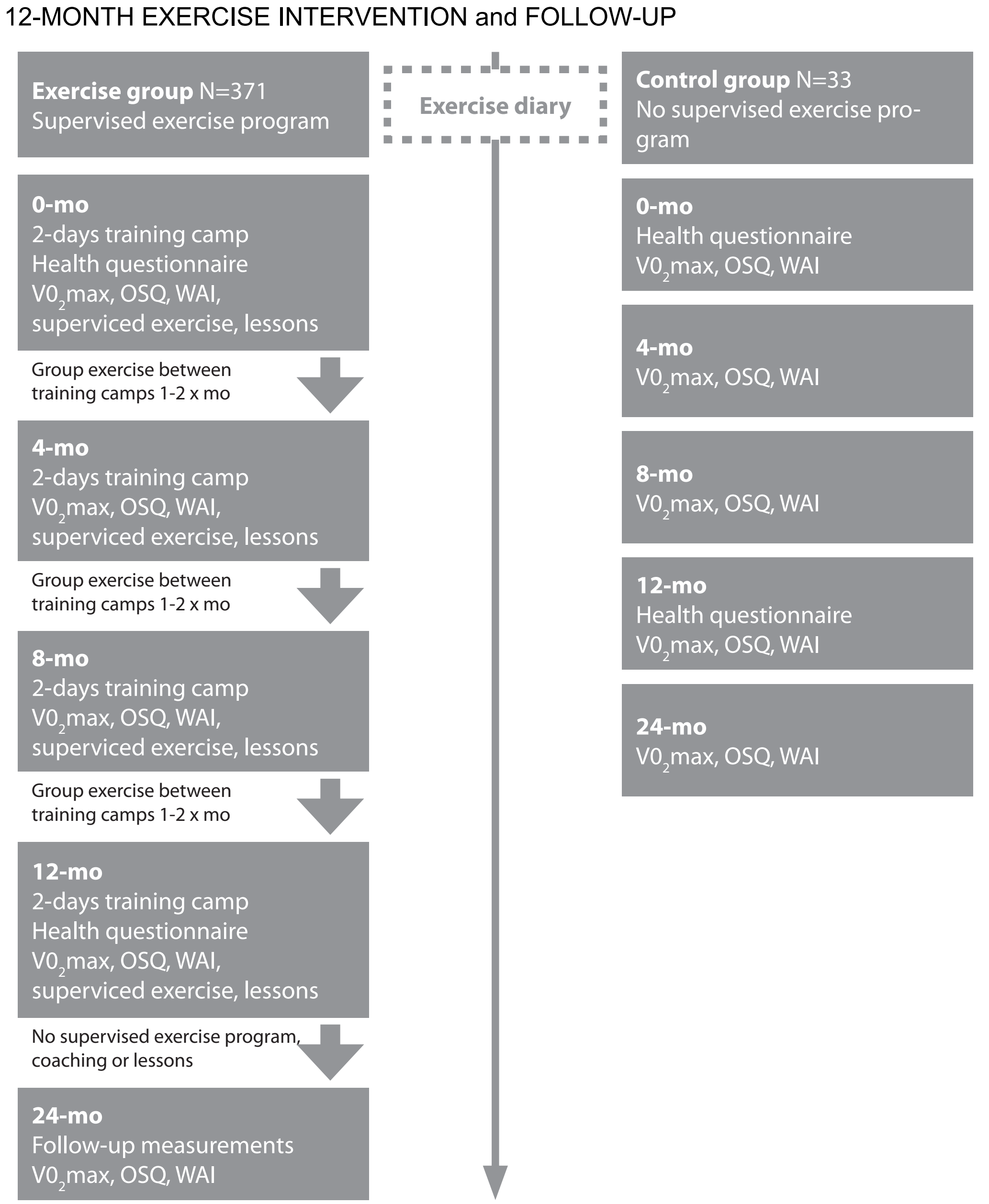

Figure 5. 12-month exercise intervention and 12-month follow-up of the exercise group and control group.

4.6. Statistical analyses

4.6.1. Statistical analysis of the cross-sectional study

For statistical analysis PASW software version 18.0 was used in study I-II. The results are presented as means with standard deviations. After the examination of assumptions, the effects of physical activity and fitness (both cardiorespiratory and musculoskeletal fitness) on stress symptoms and mental resources among groups were tested using analysis of variance (ANOVA) and by using age, BMI, tobacco and alcohol use as covariates (ANCOVA). For the analysis, the study group was divided in three groups (high, moderate and low) concerning volume of LTPA, CRF and MFI levels. For the statistical analysis, subjects were divided to fitness tertiles according to both the CRF and the MFI. Cut points for cardiorespiratory fitness tertiles were 37.9 ml/kg/min and 44.9 ml/kg/min and for muscular fitness tertiles 10.5 and 14.8 points.

In Study II, means and standard deviations were used for results and calculated with standard procedures. Means of stress and mental resources index in BMI groups were examined with analysis of variance (ANOVA) followed by a Bonferroni`s correction as a *post-hoc* test where age, alcohol and tobacco consumption and the other two components of fitness and activity (CRF, MFI and LTPA) (ANCOVA) were taken as covariates. Further, subjects were divided into six subgroups based on BMI (normal vs. overweight) and cardiorespiratory fitness / muscle fitness index / leisure-time physical activity (low, moderate, high) tertiles.

4.6.2. Statistical analysis of the intervention study

Statistical analyses were run by SPSS (Statistical Package for Social Sciences, version 19.0) software. Normality of the variables was tested with the Kolmogorov-Smirnow`s test and logarithm transformations were applied in the analysis as needed. Presented means and standard deviations were calculated with transformed variables. Repeated measures ANOVA was first done for the intervention and control groups to determine the differences between stress symptoms, mental resources and VO_2max. Trial * group (intervention/control) interaction in repeated measures ANOVA was used separately for the intervention (0-mo/4-mo/8-mo/12-mo) and follow-up (0-mo/24-mo) samples. In the case of significant ANOVA, age, gender and BMI were used as covariates (ANCOVA). A paired t-test within the intervention or control group was done as a post-hoc test. Similarly, the difference among subgroups (stress symptoms, mental resources and workability) were analysed by ANOVA and ANCOVA using Bonferroni`s correction as a post-hoc test. There were no statistically significant differences in results between genders or white-collar/blue-collar employees, therefore the results are presented combined. For the statistical analysis in study III the subjects were divided into stress and mental resources tertiles according to the baseline stress symptoms and mental resources. Cut points for stress symptoms were: 6-11 points (group 1, n=72), 12-14 points (group 2, n=103), 15-17 points, (group 3, n=104), 18-30 points, (group 4, n=59). Cut points for mental resources were: 3-5 points (group 1, n=95), 6 points (group 2, n=126), and 7-15 points (group 3, n=117). Correlations between the change in VO_2max/LTPA and the change in stress symptoms/mental resources were analyzed. For the statistical analysis in study IV, subjects were divided into workability subgroups according to the baseline workability level. Cut points for workability groups were: 7-36 (poor/moderate), 37-43 (good), 44-49 (excellent).

Correlations between change in VO_2max/LTPA and change in stress symptoms, mental resources and workability during intervention were analysed.

4.7. Approval of the ethical committees

The ethical committees of the University of Jyväskylä and the Central Finland Health Care District as well as the Headquarters of the Finnish Defence Forces (Dnro 34/2007) approved the cross-sectional study (Studies I-II). The intervention study protocol was approved by the ethical committee of the Pirkanmaa hospital district (Dnro 6/2011) (Studies III-IV). Participants of the both studies were aware of the possibility to terminate their participation in the study at any time or for any reason.

5. RESULTS

The volume of leisure time physical activity and good physical fitness were associated with decreased stress symptoms and improved mental resources among young men in study I. Further, good physical fitness was associated with low stress symptoms and high mental resources among normal weight men in study II. In the 12-month exercise intervention study the improvement in cardiorespiratory fitness was associated with improvement in workability and decrease in stress symptoms.

5.1. Associations of leisure time physical activity and physical fitness on stress and mental resources of young men (Study I-II)

Participants were divided into three tertiles of CRF according to their VO_2 max: 1) <37.87 ml (kg/min), 2) 37.87-44.87 ml/kg/min and 3) >44.87 ml/kg/min and into 3 muscle fitness tertiles according to their muscle fitness index: 1) unfit with a MFI<10.5, 2) average fit with a MFI of 10.5-14.75 and 3) fit with a MFI >14.75. According to the stress questionnaires: 3% of the study group reported high stress symptoms, 8% experienced moderate SS, 31% experienced some SS, 42% reported low SS and 16% reported no SS at all. Twelve percent of the study group experienced a high level of mental resources, 59% reported a moderately high level of MR, 23% experienced some MR, and 5% reported low MR and 1% experienced no MR at all.

5.1.1. Leisure time physical activity, stress symptoms and mental resources

The amount of self-reported LTPA of the subjects was low among 31% of the participants (n=259), moderate among 39% (n=323) and high among 30% (n=249) of the participants. There was a significant difference in the stress symptoms and mental resources between the three LTPA groups (ANOVA, $p<0.0001$, in both) and the difference was significant when age, BMI, alcohol and tobacco use (ANCOVA, $p<0.0001$, in both) were taken as covariates. When CRF was further added to the ANCOVA model the results were still significant in SS ($p=0.002$) and MR ($p=0.001$). The low LTPA group reported 13% ($p<0.0001$) more SS and 12% ($p<0.0001$) less MR than the high LTPA group, respectively (Figure 6). In further analyses SS and MR were analysed in six leisure time LTPA-categories. SS decreased and MR improved linearly when LTPA increased (Figure 7).

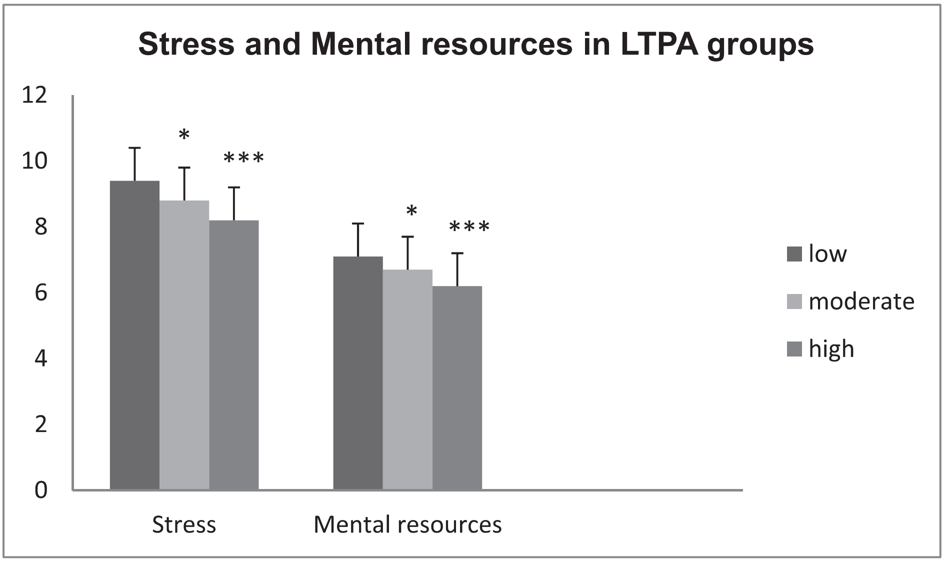

Figure 6. Stress and mental resources in leisure time physical activity (LTPA) categories low, moderate and high. Mean (±SD). *p<0.05, ***p<0.001.

