Effect of Short-Term Guided Aerobic Exercise and Diet Intervention on Overweight Women

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LLTS007 Master’s Thesis of Sport Medicine

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Abstract

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Overweight or obese persons have substantially increased risk for multiple chronic disorders, for example type 2 diabetes (T2D), dyslipidemia, hypertension and cardiovascular disease (CVD). Physical activity or exercise has an important role in the prevention and treatment of obesity related illnesses, for example T2D, CVD and metabolic syndrome (MetS). The main goal of this Master's thesis is to study the possible effects of short-term aerobic exercise and diet intervention on body composition, blood lipid profile and glucose metabolism, as well as on the risk factors of metabolic syndrome on overweight/obese women and to compare the groups with an added motivational factor or general exercise/diet guidance.

The subjects were enrolled in the Exercise and Weight Control Intervention (EWI-09) study carried out at the University of Jyväskylä in the Department of Health Sciences in summer-winter 2009. Ninety-four previously physically inactive (participating regular leisure time aerobic exercise less than two times per week, less than 45 min per session), overweight and obese women aged 20-50 years were randomly assigned into exercise (EX: body mass index > 25-33 kg/m^2) or weight control (WC: BMI > 25-38 kg/m^2) groups. They were further assigned into exercise with wrist computer (EXW), exercise control (EXC), weight control with wrist computer (WCW) and weight control control (WCC). Eighty subjects completed the study (EXW n=21, EXC n=19, WCW n=20, WCC n=20). Exercise group underwent a progressive, supervised exercise program (Nordic Walking) according to ACSM's guidelines of exercise for health promotion. The WC group received dietary instructions from a clinical nutritionist according to the guidelines of Finnish nutrition recommendations targeting weight loss. Fasting blood samples were drawn, anthropometric measurements (height, weight, BMI, waist circumference, body composition), 10m walking test and VO_2 max –tests were performed. SPSS 15.0 for Windows was used to carry out statistical analyses.

We found that the exercise group had significant reduction of their Free Fatty Acids (FFA EXW p=0.001, EXC p=0.001) and glucose metabolism (f-Gluc EXW p<0.001, EXC p=0.01) without therapeutic weight loss after 6-week intervention. The weight control group reduced their body weight, BMI and Visceral Fat Area. In addition, subjects in the exercise group with the wrist computer significantly reduced waist circumference (p=0.01), Insulin (p=0.01) and risk factors of the metabolic syndrome (p=0.04).

In conclusion, aerobic exercise, with progressive moderate intensity has health benefits without therapeutic weight loss in short time. Exercise is more effective than diet for reducing the risk factors of metabolic syndrome.

KEYWORDS: EXERCISE INTERVENTION, DIET, AEROBIC EXERCISE, BODY COMPOSITION, BLOOD LIPID PROFILE, GLUCOSE METABOLISM, OVERWEIGHT, OBESITY

Tiivistelmä

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Ylipainoisilla sekä lihavilla ihmisillä on kohonnut riski sairastua moninaisiin kroonisiin sairauksiin, kuten tyypin II diabetekseen sekä sydän- ja verisuonitauteihin. Liikunnalla tiedetään olevan näitä riskejä vähentävä vaikutus. Tämän tutkimuksen tarkoituksena on tutkia lyhyt-aikaisen harjoittelu-intervention sekä ruokavalio-ohjauksen vaikutuksia kehon koostumukseen, verenpaineeseen, veren rasva-arvoihin sekä glukoosiaineenvaihduntaan ylipainoisilla ja lihavilla naisilla sekä verrata rannetietokoneen tai yleisten ohjeiden avulla tapahtuvaa liikuntaohjausta. Tutkimustuloksia tarkasteltiin myös metabolisen oireyhtymän riskitekijöitä arvioimalla.

Tutkimusaineisto koostui EWI-09 (Exercise and Weight Control Intervention) tutkimuksen aineistosta. Tutkimus toteutettiin Jyväskylän yliopiston terveystieteiden laitoksella vuonna 2009. Tutkimuksen aloitti 94 entuudestaan fyysisesti inaktiivista (harrastivat säännöllistä vapaa-ajan liikuntaa alle kaksi kertaa viikossa, alle 45 minuuttia kerrallaan) ylipainoista ja lihavaa naista iältään 20-50 vuotta. Heidät satunnaistettiin harjoittelu- (EX: body mass index > 25-33 kg/m^2) tai painonhallintaryhmään (WC: BMI > 25-38 kg/m^2). Tämän jälkeen heidät satunnaistettiin edelleen rannetietokone-harjoitteluryhmään (EXW), harjoittelukontrolliryhmään (EXC), rannetietokone-painonhallintaryhmään (WCW) sekä painonhallintakontrolliryhmään (WCC). Kahdeksankymmentä koehenkilöä (EXW n=21, EXC n=19, WCW n=20, WCC n=20) sai tutkimuksen päätökseen. Liikuntainterventio oli progressiivinen ja valvottu. Harjoitteluohjelma (sauvakävely) oli laadittu ACSM:n terveysliikuntasuositusten mukaisesti. Painonhallintaryhmät saivat ruokavalio-ohjausta ravitsemusterapeutilta suomalaisten ravitsemusohjeiden mukaisesti. Koehenkilöiltä kerättiin paastoverinäytteet sekä tehtiin antropometriset mittaukset (pituus, paino, BMI, kehonkoostumus, vyötärönympärys), 10m kävelytesti sekä maksimaalinen polkupyöräergometritesti. Tulokset analysoitiin SPSS for Windows 15.0 ohjelmalla.