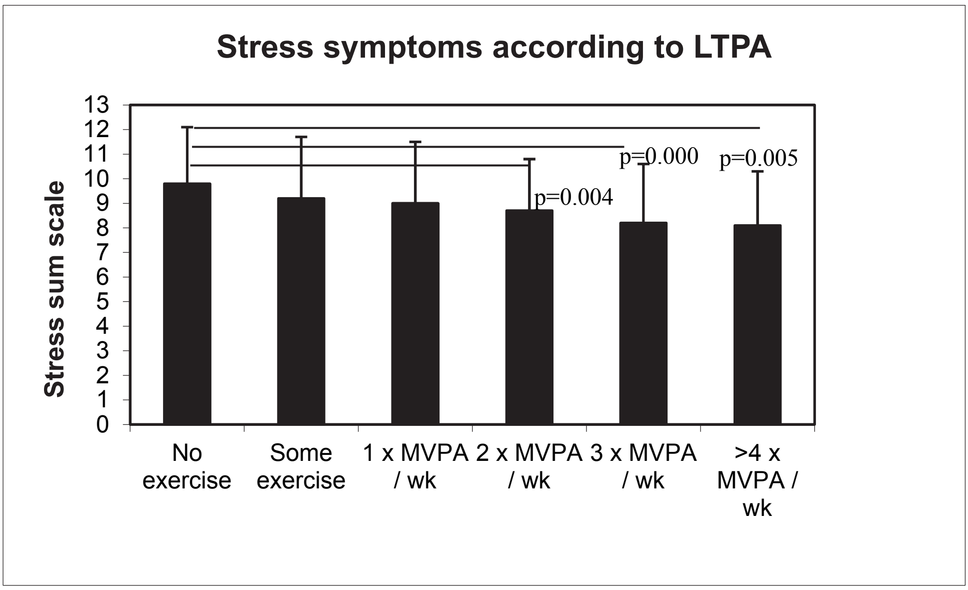

Figure 7. Stress sum scale in six leisure time physical activity (LTPA) categories. Mean (±SD), each category is compared to the no exercise category. The ANCOVA model contained age, tobacco and alcohol use as covariates. High stress sum scale means high stress. MVPA=moderate to vigorous physical activity.

5.1.2. Cardiorespiratory fitness, stress and mental resources

The mean (±SD) CRF of the subjects was 41.6 (±6.4) ml/kg/min. Thirty percent of the subjects had low CRF, 33% had moderate CRF and 33% had high CRF. The stress symptoms and mental resources were different between CRF groups when age, BMI, alcohol and tobacco use (ANCOVA, p<0.0001, in both) were taken as covariates. The results in ANCOVA were significant in SS (p=0.005) and MR (p=0.012) when LTPA was also taken as a covariate in addition to age, BMI, alcohol and tobacco use (Figure 8). The group with low CRF fitness reported 9% (p=0.005) more SS and 7% (p=0.011) less MR than the group with high CRF, respectively.

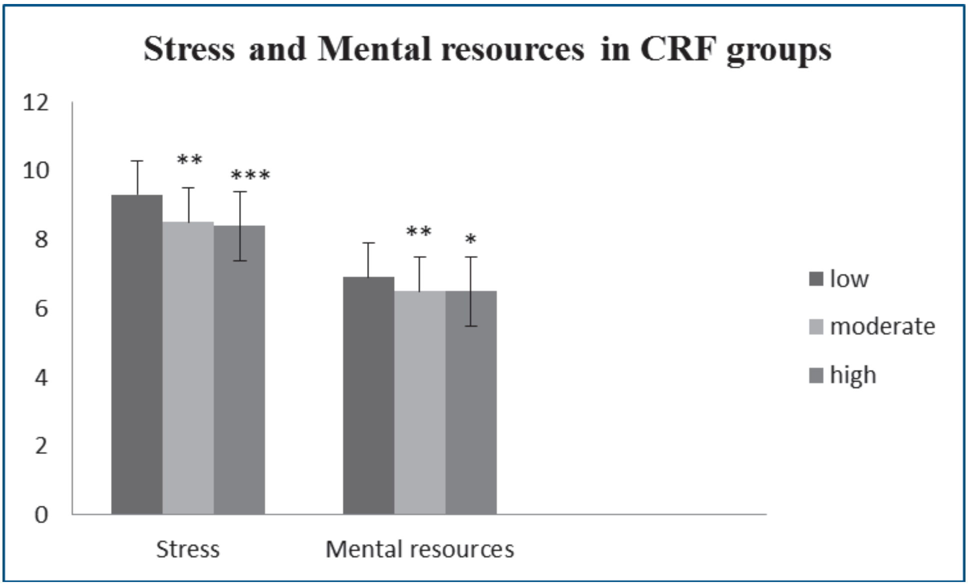

Figure 8. Stress and mental resources in cardiorespiratory fitness (CRF) $V0_2max$ (ml/kg/min) categories. Mean (±SD). *<0.05, **p<0.01, ***p<0.001.

5.1.3. Muscular fitness, stress and mental resources

The mean (±SD) muscle fitness index (MFI) of the study group was 12.4 (±3.8) points. Thirty two percent of the subjects had low MFI (n=238), 34% had moderate MFI (n=252) and 34% had high MFI (n=249). There were differences in SS and MR between the MFI groups (low, moderate, high) (ANOVA, p=0.002 and p= 0.003), and the difference was significant when age, BMI, alcohol and tobacco use (ANCOVA, p=0.037 and p=0.016) were taken as covariates, respectively. The participants with low MFI reported 8% (p=0.001) more SS and 8% less MR (p=0.005) than participants with high MFI (Figure 9).

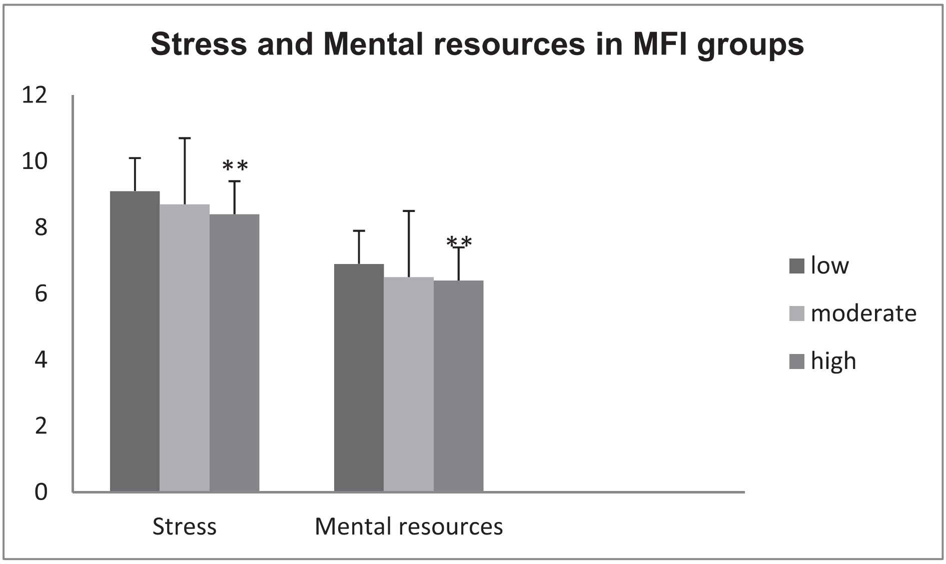

Figure 9. Stress and mental resources in muscular fitness (MFI) categories low, moderate and high. Mean (±SD). *p<0.05, **p<0.01.

5.2. Stress symptoms and mental resources in physical fitness and LTPA groups between normal weight and overweight men (Study II)

In study II, the subjects were divided according to their BMI, 486 men were included in the normal weight (BMI <24.99) and 338 men in the overweight (BMI ≥25) subgroups. For the analyses the participants were divided into six subgroups according to their BMI (normal vs. overweight) and tertiles of CRF, MFI and LTPA (low, moderate, high). Stress symptoms and mental resources were associated with good physical fitness among normal weight men, however among overweight men this association was not seen.

5.2.1. Stress symptoms and mental resources in BMI and LTPA subgroups

There were no significant differences in stress symptoms or mental resources between overweight and normal weight LTPA subgroups (low, moderate, high). The low LTPA / overweight subgroup reported 11% (p=0.047) more stress compared to the overweight subgroup with high LTPA (ANCOVA, p=0.016). Within normal weight participants the low LTPA subgroup experienced 14% (p<0.0001) more stress symptoms compared to the participants in high LTPA subgroup.

5.2.2. Stress and mental resources in BMI and CRF subgroups

The overweight participants with poor CRF reported 6% (p=0.055) lower stress symptoms compared to their normal weight counterparts with poor CFR. The overweight men with good CRF experienced 8% (p=0.039) more SS compared to their normal weight counterparts when age, tobacco and alcohol use, MFI and LTPA were considered as covariates (ANCOVA, p=0.014). Within normal weight participants those with low CRF reported 13% (p=0.004) more SS compared to those with high CRF (Figure 10).

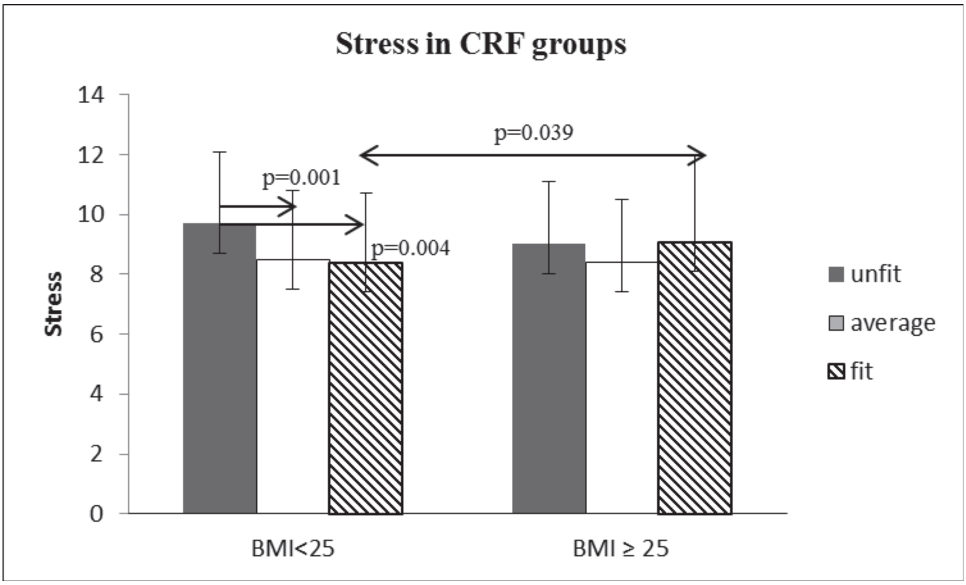

Figure 10. Stress symptoms according to Body Mass Index (BMI) / cardiorespiratory fitness index (CRF) subgroups. Mean (±SD) are presented. The ANCOVA model contained age, tobacco and alcohol use and muscle fitness index (MFI) and leisure time physical activity (LTPA). Differences between the unfit and average fit/fit subgroups within the BMI<25 group and differences between the overweight and normal weight subgroups within the fitness tertiles are presented with lines.

5.2.3. Stress and mental resources in BMI and MFI subgroups

MFI unfit / overweight participants reported 11% (p=0.003) less stress symptoms compared to their MFI unfit / normal weight counterparts. The MFI fit / overweight men experienced 7% (p=0.011) more stress symptoms compared to the MFI fit / normal weight men (ANCOVA, p<0.0001) (Figure 11). Within normal weight subgroups, the MFI unfit men reported 13% (p=0.001) higher stress symptoms compared to the participants with average MFI and 16% (p=0.002) more stress symptoms compared to the fit participants. Within normal weight participants, MFI unfit men reported 10% (p=0.034) less mental resources compared to the MFI average fit participants and 11% (p=0.076, NS) less mental resources compared to the MFI fit participants.