Tutkimuksen päätuloksena voidaan todeta, että aerobisella harjoittelulla on positiivinen vaikutus vapaisiin rasvahappoihin (FFA EXW p=0.001, EXC p=0.001) sekä glukoosiaineenvaihduntaan (f-Gluc EXW p<0.001, EXC p=0.01). Nämä liikunnan positiiviset vaikutukset olivat todettavissa ilman terapeuttista painonlaskua ja jo kuuden viikon liikuntaharjoittelun jälkeen. Ainoastaan ruokavalio-ohjauksella oli vaikutusta kehonkoostumusta mittaaviin parametreihin, kuten painoon, kehon painoindeksiin sekä viskeraalisen rasvan määrään. Lisäksi voidaan todeta, että rannetietokone-harjoitteluryhmän vyötärön ympärys (p=0.01), insuliini (p=0.01) sekä metabolisen syndrooman riskitekijät (p=0.04) alenivat merkittävästi.

Johtopäätöksenä voidaan todeta, että pelkkä liikunnan lisääminenkin aiheuttaa positiivisia terveysvaikutuksia ilman merkittävää painonlaskua tai muutoksia ruokavalioon. Liikunta on ruokavaliomuutoksia tehokkaampi keino metabolisen oireyhtymän riskitekijöiden vähentäjänä.

KEYWORDS: EXERCISE INTERVENTION, DIET, AEROBIC EXERCISE, BODY COMPOSITION, BLOOD LIPID PROFILE, GLUCOSE METABOLISM, OVERWEIGHT, OBESITY

Contents

1. INTRODUCTION

Overweight or obese persons have substantially increased risk for multiple chronic disorders, for example type 2 diabetes (T2D), dyslipidemia, hypertension and cardiovascular disease (CVD). Obesity is increasingly common among younger and younger people and so are related disorders and risks. This is becoming an epidemic in western countries and is the reason why it is exceedingly important to develop effective lifestyle strategies and practices to tackle this syndrome and premature mortality risk it causes (Carroll & Dudfield 2004, Warburton et al. 2006, Churilla & Zoeller 2008).

Metabolic syndrome is said to be an out-come of obesity and inactive or passive lifestyle. It is so called “Standard of living” - disease. These days people consume too many calories and live inactive life, which results to positive energy balance and overweight. Metabolic syndrome occurs more often on middle-aged and elderly people and is more common among men than women (Carroll & Dudfield 2004, Warburton et al. 2006, Churilla & Zoeller 2008).

It has been well established for a while now, that physical activity or exercise has an important role in prevention and treatment of the obesity related illnesses, for example T2D, CVD and metabolic syndrome (MetS). On persons with diagnosed CVD, T2D or MetS, low cardiorespiratory fitness (CRF) and physical inactivity are connected with increased mortality rates. Physical activity and exercise has direct effects on many of the risk factors of these obesity related illnesses. Aerobic and anaerobic exercise both have important role in reduction of the risk factors. Regular physical exercise has even greater effects (Gaesser 2007, Lakka & Laaksonen 2007).

The current exercise recommendations for adults (The Finnish Current Care guidelines and 2008 Physical Activity guidelines for Americans) state that a person should exercise at least 5 days per week, preferably daily, for 30 min per day of moderate-intensity exercise to gain substantial health benefits (U.S. Department of

Health and Human Services 2008, 21-22, Liikunta 2008). This amount of regular physical exercise considerably decreases the risk of developing obesity related multiple chronic disorders and maintains good cardiorespiratory and muscular fitness on overweight/obese persons (Lakka & Laaksonen 2007).

Also dietary modifications play a role in this energy equation. Effects of physical exercise and nutrition have been studied as essential factors in prevention and treatment of many diseases for a while now. Physical exercise and nutrition have their own individual effects, but in recent decades it has been recognised that they also have interactions. When these two are combined, even more favourable effects are achieved (Laaksonen & Uusitupa 2005).

The main goal of this paper is to study the possible effects of short-term aerobic exercise and diet intervention with an added motivational factor (wrist computer) or general exercise/diet guidance on body composition, blood lipid profile and glucose metabolism, as well as on the risk factors of metabolic syndrome on 20-50 year old overweight/obese women, who were previously inactive. Because of the rising amount of overweight and obesity, as well as, the increased amount of obesity related disorders, it is important to develop effective lifestyle strategies and practices to motivate people to exercise and live healthy life.

2. THE METABOLIC SYNDROME: THE RISK FACTORS AND PATHOPHYSIOLOGY

A quarter (25-30%) of adults worldwide have metabolic syndrome (Liikunta 2008, International Diabetes Federation 2009). In Finland incidence of metabolic syndrome is rising all the time. Many expert groups have tried to develop unifying definition for the metabolic syndrome, but still different associations have slightly different definitions for the criteria of the MetS. In this Master's Thesis four most widely used and accepted clinical identifications of the MetS (Table 2) will be presented. The most widely accepted definitions are the World Health Organization (WHO), National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), European Group for the Study of Insulin Resistance (EGIR) and The International Diabetes Federation (IDF). All of these groups agree that the basic criteria of the MetS are obesity, insulin resistance, dyslipidemia and hypertension, even though they present different clinical criteria to identify MetS. Many of the recently published studies concerning MetS have relied on the definition of National Cholesterol Education Program (NCEP), because it is clinically most usable (Vuori 2005, Alberti et al. 2006, Churilla & Zoeller 2008).