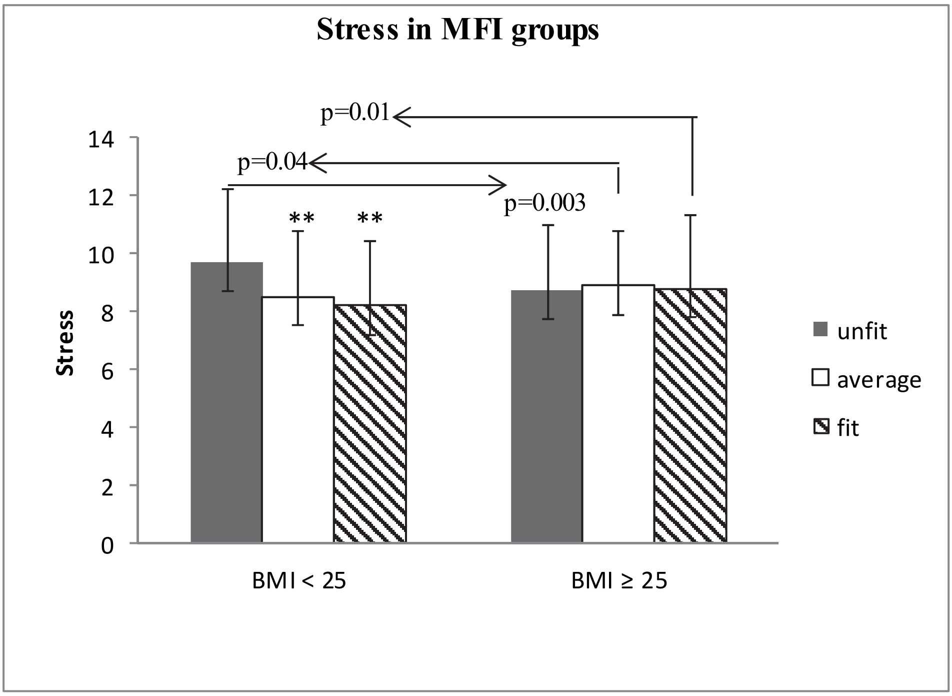

Figure 11. Stress symptoms according to Body Mass Index (BMI) and muscle fitness index (MFI) subgroups. The mean (±SD). The ANCOVA model contained age, tobacco and alcohol use, cardiorespiratory fitness (CRF) and leisure time physical activity (LTPA) as covariates. Differences between the overweight and normal weight subgroups within the fitness tertiles are presented with lines. Differences between the unfit and average fit / fit subgroups within the BMI<25 group: *p<0.05, **p<0.01.

5.3. Effects of an exercise intervention on stress symptoms, mental resources and workability among working adults (Study III-IV)

Overall 338 employees participated in the exercise intervention at baseline. The measurements were carried out at 4-month (n=276, 82%), at 8-month (n=306, 91%), at 12-month (n=306, 91%) during the intervention and after the follow-up year at 24-month (n=178, 53%). The number of employees in the control group was at baseline 33 participants, at 4-month (n=29, 88%), at 8-month (n=27, 82%), at 12-month (n=28, 85%) and after the follow-up at 24-month (n=28, 85%). At baseline the stress symptoms of the exercise group were 14.4 (±3.3) and control group and 12.4 (3.7), respectively (p=0.708). The mean sum points (±SD) of mental resources of the exercise group and control group were 6.3 (1.8) and 5.7 (1.4), respectively (p=0.140).

5.3.1. Leisure time physical activity

According to the questionnaires, the exercise group increased their self-reported LTPA, during the intervention, by 71% (p=0.016). The mean (SD) of LTPA increased from

8.3 (8.8) MET h/wk at baseline to 13.7 (45.2) MET/h/wk to 12-month in the exercise group, however, the increased physical activity did not correlate with the change in stress symptoms (r=0.05, p=0.33). The mean (SD) of LTPA of the control group was at baseline 7.7 (10.1) MET/h/wk and at 12-month 7.9 (10.2) MET/h/wk. The internet-based exercise diaries (n=209) showed that the mean LTPA of the exercise group during active year was 19.5 (11.0) MET/ h/week and during the follow-up year 15.7 (12.3) MET/h/wk. The improvement in LTPA did not correlate with the change in WAI (r=0.05, p=0.33) or changes in mental resources. The amount of LTPA at 12-month according to the questionnaires correlated with the amount of LTPA of the exercise diaries (r=0.200, p=0.0001).

5.3.2. Cardiorespiratory fitness

At baseline the mean (SD) VO_2max of the exercise group and control group were 32.1 (0.7) and 35.4 (11.3) (p=0.005). The CRF of the employees in the exercise group improved by 7% (p<0.001) during the exercise program and from baseline to 24-month by 5% (p < 0.001). No significant changes were reported in VO_2max in the control group. The correlation was significant between the change in stress symptoms and change in VO_2max (ml/kg/min) (r=-0.19, p<0.01) from baseline to 12-month, however the change in mental resources did not correlate with the change in CRF (r=-0.064, p=0.28). A negative correlation existed between the change in workability and the change in stress symptoms (r:-0.361, p<0.01).The change in VO_2max between the exercise group and control group was significant during intervention (baseline vs. 12-month) (p=0.007) and after follow-up (baseline vs. 24-month) (p=0.040), respectively.

5.3.3. Stress symptoms

At baseline the mean (SD±) stress symptoms level of the exercise group was 14.4 (3.5) and that of the control group was 12.4 (3.7) (p=0.708).The stress symptom of the exercise group decreased by 16% (p<0.0001) during the 12-month intervention, but no change was observed in the stress symptoms of the control group. The change in SS between the exercise group and the control group during intervention (baseline vs. 12-month) was p<0.0001 and after follow-up (baseline vs. 24.month) was p=0.004.

The employees of the exercise group decreased their stress symptoms significantly during the exercise program after 4 months by 10% (p<0.0001), after 8 months by 15% (p<0.0001) and after 12 months by 16% (p<0.0001). Among those who participated to the last training camp after one year follow-up (at 24-mo), stress symptoms were still decreased by 13% (p<0.0001) compared to baseline.

The employees having the most stress symptoms at baseline (n=59), decreased their symptoms the most during the exercise program (ANOVA for subgroups, p<0.001), after 4 months by 14% (p<0.0001), after 8 months by 22% (p<0.0001), and after 12 months by 26% (p<0.0001). After one year follow-up (24-mo) stress symptoms were still decreased by 21% (p<0.0001) compared to baseline. All three subgroups having moderate to high levels of stress at baseline decreased their stress symptoms significantly during intervention and SS remained decreased after follow-up (Table 5.)

Table 5. Stress symptoms. Mean (±SD) according to the baseline stress symptoms subgroups compared to baseline.

Stress symptoms	**Baseline (0-mo)**	**4-mo**	**8-mo**	**12-mo**	**24-mo**	
SS subgroup 1 (sum points 6-11)	10.0 (1.1)	10.2 (2.5)	10.1 (2.8)	10.1 (2.4)	10.4 (2.2)	n=72
SS subgroup 2 (sum points 12–14)	13.2 (0.8)	12.3 (2.3)***	11.5 (2.4)***	11.3 (2.4)***	12.2 (2.6)*	n=103
SS subgroup 3 (sum points 15–17)	15.9 (0.8)	13.1 (2.8)***	12.7 (3.1)***	13.0 (2.7)***	13.7 (2.9)***	n=104
SS subgroup 4 (sum points 18–30)	19.6 (1.6)	16.9 (3.7)***	15.2 (2.7)***	14.6 (3.5)***	15.4(2.8)***	n=59

Difference within stress subgroups when compared to baseline:*p≤0.05, ***p<0.0001

5.3.4. Mental resources

The mean (±SD) MR of the exercise group and control group at baseline were 6.3 (1.8) and 5.7 (1.4), respectively (p=0.087). The MR of the exercise group was improved by 8% (p<0.0001) at 12 months and MR remained improved by 5% (p=0.031) at 24-month compared to the baseline; while no significant changes occurred in MR of the control group (ANCOVA during intervention, p=0.001 and between baseline and 24 months, p=0.008). The employees having the lowest MR at baseline (n=117) improved their MR most, after 12 months by 18% (p<0.0001), after the follow-up year their MR remained 18% (p<0.0001) improved compared to baseline (Table 6).

Table 6. Mental resources (MR). Mean (±SD) in MR subgroups according to the baseline during intervention (0-month-12-month) and follow-up (24-month) compared to the baseline.

	Baseline (0-mo)	**4-mo**	**8-mo**	**12-mo**	**24-mo**	
MR subgroup 1 (sum points 3-5)	4.2 (0.8)	4.7 (1.3)	4.7 (1.3)	4.9 (1.4)	4.7 (1.3)	n=95
MR subgroup 2 (sum points 6)	6.0 (0.0)	5.8 (1.2)	5.7 (1.3)	5.6 (1.2)*	6.0 (2.2)	n=126
MR subgroup 3 (sum points 7-15)	8.3 (1.4)	7.3 (1.9)***	6.9 (1.6)***	6.8 (1.7)***	6.8 (1.4)***	n=117

Difference within MR subgroups compared to the baseline. *p<0.05, ***p<0.001.

5.3.5. Workability

During the exercise program the employees having poor to moderate WAI at baseline improved their WAI most. At baseline the mean WAI score of the exercise group was 41.4 (4.7) and the mean WAI of the control group was 42.4 (4.9) (p=0.792). According to the WAI score classification at baseline, 37% (n=127) of the employees had a WAI score of excellent, 50% (n=168) had WAI score good and 13% (n=43) had WAI score poor/moderate. The mean WAI score improved by 3 % (p<0.001) after 12 months among the employees in the exercise group, while no positive change was seen among controls. The employees in the exercise group having the lowest WAI at baseline improved their WAI: after 4 months by 9% (p<0.001), after 8 months by 11% (p<0.001) and after 12 months by 13% (p<0.001) and WAI remained 11% (p=0.024) better than at baseline after the 12-month follow-up (Figure 12).

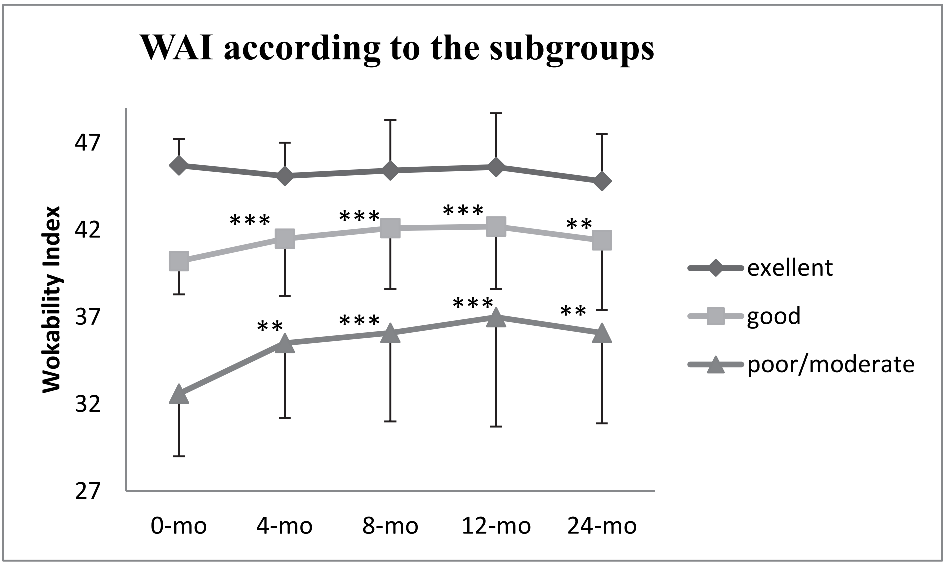

Figure 12. Workability Index (WAI) during exercise intervention (0-12-month) and after follow-up (24 month) according to the subgroups, compared to baseline. Mean (±SD). Difference within subgroups from 0-mo: *p<0.05; **p<0.01; ***p<0.001.

6. DISCUSSION

The present thesis showed that physically active young men reported lower levels of stress and higher mental resources than their inactive counterparts. Improved physical fitness was associated with lower stress levels, and improved workability among working adults. The novelty of this thesis was the importance of good muscular fitness to psychological wellbeing among young men. Based on the results reported in this study, exercise interventions can be recommended to improve employees' psychological health and workability. Exercise and especially good physical fitness can be seen as a preventive method in coping with stress and maintaining psychological wellbeing among young men and working adults.