According to all these four definitions (WHO, EGIR, NCEP ATP III, IDF) and The Finnish Current Care guidelines (Liikunta 2008) metabolic syndrome is a condition where multiple risk factors are clustered in one person. For the diagnosis, person should have abdominal obesity, that is, elevated waist circumference, and in addition to that two or more of the criteria. The pathogenesis of the MetS is not yet fully understood. There are two major risk factors that have a strong influence: insulin resistance and abdominal obesity. High fasting blood glucose can indicate insulin resistance (Vuori 2005, Alberti et al. 2006) and because abdominal obesity is highly correlated with the risk factors of the MetS, waist circumference should be the primary anthropometric marker (ACSM 2006, 219). Other risk factors of the MetS are: male gender, genetic profile, physical inactivity and ageing. Metabolic syndrome increases the risk of coronary artery disease (CAD), heart attack and T2D.

Furthermore, T2D increases the risk of CVD (Alberti et al. 2006, Churilla & Zoeller 2008, International Diabetes Federation 2009).

Body Mass Index, BMI, is commonly used tool to estimate the degree of overweight and obesity. BMI is weight relative to height. It is calculated by dividing body weight (kg) by height (m) squared (kg/m^2). BMI can be used to estimate under-, normal- or overweight, but is not to be used to estimate body composition, because BMI can't distinguish between body tissues (Table 1). The reference limits are best suited to 20-60 years old normal population. For athletes, children and youths it is not very well suited and should not be used. It has been established that obesity-related health problems increase when BMI is over 25 and are even greater with BMI over 30 (ACSM 2006, 58, Keskinen 2005).

Table 1. The definition of BMI (ACSM 2006, 58).

BMI (kg/m^2)	
< 18.5	Underweight
18.5-24.9	Recommended BMI for adults
25.0-29.9	Overweight
30.0-34.9	I° Obesity
35.0-39.9	II° Obesity
> 40	III° Obesity

Table 2. Clinical definitions of the MetS (Alberti et al. 2006)

Risk factor of the MetS	WHO (1999)	NCEP ATP III (2001)	EGIR (1999)	IDF (2005)
Abdominal obesity	> 0.90 (m)* > 0.85 (f)* and/or BMI > 30	WC > 102cm (m) > 88cm (f)	WC ≥ 94cm (m) ≥ 80cm (f)	BMI > 30
Fasting Gluc	Glucose intolerance, IGT or diabetes and/or insulin resistance	≥ 5.6 mmol/l	≥ 6.1 mmol/l (non-diabetics)	≥ 5.6 mmol/l or diagnosed T2D
Low HDL-C	< 0.9 mmol/l (m) < 1.0 mmol/l (f)	< 1.03 mmol/l (m) < 1.29 mmol/l (f)	< 1.00 mmol/l (m,f) or treatment	< 1.03 mmol/l (m) < 1.29 mmol/l (f) or treatment
High TG	≥ 1.7 mmol/l	≥ 1.7 mmol/l	≥ 2.00 mmol/l or treatment	≥ 1.7 mmol/l or treatment
Blood pressure	≥ 140/90 mmHg	≥ 130/85 mmHg	≥ 140/90 mmHg or treatment	≥ 130/85 mmHg
Other	Microalbuminuria			

WHO: the World Health Organization, NCEP ATP III: National Cholesterol Education Program Adult Treatment Panel III, EGIR: European Group for the Study of Insulin Resistance, IDF: International Diabetes Federation; m: male, f: female, *waist-to-hip-ratio, WC: waist circumference, Gluc: glucose, IGT: impaired glucose tolerance, HDL-C: high-density lipoprotein cholesterol, TG: triglyceride, Microalbuminuria: urinary albumin excretion rate ≥20µg/min or albumin:creatine-ratio ≥30mg/g

2.1 Overweight and Obesity

One can only gain weight and become obese if the energy intake exceeds energy expenditure in the long run. In Western countries this is becoming an epidemic. Even young children are overweight or obese. High-energy food is easily available and inactive lifestyle is making the problem worse. Lifestyle explains two thirds of the obesity and, one third is explained by genes. Genes can also explain why some people stay fairly healthy even they are obese and why some people get obesity related illnesses (Fogelholm & Kaukua 2005, Ohkawara et al. 2007).

Overweight (BMI >25) and obesity (BMI >30), especially abdominal fat accumulation, is a major risk factor of many health problems. The increase of obesity has increased the incidence of the MetS. The important factor with accumulation of fat is the amount of visceral adipose tissue, which is situated around internal organs and accumulates around waist. Waist circumference is a good method when assessing amount of visceral adipose tissue. Waist circumference is thought to be elevated when it is >94-102 cm on men and >80-88 cm on women (see Table 2). There are many definitions of the measure (in cm) of waist circumference depending of the guidelines (Vuori 2005, Alberti et al. 2006, Churilla & Zoeller 2008).

Many disorders related to obesity are national illnesses especially in Finland. The Finnish Current Care guidelines (Liikunta 2008) state that there is strong evidence of obesity causing T2D, hypertension and coronary artery disease (CAD) and further more moderate evidence of obesity causing MetS, gout, fatty liver, asthma and cancer. Obesity can cause health problems in many ways. Being obese causes elevated blood pressure and lowered glucose- and glycerine metabolism and this leads to diseases. Obesity is also an independent risk factor of CAD. Morbidity is strongly connected to the degree of obesity. Overweight (BMI 25.0-29.9) does not increase the risks as much as severe obesity (BMI >35). With elevated BMI it is also significant where the fat has accumulated. Abdominal fat accumulation increases the risk of high blood pressure, T2D and glycerol metabolism disorders (Fogelholm & Kaukua 2005, Alberti et al. 2006, Ohkawara et al. 2007). There is a linear connection between excess weight and obesity related health problems. Part of the increased risks for obesity related health problems is due to, not obesity itself, but inactive and unhealthy lifestyle and low fitness level it precedes (Ross et al. 2000, Vuori & Andersen 2003).

2.2 Impaired Glucose Regulation

There is strong evidence that insulin resistance has a major role in development of the MetS (Carroll & Dudfield 2004, Alberti et al. 2006). According to the Bruneck Study (Bonora et al. 1998), the degree of insulin resistance correlates with number of metabolic abnormalities. Insulin resistance was almost always present when several metabolic abnormalities were clustered together. They also noted in the Bruneck Study that hypertriglyceridemia (high TG) and low high-density lipoprotein cholesterol (HDL-C) were nearly always associated with insulin resistance, but very rarely occurred as isolated disorders. The fasting blood glucose (fGluc) level ≥ 5.6 mmol/l or if person has diagnosed diabetes, can be one of the diagnostic criteria for defining MetS (see Table 2) (Alberti et al. 2006).

Impaired glucose regulation is a condition where blood glucose levels are higher than normal, but not morbidly and can’t be diagnosed as T2D. Impaired glucose tolerance (IGT) and impaired fasting glucose (IFG) are both separate categories of impaired glucose regulation. Both of these conditions are strongly connected to MetS, cardiovascular disease (CVD), T2D, and all-cause mortality (Carroll & Dudfield 2004, Alberti et al. 2006).

Insulin resistance or a reduced sensitivity to insulin is common among obese persons and is present in the majority of people with the MetS. It is not fully understood, what mechanism links insulin resistance and the other components of the MetS. It is associated with reduced β-cell function and secretion of insulin from the pancreas. Impaired glucose tolerance (IGT) precedes T2D and it is thought that a decline in insulin secretion rather than an increase in insulin resistance can cause this outbreak of T2D. Obesity reduces the sensitivity of the insulin receptors to insulin and can lead to T2D. This disorder is especially associated with visceral fat accumulation (Bonora et al. 1998, Cerny & Burton 2001, 60-1, Carroll & Dudfield 2004, Eriksson 2005, Alberti et al. 2006).

In normal case, insulin promotes the transport of glucose from the blood to the cells and contributes to the use of glucose in cells as well as the synthesis of glycogen in liver and muscles. Insulin also increases the synthesis of triglycerides and deposition in adipose tissue. Low insulin level, for example, in case of reduced secretion of insulin from the pancreas, will increase hydrolysis of lipid molecules, which makes free lipid molecules available for energy production. This will produce a high amount of ketone bodies, which will lead to metabolic ketoacidosis, a potentially fatal condition (Vuori 1994).

Insulin resistance appears in most tissues that are dependent on insulin. Excessive production of glucose from liver, as well as muscle- and adipose tissue's reduced sensitivity to insulin, are major components increasing the risk of T2D (Eriksson 2005). Due to cells reduced sensitivity to insulin and reduced use of glucose for energy production, blood glucose level will rise and energy for cell metabolism will mostly form from oxidation of lipid molecules (Vuori 1994).

Method used to quantify insulin resistance (IR) and insulin secretion (β-cell function) is called Homeostasis Model Assessment (HOMA). It is a computer model which determines insulin resistance and secretion from paired fasting blood glucose and insulin levels using different equations (HOMA-IR index: glucose (mmol/l)*Insulin (mU/l)/22.5 and HOMA-β index: 20*Insulin (mU/l)/glucose (mmol/l)-3.5). It has been validated widely and has been proven to predict the development of T2D. There is a relationship between HOMA-IR and HOMA-β and the prevalence of IGT and T2D (Song et al. 2007).

2.3 Dyslipidemia

Dyslipidemia means abnormalities in blood lipid and lipoprotein concentrations. It is a major risk factor for coronary heart disease (CHD) and CAD. Elevated blood low-density lipoprotein cholesterol (LDL-C) and triglyceride (TG) concentrations and low high-density lipoprotein cholesterol concentrations (HDL-C) are all widespread problem in western countries. In this condition the total cholesterol, LDL-C or TG concentrations are elevated in plasma or HDL-C concentration is low or it can also be a combination of these three. Dyslipidemia is diagnosed as either elevated TG levels ≥ 1.7 mmol/l, low HDL-C <0.9 mmol/l (m) or <1.29 mmol/l (f) or previous treatment for high TG or low HDL-C (see Table 2). In prevention and treatment of dyslipidemia, diet modifications are in major part, but increasing physical activity is also important (ACSM 2006, 211, Alberti et al. 2006, Liikunta 2008).

The role of HDL-C is to transport cholesterol from tissues to liver. It also protects the body from atherosclerosis. The LDL-C works the opposite direction, transporting cholesterol from liver to tissues and is a risk factor for atherosclerosis (Heinonen 2005). The amount and quality of LDL-C in plasma are the factors that influence in the formation of atherosclerosis. In addition to this, the pathway through which HDL-C works by transporting cholesterol out of tissues influences the formation of the atherosclerotic plaque. The atherosclerosis forms into the walls of heart’s coronary vessels and if not treated in time, causes the complete occlusion of the vessel and ischemia of the heart muscle (Vuori & Kesäniemi 2005).