6.1. Stress symptoms and mental resources according to LTPA and physical fitness categories in young men (Study I-II)

The reservist study consisted of two separate studies among young Finnish men aged 20 to 42. The first study described stress symptoms and mental resources in LTPA and physical fitness categories (low, moderate and high). The second study evaluated the effect of bodyweight to the same outcomes as in study I. The Finnish Defence Force has a very well documented data of the physical fitness and health of the Finish young men. The reservist study is conducted every fifth year during which the physical fitness and health of the reservists are evaluated. For the first time also psychological health outcomes were evaluated. Study I demonstrated that both regular LTPA and good physical fitness were associated with lower stress symptoms and higher mental resources among Finnish young men who participated the reservist course year 2008. After adjusting the results with age, BMI, alcohol consumption and smoking the associations remained statistically significant. Differences among low, moderate and high leisure time physical activity, cardiorespiratory fitness and muscular fitness subgroups were relatively small but still they were statistically significant. Detailed information of the results is described in the original articles.

An interesting and novel result was the association of good muscular fitness with better psychological wellbeing. To our knowledge this was the first population based study that evaluated the association of objectively measured muscle fitness to stress and mental resources. In the study II, we investigated how body weight alters the association between physical fitness and psychological wellbeing. The study population was divided into six subgroups according to body weight (normal weight (BMI<25) and overweight (BMI>25) and LTPA / physical fitness (unfit, average fit, fit). The main finding was that physical fitness was associated with the level of stress and mental resources among normal weight men, however among overweight men this was not seen. There were no significant differences in stress and mental resources between fitness categories among overweight men. Some previous studies exist that evaluate the effects of strength training to mental health outcomes (Anderson-Hanley et al. 2010). However, they are mostly conducted among adults or elderly people with no objective muscular fitness tests. A review of randomized controlled trials by O'Connor et al. (2010) evaluated the effects of strength training to mental health benefits in adults. They found a reduction in anxiety symptoms (5 trials), depressive symptoms (2 trials), fatigue symptoms (10 trials) and improvements in self-esteem (6 trials). The association between muscle fitness on psychological wellbeing may be underestimated and less well understood as O´Connor et al. (2010) report in their review. If strength training is preferred to aerobic training this preference can influence psychological wellbeing (O´Connor et al. 2010) and when it comes to psychological wellbeing it is important that you like the exercise what you do. Exercise by force does not increase anyone's wellbeing.

The association between cardiorespiratory fitness and psychological wellbeing is more evaluated and there is strong evidence supporting but also some opposite opinions (Schully et al. 1998, Atlantis et al. 2004, Chafin & Christenfeld 2008). A meta-analysis of 73 studies by Jackson and Dishman (2006) showed that improved cardiorespiratory fitness helps recovery from stress. Improved cardiorespiratory fitness was also associated with psychological resources in a community sample (Ensel & Lin 2004). The results of the present study underline the possible stress buffering hypothesis of exercise and physical fitness (Ensel & Lin 2004, Gerber & Pühse 2009) or the idea that good physical fitness is likely to facilitate the individual`s capacity for dealing with stress (Schully et al. 1998). The result of Gerber et al. (2010) preferred improved fitness rather than exercise to be associated with reduced stress among Swiss police officers in a questionnaire-based study with self-perceived physical fitness. The strength in our study was that physical fitness was objectively measured.

Obesity and inactive life style are major concerns in modern society. Obesity increases the risk of various diseases including type 2 diabetes mellitus, hypertension and cancer and it will in the future cause further increases in incidence of chronic disease (Foss & Dyrstad 2011). The impact of the association of overweight and obesity on mental health outcomes is not as widely studied than the physiological health outcomes (Roberts et al. 2003). There is evidence of the fact that stress can cause obesity, however there is also some evidence that obesity may be a consequence of stress (Drapeau et al. 2003, Foss & Dyrstad 2011). The mechanism behind this relationship is related to hormones, for example, the complex secretion of adrenal corticosteroids on subsequent adrenocorticotropin (Dallman et al. 2003). It has been claimed that the majority of people change their eating behaviors when they are stressed or depressed. About 40% or more increase and 40% or less decrease their caloric intake and 20% keep their eating behavior normal (Dallman et al. 2003). Eating a high caloric comfort food (fat sugar, carbohydrate) when stressed leads to weight gain (Dallman et al.

2003). The theory of so-called “jolly fat”- hypothesis states that being overweight and obesity are not stressful or depressive and on the contrary, obesity reduces risk of depression (Roberts et al. 2003). Literature sources cannot explain the mechanism behind this theory, yet. Our study results support the inconclusive “jolly fat” theory among overweight men whose physical fitness was low. Half (51%) of the overweight men (n=160) had poor cardiorespiratory fitness and only 14 % (n=44) of them had good CRF. Poor muscular fitness was among 44% of the overweight participants and good muscular fitness in 25% (n=74). We cannot explain why overweight men with poor physical fitness experience less stress and more mental resources than their normal weight counterparts or why good physical fitness did not relate to low stress level and high mental resources. More research is needed to investigate the association between overweight and physical fitness, especially muscular fitness.

Strong evidence exists of the positive associations of physical activity on psychological wellbeing (Hassmen al. 2000, Taylor 2000, Thøgersen-Ntoumani & Fox 2005). Our study results strengthen this evidence. Physically active men who exercised at least three times a week or more experienced significantly lower stress levels compared to inactive men. They also experienced a higher level of mental resources than those men exercising less, however only 30% of the reservists exercised three times or more per week. The amount of stress symptoms decreased and that of mental resources increased gradually when exercise amount increased from the no exercisers to those who exercised at least 3 times per week (Figure 7). Earlier a large Finnish cardiovascular risk factor study among 25 to 64 years adults found significantly less depression, anger, cynical distrust and stress among individuals that exercised at least two to three times a week compared to those exercising less frequently or not at all (Hassmen et al. 2000). All activities above the sedentary level seem to be beneficial for mental health, however the lack of definitive recommendations for the amount and intensity of the exercise for mental health promotion still exists (Johnsdottir et al. 2010). A minimum of moderate intensity aerobic physical activity (PA) 30 minutes, five days per week, or vigorous intensity aerobic PA for a minimum of 20 minutes, three days per week, seems to be a relevant recommendation for both physical and mental health (Johnsdottir et al. 2010).

Is there practical importance of these results? The reservist courses are a good opportunity to meet young men and underline them the importance of both physical activity and especially good physical fitness while promoting psychological wellbeing and health. Maintaining good physical fitness could be recommended as an important low cost preventive and non-pharmacological method in coping with stresses in life and in maintaining mental resources.

6.2. 12-month exercise intervention improved psychological wellbeing and workability among working adults (Study III-IV)

The exercise intervention (study III-IV) demonstrated that a 12-month physical exercise intervention improved the psychological wellbeing of the employees in a large sample of 371 workers. The study population included both women and men and both skilled and unskilled workers. The constancy of the intervention results was evaluated after 12-month follow-up. Stress symptoms of the participants in the exercise group decreased, and mental resources, workability, leisure time physical activity, and cardiorespiratory fitness improved during the 12-month intervention, and these positive changes remained after the follow-up year. The improvements were the greatest among employees who had lack of wellbeing at baseline. At baseline the participants were divided into subgroups according to the score of their baseline stress symptoms, mental resources and workability, and 15% of the participants experienced a high score for stress and 13% a lowered workability at the beginning of the intervention. The employees with the lack of psychological wellbeing at baseline decreased their stress symptoms most, by 26%, and this change remained significant after the follow-up year. The exercise intervention did not include any psychological counselling or lessons. During the 12-month exercise program, the participants in the exercise group increased their leisure time physical activity, significantly. The improvement in LTPA was from baseline 120 minutes per week to 180 minutes per week at 12-month. This improvement is in line with the current recommendations for public health. Healthy adults should engage in a minimum of 150 minutes of moderate-to-vigorous intensity physical activity every week (Fletcher et al. 2013). Both the amount of leisure time physical activity and cardiorespiratory fitness of the exercise group improved, gradually, during the 12-month intervention. The decrease in stress symptoms and workability was associated with the improvement in measured cardiorespiratory fitness, but not with the increase in self-reported leisure time physical activity. Both individual exercise programs and supervised exercise sessions were planned to contain enough aerobic physical activity, which could lead to increased cardiorespiratory fitness and would therefore improve coping with stress. This highlights the result of Schnor et al. (2005) that exercise may bring about higher levels of fitness and – as an indirect consequence – a more efficient physical stress regulation (i.e., reduced secretion of hormones, lowered blood pressure) or enhanced recovery processes. Our result differs somewhat from some earlier studies reporting that physical activity, itself, rather than improvement in cardiorespiratory fitness seems to be effective in improving psychological wellbeing, especially mental health symptoms and mood (Pohjonen & Ranta 2001, Cox 2004) in employees (Taylor 2000) and the general population (Schully 1998, Hassmen et al. 2000, Thøgersen-Noumtani & Fox 2005).

In a critical review of the effectiveness of worksite physical activity programs, Proper et al. (2003) underlined the importance of implementation of worksite physical activity programs to increase physical activity among employees. Our study supports this idea.

Promoting and measuring cardiorespiratory fitness can motivate employees to adopt a more physically active lifestyle and strengthen their mental resources and ability to cope with stress.

However, in recent review (Malik et al. 2014) and meta-analyses (Abraham & Graham-Rowe 2009, Conn et al. 2009), there were inconclusive results of the effectiveness of workplace physical activity health promotion for increasing physical activity among employees. The difference in results between their and our results may be caused at least partly of the mixed methodological quality of the studies. Saksvik et al. (2002) mentioned also that evaluation of interventions programs are characteristically difficult to implement at workplaces.

The role of physical activity as a possible predictor of workability is not fully known (Tuomi 1997, Pohjonen & Ranta 2001, Punakallio et al. 2004, Arvidson et al. 2013). Nurminen et al. (2002) found no association with a worksite exercise program, performed once a week, and workability among women with physical work. A recent extensive questionnaire based study by Arvidson et al. (2013) (n= 2783 workers) suggests that the high level of physical activity seemed to be related to improved workability. Among participants that reported increased level of PA, the reporting of poor or moderate workability decreased (Arvidson et al. 2013). The differences in results between previous studies may be explained by the heterogeneity of study populations and the way of assessing self-reported physical activity.

According to the data collected in the previous literature and in the present study, we may say that the exercise intervention was effective. This kind of intervention could be recommended for future implementation, especially among employees with low baseline workability and high levels of stress. Targeting employees at high risk and great need is a challenge for company’s wellbeing (Thøgersen-Ntoumani & Fox 2005). The occupational health care of the companies should be involved to the selection process for identifying employees with the health risks early enough. Important factors associated with a lowered workability are the lack of leisure time vigorous physical activity, poor musculoskeletal capacity, older age, obesity, high mental work demands, lack of autonomy, poor physical work environment and high physical work load (Van den Berg et al. 2008). To our knowledge, there were no significant changes in work organization in work environment or work content in the companies which participated to the exercise intervention and might have affected the results of our study.

According to Conn et al. (2009), some physical exercise programs are effective without direct health benefits and even modest reduction in absenteeism may result in substantial fiscal savings when multiplied by many employees. There is a need for evaluation of the long-term benefits of the intervention treatments (Linton & van Tulder 2001, Dworkin et al. 2005). In our follow-up study, 24 months after baseline measurements, there were still significantly improved values representing decreased stress symptoms, heightened mental resources and greater cardiorespiratory fitness in the exercise group. Also among the participants with poor or moderate and good workability, the improvement in WAI was significant at 24 months compared to baseline. We think that these findings are important to individuals themselves as well as to the companies, because all efforts for maintaining and improving workability and employee wellbeing are more than welcome. Poor mental health is an equal of greater threat to people's availability for work, their workability and their likelihood of success at work and increase in absence from work (Cox et al. 2004). The psychological wellbeing of the workforce is increasingly recognized as an important issue for employers and other workplace stakeholders in European countries (WRC 2014). Poor psychological wellbeing and elevated level of stress may cause lowered workability and sick leaves among workers and increase health-related costs of companies. Therefore, employers should be interested in paying more attention to actions that may improve psychological wellbeing of the employees.