2.4 Hypertension

Hypertension has been diagnosed in 15-30% of middle-aged population in Western countries (Jensen-Urstad M. & Jensen-Urstad K. 2003). Current classification is that blood pressure <120/<80 mmHg is considered optimal and <130/<85 mmHg as normal for adults. Hypertension can be classified from mild (grade I, 140-159/90-99 mmHg) to severe (grade III, ≥ 180/≥ 110 mmHg) and depending of the grade of the disease is treated with lifestyle modifications and/or medication. Hypertension increases the risk of cardiovascular events and is related to the level of blood pressure. It has been established that a prolonged higher level of diastolic blood pressure, which is 5 mmHg higher than the recommended value is associated with a 35-40% higher risk of cardiovascular events (Vuori & Andersen 2003). Hypertension is defined according to the MetS definition criteria (WHO, EGIR, NCEP ATP III, IDF, see Table 2) as systolic pressure ≥ 130 mmHg and diastolic pressure ≥ 85 mmHg or treatment for hypertension (Alberti et al. 2006).

The utmost reasons for hypertension are not very well established. It has been, however, verified which are the risk factors for elevated blood pressure. Risk factors include genetic factors as well as high intake of salt, fat and alcohol in diet, insulin resistance and hyperinsulinemia, excess weight and obesity, physical inactivity and stress (Vuori & Andersen 2003, Alberti et al. 2006). In 95% of the cases the primary reason for high blood pressure is unknown. The high resistance of peripheral artery vessels, caused by over-sensitive adrenergic sympathetic activity, will lead to irrevocable changes in the wall structure of the peripheral vessels (thickening of the wall) which in turn will lead to elevation of the systolic pressure in the heart (because of increased resistance of the peripheral vessels) and that way the pressure inside the heart will rise. This in turn will lead to enlargement of the left ventricular wall and increased oxygen demand of the heart muscle. When the situation worsens, heart muscle will not get enough oxygen and this will eventually lead to the heart failure (Uusitalo 1994).

3. PHYSICAL ACTIVITY AND EXERCISE TRAINING

In literature physical activity is defined as “bodily movement that is produced by the contraction of skeletal muscle and that substantially increases energy expenditure”. This definition is quite extensive and is usually understood very differently by different individuals. Term physical exercise is defined as “a type of physical activity that is planned, structured and repetitive bodily movement done to improve or maintain one or more components of physical fitness” (ACSM 2006, 3). In this Master’s Thesis I will concentrate on term “exercise training”, which has been carried out as an exercise intervention to the subjects of the study. Exercise training sessions are carefully planned by the research team (Carroll & Dudfield 2004).

Physical fitness is a very multidimensional concept, which comprises skill-related (motor skills), health-related and physiologic components. It refers to a physiological state of well-being and is connected to health. Health-related components include the abilities to perform daily activities as well as the traits and capacities that one has which are connected to the low risk of premature development of the sedentary lifestyle- associated disorders. One of the health-related components is fitness, which comprises cardiovascular endurance, muscular strength, flexibility, body composition and metabolism. Physiologic components include components that are not performance related and relate to biological systems influenced by habits of every–day-living (for example diet, activity and smoking). Health-related and physiologic fitness can both be modified with regular physical exercise. They are both also closely connected to health promotion and disease prevention (ACSM 2006, 3, Warburton et al. 2006).

Exercise training programs are usually developed to promote health and fitness, to increase working capacity and to rehabilitate. It is necessary that the exercise program provides appropriate overload to be effective and to give the wanted health benefits. It is possible through manipulation of exercise intensity, duration, frequency and changes in exercise program. Overload adapted to the individual’s fitness level offers sufficient stress on the body and that way stimulates the desired adaptive responses. In other words, if the addition of strength is the desired goal, the resistance used during exercise training must be high enough to stimulate the physiological responses that will be reflected in greater strength. Intensity and duration of the exercise are the factors to be alternated if increasing cardiovascular capacity is the desired goal. The exercise session must be strenuous enough to stimulate desired changes in the cardiovascular system. In both forms of exercise, aerobic and anaerobic, the increase of the overload must be applied progressively for it to be safe and for an individual to stay free of injuries (Cerny & Burton 2001, 297, ACSM 2006, 133-35).

Physical activity or exercise training is very important factor in prevention, treatment and rehabilitation of most Finnish national diseases, such as CVD, T2D, pulmonary diseases and osteoporosis. Physical inactivity is detrimental to health; conversely, exercise, when carried out correctly, has very few disadvantages to person’s health (Liikunta 2008). It seems that there is a linear relationship between person’s physical activity and health status. The higher the amount of physical exercise is the greater are the health benefits one gains (Warburton et al. 2006).

3.1 Aerobic or Endurance Exercise and Current Exercise Recommendations for Adults

The purpose of endurance or aerobic exercise is to increase the condition of cardiovascular system and enable a person to exercise longer periods at one time with minimal amount of fatigue. Endurance or aerobic fitness can be muscular or cardiovascular endurance. Muscular endurance can be defined as the ability of specific muscle or specific groups of muscles to perform work over time. This ability can be exercised with high amount of repetitions and low resistance. Cardiovascular endurance or aerobic capacity is trained by increasing the capacity of cardiovascular system which, as a result of endurance training, will lead to favourable physiological changes in ones cardiovascular- and pulmonary system. To achieve the optimal development of the cardiovascular system exercise session should be low enough in intensity so that it can last at least 10-15 minutes, even though, usual exercise recommendations advise that the exercise should last minimum 30 minutes at the time and the intensity to be 55-85% of the person’s maximum aerobic capacity (Cerny & Burton 2001, 299, ACSM 2006, 139).

There are many ways and practises to measure aerobic exercise intensity. Intensity can be defined as light/low, moderate, vigorous or hard. Assessing exercise intensity this way, it is always a subjective estimate and is not very reliable. Heart rate (HR) monitoring is the standard tool, but can be difficult and inconvenient for many. Aerobic exercise intensity can also be assessed by measuring maximal oxygen uptake (VO_2 max/peak), which is related closely to functional capacity of the heart and gives a reliable picture of cardiorespiratory fitness. Metabolic equivalents (METs) can also be used to measure exercise intensity. MET values express oxygen uptake (VO_2) relative to resting values, so that, for example, intensity of 10 METs means that the oxygen requirement of the exercise is ten times the resting value. As with any other indirect measurement, this is always only an estimate of exercise intensity (Cerny & Burton 2001, 302-3, ACSM 2006, 4, 66, 146, 290-1).