There is a growing evidence to support the idea that workplace health promotion interventions may increase a company`s profit as well (Cooper & Dewe 2008). In the future, longer follow-up studies could determine the enduring economic impact of programs (Conn et al. 2009). It would have been interesting to evaluate cost-benefits and cost-effectiveness of the present results as well. Thus, an economical evaluation of work related interventions would be a recommendation for future research. A small control group and high amount of drop-outs during the follow-up year in the present exercise group does not allow in overestimating our results. The drop-out rate of the control group stayed stable during the intervention and follow-up year. It is also impossible to say whether the positive results after the follow-up year are due to the exercise intervention or due to other changes in participant's individual life or workplace.

6.3. Strengths and limitations of the study

In this thesis, both a cross-sectional study design (study I-II) and longitudinal study design (intervention with follow-up, study III-IV) were used to evaluate the effects of PA and fitness on stress and mental resources of healthy adults. The measurement of psychological wellbeing is somewhat challenging. There is a lack of precise definition of mental health and psychological- or mental wellbeing. There is also considerable heterogeneity in defining and measuring stress, which causes difficulties to compare results with previous studies using different estimates of mental health (Milles 2007, Gerber & Pühse 2009, Roscoe 2009). However, despite the methodological diversity to evaluate stress symptoms and mental resources, the present results are in accordance with earlier studies. The single question of measuring stress of the OSQ questionnaire is validated to measure both occupational and individual normal life stress (Elo et al. 2003). We used systematically the same questions of OSQ questionnaire, although all participants of the reservist study did not have long experience in working life.

Strengths in our studies is that we used both self-reported LTPA and objectively measured physical fitness at the same time to evaluate the association of exercise on SS and MR. Most previous studies have used only LTPA, few have used measured fitness tests and just few both LTPA and physical fitness. It would have improved the validity and reliability of the present studies if we could have had objectively measured LTPA instead of self-reported questionnaire and exercise diary to evaluate the amount of PA. However, measurements in large populations and in real working life interventions is somewhat challenging and we decided to use the questionnaires.

6.3.1. Strengths and limitations of studies I-II

In the studies I-II, the reasonably large sample size represents quite well Finnish young men and this is the strength in these studies. Because of the compulsory military service, the study population is a geographically representative sample of healthy young men. Its limitations were the cross-sectional design of the study, which reduces its power to establish causal relationships. Both CRF and muscle fitness were objectively measured according to the standards of the Finnish Defence Force. The actual physical fitness tests used in the study are well-recognized and widely used for the determination of physical fitness status in young men (Fogelholm et al 2006a, 2006b). VO_2max levels are highly associated with cardiovascular disease morbidity and mortality. On the other hand, muscular fitness seems to also have associations with cardiovascular diseases and the muscle fitness tests employed were selected for muscle group coverage and reference values (Katzmarzyk & Craig 2002). With a combination of cardiorespiratory and muscular fitness assessments, we were able to obtain sufficient and comparable data from the cohort. The weekly LTPA frequency and intensity was determined from responses to a single question (SIVAQ) with six categories (Fogelholm et al. 2006b). The strength and novelty of the present study was that to our knowledge, this was the first population based study to evaluate the effect of objectively measured muscular fitness on stress and mental resources. Also, examining the association of bodyweight to mental wellbeing and objectively measured physical fitness has not been done earlier.

6.3.2. Strengths and limitations of exercise intervention

There is some evidence suggesting that work-related interventions may increase PA. A recent review of 58 studies by Malik et al. (2014) found an inconclusive result for the effectiveness of workplace health promotion interventions for increasing PA. The same inconclusive result was found in a meta-analysis of workplace PA interventions by Abraham & Graham-Rowe (2009) and Conn et al. (2009). Only few of the studies that were evaluated in the above mentioned reviews and meta-analysis included an actual physical activity component (Malik et al. 2014) and that may explain at least partly the diverse results.

We included actual PA components in our intervention by using an individual training program that was based on the CRF test every four months. Our training camps included several PA sessions and there were group exercise sessions between training camps, and the exercise amount was controlled by individual exercise diaries. In accordance with our results, team-based health promotion is suggested to be more effective with PA behavior than with individual health counselling (Elliot et al. 2004, Mac Kinnon et al. 2010). Support of the co-workers might play also an important role in work-related interventions, while social influences is found to play a greater role in an individual`s health behavior choices than individual factors alone (Malik et al 2014). In addition, programs with contact to the participants, for example, an exercise program with instructor and regular encouragement and motivation are more likely to be effective (Rongen et al. 2013). However, more well-designed and good quality studies to identify the types of interventions that show the most promise are needed (Abraham & Graham-Rowe 2009, Conn et al. 2009, Malik et al 2014).

The strength in the intervention study is that our sample size was rather high for a working population (n=371), and it represents quite well employees of medium-sized companies. The present study examined blue and white collar employees with women and men of different ages. The lack of randomization and the small size of the control group may have diminished the methodological quality of the intervention study. In the present study, we decided to use a protocol of a “real-life” setting (work life). It was very clear that a randomized controlled design would not be the most realistic design. Only 10% of the participants were allocated to the control group. Also, the subjects in the control group were collected from different working places than the subjects in the intervention group. At baseline, the age, height, weight, BMI, use of alcohol, PA level and smoking status did not differ between the control and intervention groups. However, aerobic fitness at baseline was somewhat higher in the control group. Furthermore in order to diminish the bias, we used: A) high number of participants from several companies, B) several sampling points (4 time points of measurements) during the intervention, C) one year follow-up and D) different methods to evaluate the PA (questionnaire, exercise diary, fitness tests 5 times). By using these methods, we consider that it is valid to conclude that the exercise intervention was the most likely factor resulting in an increased LTPA, improved fitness together with better WAI and decreased stress symptoms. Also, the improvement of WAI and a decrease in stress symptoms correlated with the improvement of CRF. And it is not likely that, at the same time, something else would have increased the WAI and CRF fitness simultaneously found in several small- and medium-sized companies in the exercise group. However, in the 33 control subjects from same companies, but a different work place, both the WAI and the CRF somewhat decreased.

The amount of drop-outs was low during the intervention period, but somewhat higher than expected during the follow-up year. A call-up letter was sent to the drop-outs and a lack of compliance in the follow-up measurement was most likely due to retirement, changing the employer, sickness and other personal reasons. Non-randomized trials may have methodological problems. Therefore, we tried to diminish this by using a high number of participants from several different companies, several time points in the measurements during the intervention, a one year follow-up and different methods to evaluate the physical activity/fitness (questionnaire, exercise diary, fitness tests five times).

It is not possible to say whether the positive changes found after the follow-up year are due to the intervention or to other changes in the participant`s personal or working life. However, it is unlikely that there would have been changes in the workplaces in different companies at the same time. Implementing randomized controlled studies in real working life is somewhat difficult (Sephard 1996, Tveito et al. 2008), as both management and employees should accept a random assignment of employees between two alternative types of treatment. The evaluation of both self-reported LTPA (questionnaire and exercise diary) and measured CRF several times during the study instead of assessing either LTPA or CRF once during the study, is a strength in this intervention.

7. CONCLUSION

1. The volume of leisure time physical activity and good physical fitness, both cardiorespiratory and muscle fitness, were significantly associated with lower stress symptoms and higher mental resources in young men when age, alcohol consumption and tobacco use were taken into consideration.

2. Good cardiorespiratory and muscle fitness were associated with lower stress symptoms and higher mental resources among normal weight men but not in overweight men. The current results underline how important the factor, body weight, can be when analysing associations between psychological wellbeing and physical fitness or physical activity.

3. A 12-month physical exercise intervention decreased stress symptoms and improved mental resources significantly among healthy working adults. Stress symptoms remained decreased and mental resources remained improved after 12-month follow-up. The decreased stress symptoms were associated with improved cardiorespiratory fitness.

4. A 12-month exercise intervention improved the workability of healthy working adults, especially among employees with low baseline workability. The improved WAI was associated with improved cardiorespiratory fitness.

5. These results promote programs to improve physical fitness and the workability potential among employees in workplaces. Implementing physical activity programs, at workplaces and at refresher courses, can be recommended to strengthen people's ability to cope with stress and improve their psychological wellbeing and workability.

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Heinola January 2015

Oili Kettunen

9. REFERENCES

Abbas SG, Farah A, Apkinar-Sposito C. Measuring the immeasurable. An overview of stress & strain measuring instruments. Mediterranean Journal of Social Sciences 2013; 4: 480-489.

Abraham C, Graham-Growe E. Are worksite interventions effective in increasing physical activity? A systematic review and meta-analysis. Health Psychology Review 2009; 3: 108-144.

Abu-Omar K, Rütten A, Lehtinen V. Mental health and physical activity in the European Union. Sozial und Praventive Medizine 2004a; 49: 301-309.

Abu-Omar K, Rütten A, Robine J-M. Self-rated health and physical activity in the European Union. Sozial und Praventive Medizine 2004b; 49: 235-242.

Adams T, Bezner J, Steinhardt M. The conceptualization and measurement of perceived wellness: Integrating balance across and within dimensions. American Journal of Health Promotion 1997; 11: 208-218.

Aittomäki, A, Lahelma E, Roos E. Work conditions and socioeconomic inequalities in work ability. Scandinavian Journal of Work, Environment & Health 2003; 29: 159–165.

Aldana SG, Sutton LD, Jacobson BH, Quirk MG. Relationships between leisure time, physical activity, and perceived stress. Perceptual and Motor Skills 1996; 82**:** 315-321.

Allen M. The psychobiology of athletic training. In: Bergel D, Burton RW (Eds). Sport psychiatry: theory and practice. New York, WW Norton & Company 2000: 22-44.

Allgöwer A, Wardle J, Steptoe A. Depressive symptoms, social support and personal health behaviours in young men and women. Health Psychology 2001; 20**:** 223-227.

American College of Sport Medicine. ACSM's guidelines for exercise testing and prescription. Philadelphia, Lippincott Williams & Wilkins 2000: 845.

Anderson LM, Quinn TA, Glanz K, Ramirez G, Kahwati LC, Johnson DB, Buchanan CR, Archer WR, Chattopadhyay S, Kalra GP, Katz DL. The effectiveness of worksite nutrition and physical activity interventions for controlling employee overweight and obesity: a systematic review. American Journal of Preventive Medicine 2009; 37: 340-357.

Anderson-Hanley C, Nimon J-P, Westen SC. Cognitive health benefits of strengthening exercise for community-dwelling older adults. Journal of Clinical and Experimental Neuropsychology 2010; 32: 996-1001.

Antonovsky A. Health, stress and coping. San Francisco, CA, Jossey- Bass 1979: 30-50.

Arent SM, Landers DM, Etnier JL. The effects of exercise on mood in older adults: A meta-analytic review. Journal of Ageing and Physical Activity 2000; 8: 407-430.

Arvidson E, Börjesson M, Ahlborg G, Lindegård A, Jonsdottir IH. The level of leisure time physical activity is associated with work ability- a cross sectional and prospective study of health care workers. BMC Public Health 2013; 13: 855.

Atlantis E, Chow C-M, Kirby A, Sing MF. An effective exercise-based intervention for improving mental health and quality of life measures: a randomized controlled trial. Preventive Medicine 2004; 39: 424-434.

Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review 1977; 84: 191-215.

Berger BG, Motl RW. Exercise and mood: A selective review and synthesis of research employing the profile of mood states. Journal of Applied Sport Psychology 2000; 12: 69-92.

Biddle SHJ, Mutrie N. Psychology of physical activity. Determinants, wellbeing and interventions. London, Routledge 2001: 161-243.

Blair S, Cheng Y, Holder S. Is physical activity or physical fitness more important in defining health benefits? Medicine and Science in Sports and Exercise 2001; 33: 379-399.

Blake H, Mo P, Malik S, Thomas S. How effective are physical activity interventions for alleviating depressive symptoms in older people? A systematic review. Clinical Rehabilitation 2009; 23: 873-887.

Bouchard C, Shephard RJ, Stephens T. Physical activity fitness and health consensus statement. Champaign, IL, Human Kinetics Publishers 1993: 204-213.

Boullosa DA, Hautala AJ, Leicht AS. Introduction to the research topic: the role of physical fitness on cardiovascular responses to stress. Frontiers in Physiology 2014; 5: 1-2.

Brown DW, Balluz LS, Heath GW, Moriarty DG, Ford E, Giles WH, Mokdad AH. Associations between recommended levels of physical activity and health-related quality of life: findings from the 2001 behavioral risk factor surveillance system (BRFSS) survey. Preventive Medicine 2003; 37: 520-528.

Brown HE, Gilson ND, Burton NW, Brown DJ. Does physical activity impact on presenteeism and other indicators of workplace wellbeing? Sports Medicine 2011; 41: 249-262.

Brumby S, Chandrasekara A, Mc Coombe S, Torres S, Kremer P, Lewandowski P. Reducing psychological distress and obesity in Australian farmers by promoting physical activity. BMC Public Health 2011; 11: 362.

Cancelliere C, Cassidy JC, Ammendolia C, Cote P. Are workplace health promotion programs effective at improving presenteeism in workers? A systematic review and best evidence synthesis of the literature. BMC Public Health 2011; 11: 395.

Carless D, Faulkner G. Physical activity and mental health. In: McKenna J and Riddoc C (Eds). Perspectives on health and exercise. Hampshire, Palgrav Macmillan 2003: 61-82.

Ceballos WA, Hooker S, Al` Absi M. Sex specific associations of body mass index with mood disturbance during smoking abstinence. Neuropsychobiology 2009; 60: 37-43.

Chafin, S, Christenfeld N, Gerin W. Improving cardiovascular recovery from stress with brief post stress exercise. Health Psychology 2008*;* 27**:** 64-72.

Chida Y, Steptoe A. Positive psychological wellbeing and mortality: A quantitative review of prospective observational studies. Psychosomatic Medicine 2008; **7:** 741-756.

Chrisp AH, McGuinnes B. Jolly fat: relationship between obesity and psychoneuroses in the general population. British Medical Journal 1976; 1: 7-9.

Conn VS, Hafdahl AR, Cooper PS, Brown IM, Lusk SI. Meta-analysis of workplace physical activity interventions. American Journal of Preventive Medicine 2009; 37: 330-339.

Cooper C, Dewe P. Wellbeing-absenteeism, presenteeism, costs and challenges. Occupational Medicine 2008; 58: 522-524.

Corbin CB, Pangrazi RP, Frank B. Definitions: health, fitness, and physical activity. Resident`s council on physical fitness and sports research digest 2000; 9: 1-9.

Cox T, Leka S, Ivanov I, Kortum E. Work, employment and mental health in Europe. Work & Stress 2004; 2: 179-185.

Dallman MF, Pecoraro NC, la Fleur SE. Chronic stress and comfort foods: Self-medication and abdominal obesity. Brain, Behavior and Immunity 2003; 19: 275-280.

Diener E, Suh M, Lucas E, Smith H. Subjective wellbeing: Three decades of progress. Psychological Bulletin 1999; 125: 276-302.

Diener E. Subjective wellbeing: The science of happiness and a proposal for a national index. American Psychologist 2000; 55: 34–43.

Diener E. Subjective wellbeing. In: Diener E (Eds). The science of wellbeing. New York, Spring 2009: 11-58.

Dishman RK, Oldenburg B, O'Neal H, Shephard RJ. Workplace physical activity interventions. American Journal of Preventive Medicine 1998; 15: 344-361.

Dishman RK, Dejoy DM, Wilson MG, Vandenberg RJ. Move to improve. A randomized workplace trial to increase physical activity. American Journal of Preventive Medicine 2009; 36: 133-141.

Dodge R, Daly AP, Huyton J, Sanders LD. The challenge of defining wellbeing. International Journal of Wellbeing 2012; 2: 222-235.

Doll HA, Petersen SEK, Stewart-Brown SL. Obesity and physical and emotional wellbeing: Associations between body mass index, chronic illness, and the physical and mental components of the SF-36 questionnaire. Obesity Research 2000; 8: 160-170.

Drapeau V, Provencher V, Lernieux S, Despres J-P, Bouchard C, Tremblay A. Do 6-y changes in eating behaviors predict changes in body weight? Results from the Québec family study. International Journal of Obesity 2003; 27**:** 808–814.

Dunn AL, Dishman RK. Exercise and the neurobiology of depression. Exercise Sport Science Review 1991; 19: 41-98.

Dunn AL, Trivedi MH, O`Neal HA. Physical activity dose-response effects on outcomes of depression and anxiety. Medicine and Science in Sport and Exercise 2001; 33: 587-597.

Dworkin, R.H, Turk DC, Farrar JT, Haythornthwaite JA, Jensen MP, Katz NP. Topical review and recommendations, core outcome measures for chronic pain clinical trials: Impact recommendations. Pain 2005; 113: 9–19.

Ekeland E, Heian F, Hagen K, Coren E. Can exercise improve self-esteem in children and young people? A systematic review of randomized controlled trials. British Journal of Sports Medicine 2005; 39:792-798.

Ekkekakis P. Pleasure and displeasure from the body: Perspectives from exercise. Cognition and Emotion 2003; 17: 213–239.

Ekkekakis P, Parfitt G, Petruzzello S J. The pleasure and displeasure people feel when they exercise at different intensities. Sports Medicine 2011; 41: 641–671.

Elliot DL, Goldberg L, Duncan TE, Kuehl KS, Moe EL, Breger RK, DeFrancesco CL, Ernst DB, Stevens VJ. The PHLAME; firefighters` study: feasibility and findings. American Journal of Health Behavior 2004; 28: 13-23.

Elo A-L, Leppänen A, Lindström K, Ropponen T. OSQ, Occupational stress questionnaire- users instructions. Reviews 19. Helsinki. Finnish Institute of Occupational Health 1992: 3-43.

Elo A-L, Leppänen A, Sillanpää P. Applicability of survey feedback for an occupational health method in stress management. Occupational Medicine 1998; 3: 181-188.

Elo A-L, Leppänen A, Jahkola A. Validity of a single-item measure of stress symptoms. Scandinavian Journal of Work, Environment & Health 2003; 29: 444-451.

Engbergs LH, van Poppel MNM, Chin A, Paw MJM, van Mechelen W. Worksite health promotion programs with environmental changes. A systematic review. American Journal of Preventive Medicine 2005; 29: 61-70.

Ensel WM, Lin N. Physical fitness and stress process. Journal of Community Psychology 2004; 32: 81-101.

Eriksen HR, Ihlebæk C, Mikkelsen A, Grønninggsæter H, Sandal GM, Ursin H. Improving subjective health at the worksite: a randomized controlled trial of stress management training, physical exercise and an integrated health programme. Occupational Medicine 2002; 52: 383-391.

Eskelinen L, Kohvakka A, Merisalo T, Hurri H, Wägar G. Relationship between the self-assessment and clinical assessment and clinical assessment of health status and workability. Scandinavian Journal of Work, Environment & Health 1991; 17: 40- 47.

European Commission. Eurobarometer on mental health 2010. Available at: http://ec.europa.eu/health/mental_health/eurobarometers/index_en.htm.

Fabricatore A N, Wadden TA, Higginbotham AJ, Faulconbridge LF, Nguyen AM, Heymsfield SB, Faith MS. International Journal of Obesity 2011; 35: 1363-1376.

Feldt T, Hyvönen K, Mäkikangas A, Kinnunen U, Kokko, K. Development trajectories of Finnish managers' workability over a 10-year follow-up period. Scandinavian Journal of Work, Environment & Health 2009; 35: 37–47.

Fevre M, Kolt G, Matheny J. Eustress, distress and their interpretation in primary and secondary occupational stress management interventions: which way first? Journal of Managerial Psychology 2006; 21: 547-565.

Fletcher GF, Ades PA, Kligfield P, Arena R, Balady GJ, Bittner VA, Coke LA, Fleg JL, Forman DE, Gerber TE, Gulati M, Madan K, Rhodes J,Thompson PD, Williams MA. Exercise standards for testing and training. A scientific statement from the American heart association. Circulation 2013 ; 128 : 873-934.

Fogelholm M, Malmberg J, Suni J, Santtila M, Kyröläinen H, Mäntysaari M. Waist circumference and BMI are independently associated with the variation of cardiorespiratory and neuromuscular fitness in young men. International Journal of Obesity 2006a; 30**:** 962-969.

Fogelholm M, Malmberg J, Suni J, Santtila M, Kyröläinen H, Mäntysaari M, Oja P. International physical activity questionnaire: Validity against fitness. Medicine and Science in Sports and Exercise 2006b; 38: 753–760.

Fogelholm M, Stigman S, Huisman T, Metsämuuronen J. Physical fitness in adolescents with normal weight and overweight. Scandinavian Journal of Medicine and Science in Sports 2008; 18: 162-1670.

Forcier K, Stroud LR, Papandonatos GD, Hitsman B, Reiches M, Krishnamoorthy J, Niaura R. Links between physical fitness and cardiovascular reactivity and recovery to psychological stressors: a meta-analysis. Journal of Health Psychology 2006; 25: 723-739.

Foss B, Dyrstad SM. Stress in obesity: Cause or consequence? Medical hypotheses 2011; 77: 7-10.

Fox K. The influence of physical activity on mental wellbeing. Public Health Nutrition 1999; 2: 411-418.

Fuchs R, Hahn A, Schwarzer R. Effekte sportlicher aktivität auf selbstwirksamkeits-erwartung und gesundheit in einer stressreichen lebenssituation (Effects of exercise on self-efficacy and health in a stressful life situation). Sportwissensaft 1994; 24: 67-81.

FukukawaY, Nakashima C, Tsuboi S, Kozakai R, Doyo W, Niino N. Age differences in the effect of physical activity on depressive symptoms. Psychology of Aging 2004; 19**:** 346-351.

Gabriel P, Liimatainen M.R. Mental health in the workplace. Geneva, International Labour Office 2000: 1-27. Available at: http://digitalcommons.ilr.cornell.edu/gladnetcollect/223.

Galper DI, Trivedi MH, Barlow CE, Dunn AL, Kampert JB. Inverse association between physical inactivity and mental health in men and women. Medicine and Science in Sport and Exercise 2006; 38: 173-178.

Gauvin L, Brawley L R. Alternative psychological models and methodologies for the study of exercise and affect. In: Seraganian P (Eds). Exercise psychology*:* The influence of physical exercise on psychological processes. New York, John Wiley & Sons, Inc 1993: 146-171.

Gerber M, Pühse U. Do exercise and fitness protect against stress-induced health complaints? A review of the literature. Scandinavian Journal of Public Health 2009; 37**:** 801-819.

Gerber M, Kellmann M, Hartmann T, Pühse U. Do exercise and fitness buffer against stress among Swiss police and emergency response service officers? Psychology of Sport and Exercise 2010; 11: 286-294.

Golaszewski T. The limitations and promise of health education in managed care. Health Education Behavior 2000; 27: 402-416.

Gondoh Y, Sensui H, Kinomura S, Fukuda H, Fujimoto T, Masud M, Nagamatsu T, Tamaki H, Takekura H. Effects of aerobic exercise training on brain structure and psychological well-being in young adults. Journal of Sports Medicine and Physical Fitness 2009; 49: 129-135.

Goodwin RD. Association between physical activity and mental disorders among adults in the United States. Preventive Medicine 2003; 36: 698-703.

Groeneveld IF, Proper KI, van der Beek AJ, Hildebrandt VH, van Mechelen W. Lifestyle focused interventions at the workplace to reduce the risk of cardiovascular disease- a systematic review. Scandinavian Journal of Work, Environment & Health 2010; 36: 202-215.

Gutin B, Yin Z, Humphries MC, Barbeau P. Relations to moderate and vigorous physical activity to fitness and fatness in adolescents. American Journal of Clinical Nutrition 2005; 81: 746-750.

Harward Health Publications. Exercise is an effective stress buster. November 2014. Available at http://www.health.harvard.edu/healthbeat/exercise-is-an-effective-stress-buster.

Hamer M, Taylor A, Steptoe A. The effect of acute aerobic exercise on stress related blood pressure responses: a systematic review and meta-analysis. Biological Psychology 2006; 71: 183-190.

Haskell W, Lee I-M, Russell R, Pate R, Powell K, Blair S, Barry A, Franklin A, Macera CA, Heath GW, Thompson PD. Physical activity and public health: Updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. Medicine and Science in Sport and Exercise 2007; 39: 1423-1434.