According to The Finnish Current Care guidelines and 2008 Physical Activity guidelines for Americans, any activity is better than none for adults. Adults who perform any amount of physical activity gain health benefits. To gain substantial health benefits one needs to exercise at least 150 minutes (2 hours 30 minutes) of moderate-intensity (approximately 5-7 METs) or 75 minutes (1 hour 15 minutes) of vigorous-intensity (approximately 8-10 METs) aerobic exercise in a week or perform a combination of these two. The amount should be spread through out the week, so that one performs aerobic exercise at least three times a week. Aerobic exercise can be performed in series lasting no less than 10 minutes at the time and repeated three times a day. This amount is the minimum amount to gain substantial health benefits. The higher the amount is per week and intensity per exercise session, the greater are the benefits of the exercise (Vuori 2005, ACSM 2006, 4, U.S. Department of Health and Human Services 2008, 21-22, Liikunta 2008).

3.2 Nordic Walking and Benefits of Walking

Walking offers tolerable and fairly safe exercise intensity and is one of the most common forms of exercise among women. It can be easily regulated for improving physical fitness. The risk of injury is relatively low in walking. Even fairly slow walking (<4km/h^{-1}, approx. 2 METs) can produce health benefits and help to achieve the minimum exercise goals to low-fit persons. On the other hand, brisk walking (4.5-6 km/h^{-1}, approx. 5 METs) provides enough intensity to increase aerobic capacity and physical fitness. Walking uses large muscle groups and it is rhythmic in nature. It has been proven that the greatest improvement in VO_2max occurs when large muscle groups are used over prolonged periods in rhythmic manner (Williams 2005, ACSM 2006, 140).

In Nordic walking, normal walking is intensified with pole thrusts and arms are also doing rhythmical muscle work. When Nordic walking is practiced walking speed usually increases which, together with upper body muscle work, increases exercise intensity and energy expenditure approximately by 20% (Kukkonen-Harjula et al. 2007). Church et al. (2002) stated that walking with poles increases oxygen consumption by 21%, heart rate by 6% and energy expenditure by 20% compared to normal walking.

The study of Williams (2005) states that the greatest benefits of walking to body weight and BMI are gained among the most obese women. He also stated that the decreases in the BMI of the women doing walking exercise are greatest at the shorter weekly distances and diminish in magnitude as distance increased (Williams 2005).

3.3 Exercise in Prevention of Diseases

Two of the main pathophysiological aspects of the metabolic syndrome; accumulation of the visceral adipose tissue and insulin resistance as well as activity of the sympathetic nervous system, can be affected by exercise. Exercise has positive effects to many, if not all, of the risk factors of the metabolic syndrome. Regular exercise improves insulin sensitivity in muscle and fat tissues and in liver. In this way, regular exercise improves blood lipid profile, glucose metabolism and lowers blood pressure (Eriksson 2005, Vuori 2005).

In the study of Tjønna et al. (2008) 46% of the aerobic interval training (AIT) group and 37% of the continuous moderate exercise (CME) group no longer had MetS at the end of the 4 months long training period. Stewart et al. (2005) observed significant increase in lean body mass and HDL-C as well as reduction in total and abdominal fat and DBP after the 6 months exercise period. The reduction in total and abdominal fat and increase in lean body mass were strongly associated with favourable changes in reduction of the risk factors of the MetS, especially insulin resistance, BP and blood lipids.

3.3.1 Overweight and Obesity

Exercise has positive effects on basal metabolism and appetite. It increases energy consumption and basal metabolism. Normal control of appetite is also easier to achieve when regular exercise is performed. During exercise, lipolysis in adipose tissue is stimulated by an increased sympatho-adrenergic activity. Continuous regular endurance exercise has been found to increase lipolytic sensitivity to catecholamines in subcutaneous, visceral adipose tissue. Fat loss has also been found to increase with the amount of energy spent on regular exercise (Fogelholm & Kaukua 2005, Fogelholm et al. 2006).

According to Johnson et al. (2007) exercise significantly reduced the risk factors of the MetS on overweight or obese persons. Waist circumference was significantly reduced after the 8-months exercise intervention. Kemmler et al. (2009) presented similar results to Johnson et al. (2007). Many of the parameters of MetS (for example, total body fat, total cholesterol, HDL-C, TG and BP) were significantly affected by the 12-months exercise intervention.

In the RCT of Irving et al. (2008) they presented only minor reductions in the risk factors of MetS after their 16-weeks exercise training period. Even though, they observed significant improvements in body composition, waist circumference and abdominal visceral fat, the risk factors associated with MetS (low HDL-C, high TG, high fasting glucose and elevated SBP and DBP) were not significantly affected. On the other hand, they observed reduction in the prevalence of the MetS by 30.3% in the exercise group compared with 15.6% in the control group.

Unhealthy weight gain can be prevented with physical activity. To help prevent that, some adults will need to exceed the recommended minimum amount of physical activity to get the same health benefits than others. Exceeding the recommended minimum amount to get to the point that is individually effective to prevent unhealthy weigh gain some adults also need to consider their food intake as well as other factors that affect body weight (Haskell 2007).