Hassan MK, Joshi AV, Madhavan SS, Amonkar MM. Obesity and health-related quality of life: a cross-sectional analysis of the US population. International Journal of Obesity 2003; 27: 1227-1232.

Hassmen P, Koivula N, Uutela A. Physical exercise and psychological wellbeing. A population study in Finland. Preventive Medicine 2000; 30: 17-25.

Hettler B. Wellness promotion on a university campus. Family and Community Health: Journal of Health Promotion and Maintenance 1980; 3: 77-95.

Hobfoll SE, Freedy JR, Green BL, Salomon SD. Coping reactions to extreme stress: The roles of resource loss and resource availability. In: Zeidner M and Endler NS (Eds). Handbook of coping: theory, research, applications. New York, Wiley & Sons 1996: 322-349.

Hobfoll SE. Stress, culture, and community: The psychology and physiology of stress. New York, Plenum 1998:1-50.

Holmes ME, Ekkekakis P, Eisenmann JC. The physical activity, stress and metabolic syndrome triangle: a guide to unfamiliar territory for the obesity researcher. Obesity reviews 2010; 11: 492-507.

Huang IC, Frangakis C, Wu AW. The relationship of excess body weight and health-related quality of life: evidence from a population study in Taiwan. International Journal of Obesity 2006; 30: 1250-1259.

Hutchinson AD, Wilson C. Improving nutrition and physical activity in the workplace: a meta-analysis of intervention studies. Health Promotion International 2012; 27: 238-249.

Häkkinen A, Rinne M, Vasankari T, Santtila M, Häkkinen K, Kyröläinen H. Association of physical fitness with health-related quality of life in Finnish young men. Health and Quality of Life Outcomes 2010; 8:15. Doi:10.1186/1477-7525-8-15.

Ilmarinen, J, Tuomi K, Klockars M. Changes in the work ability of active employees over an 11-year period. Scandinavian Journal of Work, Environment & Health 1997; 23: 49-57.

Ilmarinen J. The work ability index (WAI). Occupational Medicine 2007; 57: 160.

Ilmarinen, J, Tuomi K. Past, present and future of work ability. People and Work Research Reports 2004; 65: 1-25.

lmarinen J, Rantanen J. Promotion of work ability during aging. American Journal of Industrial Medicine 1999; 38: 21-23.

Jackson EM, Dishman RK. Cardio respiratory fitness and laboratory stress: A meta-regression analysis. Psychophysiology 2006; 43: 57-72.

Jasienska G, Ziomkiewiz A, Gorkiewicz M, Pjak A. Body mass, depressive symptoms and menopausal status: an examination of the “jolly fat” hypothesis. Womens health issues 2005; 15: 145-151.

Johnsdottir IH, Rojder L, Hadzibajramovic E, Börjesson M, Ahlborg Jr.G. A prospective study of leisure time physical activity and mental health in Swedish health care workers and social insurance officers. Preventive Medicine 2010; 51: 373-377.

Jorm AF, Korten AE, Christensen H, Jacomb JA, Rodgers B, Parslon RA. Association of obesity with anxiety, depression and emotional well-being: a community survey. Australian Journal of Public Health 2003; 27: 434-440.

Kahneman D, Diener E, Schwarz N (Eds). Wellbeing: Foundations of hedonic psychology. New York, Russell Sage Foundation Press 1999: 3-25.

Kaleta D, Makowiec-Darbowska, Jegier A. Lifestyle index and workability. International Journal of Occupational Medicine and Environmental Health 2006; 19: 170-177.

Katz DA, Mc Horney CA, Atkinson RL. Impact of obesity on health- related quality of life in patients with chronic illness. Journal of General Internal Medicine 2000; 15: 789-796.

Katzmarzyk PT, Craig CL. Musculoskeletal fitness and risk of mortality. Medicine and Science in Sports Exercise 2002; 34: 740–744

Kell RT, Bell G, Quinney A. Musculoskeletal fitness, health outcomes and quality of life. Sports Medicine 2001; 31: 863-873.

Keyes CL, Smotkin D, Ryff CD. Optimizing wellbeing: The empirical encounter of two traditions. Journal of Personality and Social Psychology 2002; 82: 1007-1022.

Kobasa SC. Stressful life events, personality, and health: An inquiry into hardiness. Journal of Personality and Social Psychology 1979; 37: 1-11.

Kuoppala J, Lamminpää A, Husman P. Work health promotion, job wellbeing, and sickness absences. A systematic review and meta-analysis. Journal of Occupational and Environmental Medicine 2008; 50: 1216-1227.

Krohne HW. Stress and coping theories 2002: 1-13. Available at: http://userpage.fu-berlin.de/shuez/folier/Krohne-Stress.pdf

Kruger J, Bowles HR, Jones DA, Ainsworth BE, Kohl HW. Health-related quality of life, BMI and physical activity among US adults (≥ 18 years): National physical activity and weight loss survey. International Journal of Obesity 2007; 31: 321-327.

Kyröläinen H, Häkkinen K, Kautiainen H, Santtila M, Pihlainen K. A. Physical fitness, BMI and sickness absence in male military personnel. Occupational Medicine (London) 2008; 58, 251-256.

Lahti J, Laaksonen M, Lahelma E , Rahkonen O. The impact of physical activity on sickness absence. Scandinavian Journal of Medicine and Science in Sports 2010; 20: 191-199.

Lampinen P, Heikkinen RL, Ruoppila I. Changes in intensity of physical exercise as predictors of depressive symptoms among older adults: An eight year follow up. Preventive Medicine 2000; 30: 371-380.

Lane AM, Lovejoy DJ. The effects of exercise on mood changes: the moderating effect of depressed mood. Journal of Sports Medicine and Physical Fitness 2001; 41: 239-245.

Lazarus RS. Emotion and Adaptation. New York, Oxford University Press 1991: 50-70.

Lazarus RS. Coping theory and research: Past, present, and future. Psychosomatic Medicine 1993; 55: 234-247.

Lindwall M, Hadzibajramovic E, Johansdottir IH. Self-reported physical activity and aerobic fitness are differently related to mental health. Mental Health and Physical Activity 2012; 5: 28-34.

Linton SJ, van Tulder M. Preventive interventions for back and neck pain problems: What is the Evidence? Spine 2001; 26: 778-787.

Louhevaara, V, Hopsu L, Pohjonen T, Punakallio A. Ergonomic interventions and the work ability index. In Proceedings of the 13th Triennal Congress of the International Ergonomics Association, Helsinki, 1997.

Lucassen PJ, Preuessner J, Sousa N, OFX Almeida, Van Dam AM, Rajkowska G, Swaab DF, Czéh B. Neuropathology of stress. Acta Neuropathology 2014; 127: 109-135.

Lyubomirsky S, Lepper HS. A measure of subjective happiness: Preliminary reliability and construct validation. Social Indications Research 1999; 46: 137-155.

Mac Kinnon DP, Elliot D, Thoennest F, Kuehl K, Moe E, Goldberg L, Burrell G, Ranby KE. Long-term effects of worksite health promotion program for firefighters. American Journal of Health Behaviour 2010; 34: 695-706.

Maes I, Van Cauwenberghe E, Van Lippevelde W, Spittaels H, De Pauw E, Oppert J-M, Van Lenthe J, Burg J, De Bourdeaudhuij J. Effectiveness of workplace interventions in Europe promoting healthy eating: a systematic review. European Journal of Public Health 2012; 22: 677-683.

Maher CG. A systematic review of workplace interventions to prevent low back pain. Australian Journal of Physiotherapy 2000; 46: 259–269.

Malik SH, Blake H, Suggs S. A systematic review of workplace health promotion interventions for increasing physical activity. British Journal of Health Psychology 2014; 19: 149-180.

Miller W. Effective diet and exercise treatments for overweight and recommendations for intervention. Sports Medicine 2001; 31: 717-724.

Milles L. Physical activity and health. Nutrition bulletin 2007; 32: 314-363.

Morgan WP. Affective beneficence of vigorous physical activity. Medicine and Science in Sport and Exercise 1985; 17: 94-100.

Morris M, Steinberg H, Sykes EA, Salmon P. Effects of temporary withdrawal from regular running. Journal of Psychosomatic Research 1990; 34: 493-500.

Myers JE, Sweeney TJ, Witmer JM. The wheel of wellness: A holistic model for treatment planning. Journal of Counseling and Development 2000; 78: 251-266.

Myers A, Resen J. Obesity stigmatization and coping: relation to mental health symptoms, body image and self-esteem. International Journal of Obesity Related Metabolic Disorders 1999; 23: 221-230.

Netz Y, Wu MJ, Becker BJ, Tenenbaum G. Physical activity and psychological wellbeing in advanced age: a meta-regression analysis of intervention studies. Psychology of Aging. 2005; 20: 272-284.

Nicoloff G, Schwenk TS. Using exercise to ward of depression. Physician and Sports Medicine 1995; 23: 44-58.

Ni Murchu C, Aston IM, Jebb SA. Effects of worksite health promotion interventions on employee diets: A systematic review. BMC Public Health 2010; 10: 62.

North TC, McCullagh P, Tran ZV. Effect of exercise on depression. Exercise and Sport Sciences Reviews 1990; 18: 379-415.

Nurminen E, Malmivaara A, Ilmarinen J, Ylöstalo P, Mutanen, P, Ahonen G, Aro, T. Effectiveness of a worksite exercise program with respect to perceived work ability and sick leaves among women with physical work. Scandinavian Journal of Work, Environment & Health 2002; 28: 85–93.

Nygård C-H, Eskelinen L, Suvanto S, Ilmarinen J. Associations between functional capacity and work ability among elderly municipal employees. Scandinavian Journal of Work, Environment & Health 1991; 17: 122-127.

O`Connor MP, Herring MP, Caravalho A. Mental Health Benefits of Strength Training in Adults. American Journal of Lifestyle Medicine 2010; 4**:** 377-396.

Ogden CL, Carroll MD, Curtin LR, Mc Dowell MA, Taback CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. Journal of the American Medical Association 2006; 295: 1549-1555.

Oinonen KA, Mazmanian D. Does body fat protect against negative moods in women? Medical hypotheses 2001; 57: 387-388.

Ortega FB, Lee D-C, Sui X, Kubzansky LD, Ruiz JR, Baruth M, Castillo MJ, Blair S. Psychological well-being, cardiorespiratory fitness, and long-term survival.

American Journal of Preventive Medicine 2010; 39: 440-448.

Page KM, Milner A, Martin A, Turrell G, Giles-Corti B, LaMontagne AD. Workplace stress. What is the role of positive mental health? Journal of Occupational and Environmental Medicine 2014; 56: 814-819.

Paluska SA, Schwenk TL. Physical activity and mental health: current concepts. Sports Medicine 2000; 29: 167-180.

Peluso M, de Andrad L. Physical activity and mental health: the association between exercise and mood. Clinics 2005; 60**:** 61-70.

Penedo FJ, Dahn JR. Exercise and wellbeing: A review of mental and physical health benefits associated with physical activity. Current Opinion in Psychiatry 2005; 18: 189–193.

Petruzello SJ, Landers AC, Hatfield BD, Kubitz KA, Salar W. A meta- analysis on the anxiety-reducing effect of acute and chronic exercise: outcomes and mechanisms. Sports Medicine 1991; 11: 143–182.

Physical Activity Guidelines Advisory Committee. Physical activity guidelines advisory committee report. Surgeon General. Washington, DC, U.S. Department of Health and Human Services 2008: 1-56.

Pihlainen K, Santtila M, Ohrankämmen O, Ilomäki J, Rintakoski M, Tiainen S (Eds). Manual for fitness tester of Finnish Defense Force. 1st edition. General Staff of Defense Force: Department of Personnel, Helsinki, Finland 2009: 66.

Pohjonen T, Ranta R. Effects of worksite physical exercise intervention on physical fitness, perceived health status, and work ability among home care workers: five-year follow-up. Preventive Medicine 2001; 32: 465-475.

Poppel MNM, Hooftman WE, Koes BW. An update of a systematic review of controlled clinical trials on the primary prevention of back pain at the workplace. Occupational Medicine 2004; 54: 345–352.