3.3.2 Impaired Glucose Regulation

As mentioned earlier, exercise has positive effects on glucose and lipid metabolism and it increases the utilization of glucose in the muscles. The effects of exercise on metabolism are highly influenced by the intensity and duration of the exercise session. Exercise improves body composition and that improvement has effects on insulin sensitivity, but it also increases GLUT4 content, glycogen synthase activity, mitochondrial enzyme activity, capillary and mitochondrial density in skeletal muscle, improves endothelial function and may alter muscle fibre type (Eriksson 2005, Lakka & Laaksonen 2007, Tjønna et al. 2008).

Insulin sensitivity of the tissues is improved immediately and even after only one exercise session, but the effects only last 48-72 hours. To maximize the benefits of exercise on insulin sensitivity, exercise should be practiced regularly. This improvement in the insulin sensitivity of the tissues is proposed to result from the peripherally enhanced insulin response and signalling in the muscles, such as an increased insulin-independent translocation of GLUT4 glucose transporters to the cell surface (Eriksson 2005, Lakka & Laaksonen 2007, Tjønna et al. 2008).

It is well established that exercise promotes insulin action in muscles by decreasing the intracellular accumulation of triglycerides and fatty acid oxidation. Insulin production is decreased during long lasting exercise on healthy individuals. Because of this decrease, the production of glucose from the liver is increased and this mechanism is also affected by antagonist hormone (for example glucagon, adrenalin, noradrenalin, growth hormone and cortisol) production. Decreased insulin level enables the release of lipid molecules from the fat tissue and the usage of the lipid molecules as a source of energy. In rest, the primary sources of energy for muscle tissues come from free lipid molecules. When physical exercise is performed, the usage of glucose as a source of energy increases in muscles even up to 20 fold and they consume their own glycogen supplies. When exercise session is long lasting, the glycogen supplies will be used up and usage of lipid molecules increases. Human body will try and keep the blood glucose levels steady during exercise with glucose production from the liver (Eriksson 2005, Tjønna et al. 2008).

Skeletal muscle is an important target organ of insulin and its energy metabolism holds a specific role in developing chronic metabolic diseases. Dysfunction of the muscle cell mitochondria is thought to have a role in pathophysiology of the insulin resistance. In this case, muscle tissue capacity to synthesise ATP is 30% lower than in normal case (Rauramaa 2005).

3.3.3 Dyslipidemia

Exercise training has direct and widespread effects on blood lipids and lipoproteins. These effects appear even after one acute bout of exercise, which increases hydrolysis of triacylglycerol (lipolysis) in the adipose tissue and oxidation of lipids in the skeletal muscle. An acute bout as well as regular aerobic exercise effects on blood lipid concentration by increasing HDL-C concentration approximately 5% from the starting-point and decreasing LDL-C by 5% and TG concentration by 4% in blood. These effects are individual, depending on genes and body's response to exercise. These effects may be the mechanism by which exercise decreases the risk of CVD. It has been established that aerobic exercise can lower plasma concentrations of LDL-C, TG and apolipoprotein B as well as increase the size of LDL-C particles and plasma apolipoprotein A levels (Rauramaa 2005, Fogelholm et al. 2006, Lakka & Laaksonen 2007, Liikunta 2008).

At its best; exercise has similar effects to blood lipids and lipoproteins than medication used to treat high cholesterol. The effect of exercise training on blood lipids and lipoproteins is mainly based on elevated energy consumption of muscles during exercise and partly on body's elevated basal metabolism after exercise. In addition to elevated energy consumption, exercise also effects on regulation mechanisms of the energy metabolism in liver and pancreas (Rauramaa 2005, Fogelholm et al. 2006, Liikunta 2008).

3.3.4 Hypertension

Exercise training, and most importantly aerobic exercise, lowers systolic BP approximately by 7 mmHg and diastolic BP by 5 mmHg on persons with elevated BP. During aerobic exercise, systolic BP increases in relation to the intensity of the exercise. Endurance exercise can decrease the activity of the sympathetic nervous system, which usually is increased when person has elevated blood pressure. The decrease in activity of the sympathetic nervous system occurs at rest, which in turn, decreases the pressure of the peripheral vessels. The BP levels will drop below resting BP levels 2-4 hours after exercise session lasting no less than 20 minutes (Kukkonen-Harjula & Rauramaa 2005, Lakka & Laaksonen 2007, Liikunta 2008).

Exercise also has effects on the activity of insulin in different tissues as well as on the function of the blood vessel endothelium and segregation of sodium through kidneys. Exercise increases peripheral blood flow and insulin sensitivity as well as decreases the amount of fat in the body especially visceral adipose tissue. Decrease in BP occurring as a result of regular aerobic exercise may be result of improvements in body composition, insulin sensitivity, endothelial dysfunction and autonomic balance (Kukkonen-Harjula & Rauramaa 2005, Lakka & Laaksonen 2007, Liikunta 2008).

3.4 Dose-Response Relationship

It has been proven by several scientific studies that physical inactivity is a major risk factor for many diseases and premature death. Many of the scientific studies have indicated the importance of physical activity, started even at the advanced age, and its positive influence on risk factors of the sedentary lifestyle-associated disorders (Jensen-Urstad & Jensen-Urstad 2003, Ohkawara et al. 2007). Due to a sedentary lifestyle one can experience general disturbances in function of organs, organ specific problems and disorders in hormonal catabolism. Physical exercise can prevent the primary manifestation of the disease and certain disorders or diseases can be influenced greatly by physical activity (Jensen-Urstad & Jensen-Urstad 2003, Fogelholm et al. 2006).