Proper KI, Staal BJ, Hildebrand VH, van der Beek A, van Mechelen W. Effectiveness of physical activity programs at worksites with respect to work-related outcomes. Scandinavian Journal of Work, Environment & Health 2002; 28: 75–84.

Proper K, Koning M, van der Beek A, Hildebrandt V, Bosscher R, van Mechelen W. The effectiveness of worksite physical activity programs on physical activity, physical fitness, and health. Clinical Journal of Sports Medicine 2003; 13: 106-117.

Punakallio A, Lusa S, Luukkonen R. Functional, postural and perceived balance for predicting the workability of firefighters. International Archives of Occupational and Environmental Health 2004; 77: 482-490.

Ransford CP. A role for mines in the antidepressant effect of exercise: a review. Medicine and Science in Sports and Exercise 1982; 4: 1-10.

Rejeski WJ, Mihalko SL. Physical activity and quality of life in older adults. The Journals of Gerontology Series A 2001; 56: 23–35.

Renger RF, Midyett SJ, Mas FG, Erinn TE, McDermott HM, Papenfuss RL, Eichling PS, Baker DH, Johnson KA, Hewitt MJ. Optimal living profile: An inventory to assess health and wellness. American Journal of Health Promotion 2000; 24: 403-412.

Roberts RE, Deleger S, Strawbridge WJ, Kaplan GA. Prospective association between obesity and depression: evidence from the Alameda county study. International Journal of Obesity 2003; 27**:** 514–521.

Rongen A, Robroek SJW, van Lenthe FJ, Burdorf A. Workplace health promotion. A meta-analysis of effectiveness. American Journal of Preventive Medicine 2013; 44: 406-415.

Roscoe L. Wellness: A review of theory and measurement for counselors. Journal of Counseling and Development 2009; 87: 216-226.

Ryff CD. Happiness is everything, or is it? Explorations on the meaning of psychological wellbeing. Journal of Personality and Social Psychology 1989a; 57: 1069-1081.

Ryff CD. Beyond Ponce de Leon and life satisfaction: New directions in quest of successful ageing. International Journal of Behavioral Development, 1989b; 12: 35-55.

Saksvik PØ, Nytrø K, Dahl-Jørgensen C, Mikkelsen A. A process evaluation of individual and organizational occupational stress and health interventions. Work & Stress 2002; 16: 37-57.

Sallis JF, Owen N. Physical activity and behavioral medicine. Thousand Oaks, California, Sage Publications Inc 1999: 5-30.

Santtila MA, Häkkinen K, Pihlainen K, Kyröläinen H. Comparison between direct and predicted maximal oxygen uptake measurement during cycling. Military Medicine 2013; 178: 234–238.

Scheier MF, Carver CS, Bridges MW. Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): A re-evaluation of the life orientation test. Journal of Personality and Social Psychology1994; 67: 1063-1078.

Schnohr P, Kristensen TS, Prescott E, Scharling H. Stress and life dissatisfaction are inversely associated with jogging and other types of physical activity in leisure time – The Copenhagen city heart study. Scandinavian Journal of Medicine and Science in Sports 2005; 15: 107-112.

Scully D, Kremer J, Meade MM, Graham R, Dudgeon K. Physical exercise and psychological wellbeing: a critical review. British Journal of Sports Medicine 1998; 32: 111-120.

Seliger V, Bartunek Z. Mean values of indices of physical fitness in the investigation of Czechoslovak population aged 12–55 years; Czechoslovak association of physical culture: Prague, Czechoslovakia 1976.

Selye, H. Stress without distress. Philadelphia, JB Lippincott 1974:27-33.

Selye, H. Forty years of stress research: Principal remaining problems and misconceptions. The Canadian Medical Association Journal 1976; 115: 53–55.

Schwarzer R, Leppin A. Social support and health: A theoretical and empirical overview. Journal of Social and Personal Relationships 1991; 8: 99-127.

Shephard RJ. Worksite fitness and exercise programs: A review of methodology and health impact. American Journal of Health Promotion 1996; 10: 436-452.

Sjögren T, Nissinen KJ, Järvenpää SK, Ojanen MT, Vanharanta H, Mälkiä EA. Effects of physical exercise intervention on subjective physical wellbeing, psychosocial functioning and general wellbeing among office workers: A cluster randomized-controlled cross-over design. Scandinavian Journal of Medicine and Science in Sports 2006; 16: 381-390.

Sjögren-Rönkä T, Ojanen M, Leskinen E, Mustalampi E, Mälkiä E. Physical and psychosocial prerequisites of functioning in relation to work ability and general subjective wellbeing among office workers. Scandinavian Journal of Work, Environment & Health 2002; 28: 184–190.

Smith G. "The self, appraisal and coping", Handbook of social and clinical psychology: The health perspective. New York, NY, Pergamon Press 1991: 116-137.

Smolander J, Blair S, Kohl HW. Work ability, physical activity, and cardio respiratory fitness: 2-year results from project active. Occupational and Environmental Medicine 2000; 42: 906–910.

Soininen, H. The feasibility of worksite fitness programs and their effects on the health, physical capacity and workability of aging police officers. Kuopio University Publications D. Medical Sciences 68. Kuopio, University of Kuopio 1995.

Sonnentag S. Work, recovery activities, and individual wellbeing: A diary study. Journal of Occupational Health Psychology 2001; 6: 196-210.

Sonnentag S, Natter E. Flight attendants` daily recovery from work: Is there no place like home? International Journal of Stress Management 2004; 114: 366-391.

Steptoe A, Krarsley N, Walters N. Cardiovascular activity during mental stress following vigorous exercise in sportsmen and inactive men. Psychophysiology 1993; 30: 245-252.

Stiglitz J, Sen A, Fitoussi J-P. Report by the commission on the measurement of economic performance and social progress 2009. Available at: http://www.stiglitz-sen-fitoussi.fr/documents/rapport_anglais.pdf.

Stunkard AL, Faith MS, Allison KC. Depression and obesity. Biological Psychiatry 2003; 54: 330-337.

Ströhle A. Physical activity, exercise, depression and anxiety disorders. Journal of Neural Transmission 2009; 116: 777–784.

Sörensen L, Pekkonen M, Männikkö K, Louhevaara V, Smolander J, Alen M. Associations between workability, health-related quality of life, physical activity and fitness among middle-aged men. Applied Ergonomics 2008; 39*:* 786–791.

Sörensen L, Smolander J, Louhevaara V, Korhonen O, Oja P. Physical activity, fitness and body composition of Finnish police officers: A 15-year follow-up study. Occupational Medicine 2000; 50: 3–10.

Taylor SE, Kemeny ME, Reed GM, Bower JE, Grenwald JE. Psychological resources, positive illusions, and health 2000; 55: 99-109.

Taylor AH. Physical activity, anxiety and stress. In: Biddle SHJ, Fox KR, Boutcher SH, (Eds). Physical activity and psychological wellbeing. London, Routledge 2000: 10-14.

Teisala T, Mutikainen S, Tolvanen A, Rottenstainer M, Leskinen T, Kaprio J, Kolehmainen M, Rusko H, Kujala U. Associations of physical activity, fitness and body composition with heart rate variability-based indicators of stress and recovery on workdays: a cross-sectional study. Journal of Occupational Medicine and Toxicology 2014; 9:16. Doi:10.1186/1745-6673-9-16

Thirlaway K, Benton D. Participation in physical activity and cardiovascular fitness have different effects on mental health and mood. Journal of Psychosomatic Research 1992; 36: 657-665.

Thøgersen- Ntoumani C, Fox KR. Physical activity and mental wellbeing typologies in corporate employees: A mixed methods approach. Work & Stress 2005; 19**:** 50-67.

Thorne C, Bartholomew J, Craig J, Farrar R. Stress reactivity in fire fighters: An exercise intervention. International Journal of Stress Management 2000; 7: 235-245.

Tolmunen T, Laukkanen J, Hintikka J, Kurl S, Viinamäki H, Salonen R, Kauhanen J, Kaplan G, Salonen TJ. Low maximal oxygen uptake is associated with elevated depressive symptoms in middle-aged men. European Journal of Epidemiology 2006; 21: 701-706.

Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. Medicine and Science in Sport and Exercise 2008; 40: 181-188.

Tulppo MP, Piira OP, Hautala AJ, Kiviniemi AM, Miettinen JA, Huikuri HV. Exercise capacity is associated with endothelin-1 release during emotional excitement in coronary artery disease patients. American Journal of Physiology Heart Circulation Physiology 2014; 307: H391-H396.

Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work Ability Index, 2nd edition. Finnish Institute of Occupational Health Helsinki, Finland, 1997.

Tuomi K, Ilmarinen J, Seitsamo J, Huuhtanen P, Martikainen R, Nygård C-H, Klockars W. Summary of the Finnish research project (1981–1992) to promote the health and work ability of aging workers. Scandinavian Journal of Work, Environment & Health 1997; 23: 66–71.

Tuomi K. Eleven year follow-up of aging workers. Scandinavian Journal of Work, Environment & Health 1997; 23: 66-71.

Tuomi K, Huuhtanen P, Nykyri E, Ilmarinen J. Promotion of workability, the quality of work and retirement. Occupational Medicine (London) 2001; 51: 318-324.

Tveito TH, Eriksen HR. Integrated health program: A workplace randomized controlled trial. Journal of Advanced Nursing 2009; 65: 110–119.

Valtonen M, Laaksonen DE, Laukkanen J, Tolmunen T, Rauramaa R, Viinamäki H, Tolmunen T, Raurama T, Viinamäki H, Kauhanen J, Lakka T, Niskanen L. Leisure time physical activity, cardio respiratory fitness and feelings of hopelessness in men. Public Health 2009; 9: 204. Doi: 10.1186/1471-2458-9-204

Van den Berg T, Alavinia SM, Bredt FJ, Lindeboom D, Elders LAM, Burdorf A. The influence of psychological factors at work and life style on health and workability among professional workers. International Archives of Occupational and Environmental Health 2008; 81: 1029-1036.

Van den Berg TIJ, Elders LAM, de Zwart BCH, Burdorf A. The effects of work-related and individual factors on the work ability index: A systematic review. Occupational and Environmental Medicine 2009; 66: 211–220.

Vasankari TJ, Kujala U, Vasankari T, Ahotupa M. Reduced oxidized LDL levels after a ten-month exercise training program. Medicine and Science in Sports Exercise 1998; 30: 1496-1501.

Waterman AS. Two conceptions of happiness: Contrasts of personal expressiveness (eudaimonia) and hedonic enjoyment. Journal of Personality and Social Psychology 1993; 64: 678-691.

Weyerer S, Kupfer B. Physical exercise and psychological health. Sports Medicine 1994; 17: 108-116.

Viljanen T, Viitasalo JT, Kujala UM. Strength characteristics of a healthy urban adult population. European Journal of Applied Physiology 1991; 63: 43-47.

Witmer M, Sweeney TJ. A holistic model for wellness and prevention over the life span. Journal of Counseling and Development 1992; 71: 140-148.

Work Research Centre, Prevent. Promoting mental health in the workplace: Guidance to implementing a comprehensive approach. Draft guidance document. University of Nottingham, June 2014.

World Health Organization. Mental health: Strengthening mental health promotion. Fact sheet No 220. Updated August 2014. Available at: http://www.who.int/ mediacentre/factsheets/fs220/en.

World Health Organization. Obesity and overweight. Fact sheet No 311. Updated March 2013. Available at: http//www.whoint/mediacentre/factsheets/fs311/en/index.html.

Yin Z, Davis C, Moore J, Treiber F. Physical activity buffers the effects of chronic stress on adiposity in youth. American Journal of Behavioral Medicine 2005; 29: 29-36.

Zhao G, Ford ES, Dhingra S, Li C, Strine TW, Mokdad AH. Depression and anxiety among US adults: associations with body mass index. International Journal of Obesity 2009; 33: 257-266.

Zwart B, Frings-Diesen M, Duivenbooden J. Test-retest reliability of the workability index questionnaire. Occupational Medicine (London) 2002; 52: 177-181.