Being fit and physically active was connected to greater than 50% reduction in risk of developing CVD. Furthermore, it seems that people who are physically fit, but have other risk factors of CVD, have reduced risk of dying prematurely differently from people who are physically inactive and have no other risk factors of CVD. In other words, increasing physical activity, and that way, physical fitness, will lead to a reduction in the risk of premature mortality even if they are only small improvements (Warburton et al. 2006). It is also stated that physically active lifestyle across the lifespan will produce even greater benefits, thus it appears that dose-response relationship is evident (Warburton et al. 2006, Yang et al. 2008).

According to the review of Ohkawara et al. (2007) the volume of aerobic exercise training has a dose-response relationship with visceral adipose tissue reduction in subjects without metabolic disorders. At least 10 METs•h/week of aerobic exercise (brisk walking, light jogging) is needed for significant weight loss. In the ECSS position statement of Fogelholm et al. (2006) 250-300min/week (35-45 min/d) of at least moderate-intensity (>30-40% VO_2 max) physical activity is needed to bring beneficial changes in weight, body composition, insulin sensitivity and HDL-C. High intensity exercise (>70% VO_2 max) is even more beneficial for lipid metabolism, especially for reduction of LDL-C levels.

In the review of Lakka and Laaksonen (2007) a mild or moderate favourable effect was found between exercise training and many metabolic and cardiovascular risk factors. They also stated that regular physical activity prevents T2D, CVD and premature mortality on overweight or obese persons. At least moderate intensity exercise is recommended to maintain or increase cardiorespiratory fitness and muscle strength and to decrease the likelihood of developing the MetS. Likewise, more vigorous exercise is recommended to obtain more additional health benefits.

3.5 Motivation to Exercise

People exercise for many different reasons; health, fitness or just pleasure. Most people in Finland have a positive attitude towards physical activity and exercise. Half of the adults in Finland are known to do some kind of physical activity at least twice a week (Fogelholm 1999, 257). Promoting physical activity and motivating people to exercise includes a multitude of complex variables, including personal, programmatic, social, environmental and related factors. It is critical to get people to individually adapt to the behaviour change to facilitate a physically active lifestyle. Environmental influences play an important role in promoting or inhibiting physical activity even among the most motivated persons (Haskell et al. 2007).

In the pilot study of Quinn et al. (2008) they investigated the effect of a physical activity group-based education program on weight, physical activity, cardiovascular fitness, quality of life and attitudes to exercise in obese females (n=18). The subjects participated to four physical activity education sessions separated by 1 month in groups of 6-8 people. They reported no significant decreases in subject's weight or improvements in physical activity. However, there were significant improvements in cardiovascular fitness and attitudes towards exercise, shown by decreased barrier to exercise, decreased shyness and increased energy and enjoyment. They emphasised behavioural modifications which have been shown to increase the effects of physical intervention (Quinn et al. 2008).

4. OBJECTIVES

The main goal is to study the possible effects of short-term aerobic exercise and diet intervention guided by a wrist computer (Suunto Oy, Vantaa, Finland) or general exercise/diet guidance on body composition, blood lipid profile and glucose metabolism, as well as the risk factors of metabolic syndrome on 20-50 year-old overweight/obese women, who were previously inactive.

4.1 Questions

1. Is there a difference in body composition, blood lipid profile and glucose metabolism between an added motivational factor groups and control groups after short-term aerobic exercise and diet intervention?

2. What is the prevalence of the Metabolic Syndrome at the pre- and post-interventions measurements in Exercise and Weight Control groups and furthermore, do the groups with the added motivational factor differ from control groups after short-term aerobic exercise and diet intervention?

4.2 Hypothesis

Aerobic exercise and diet guidance have positive effects on health by improving body composition, blood lipid profile and glucose metabolism as well as on the risk factors of metabolic syndrome. Groups with an added motivational factor benefit more than just general exercise or diet guidance groups.

5. METHODS

This Master's Thesis was part of the Exercise and Weight Control Intervention (EWI-09) study carried out in the University of Jyväskylä in the Department of Health Sciences in summer-winter 2009.

5.1 Subjects and Study Design

Subjects of the study were recruited from the Central Finland Central hospital staff via staff newspaper and Internet site. The intended amount of subjects for the study was 110 previously physically inactive (participating regular leisure time aerobic exercise less than two times per week, less than 45 min per session) or sedentary overweight or obese (BMI >25 to 38) women aged 20-50 years. The final amount of subjects was ninety-four, due to exclusions and drop-outs (Appendix 1). These 94 subjects were first randomly assigned into exercise (EX: BMI > 25-33 kg/m^2) or weight control (WC: BMI > 25-38 kg/m^2) groups on the basis of inclusion criteria (see Table 3). This was partly a random allocation, but if the BMI of the subject was >33, the subject was automatically allocated to weight control group (Table 4). This was done purely to reduce the risk of injury and to reduce the strain intensive aerobic exercise can cause to joints. They were then further assigned into exercise with the wrist computer (EXW), exercise without the wrist computer (EXC), weight control with the wrist computer (WCW) and weight control without the wrist computer (WCC) groups. Eighty subjects completed the study (EXW n=21, EXC n=19, WCW n=20, WCC n=20). The form of aerobic exercise was Nordic walking, but subjects were also free to implement any other form of exercise addition to Nordic walking if so desired. The wrist computer tested during this study was a prototype of Suunto's new wrist computer and modifications will be made to the wrist computer's final version and its programs after this trial use.

Table 3. Inclusion criteria.

Inclusion criteria	
Exercise Group	**Weight Control Group**
BMI >25-33	BMI >25-38
Physically inactive (regular exercise ≤ 2 times/week and ≤ 45 min/session)	
Women	
Aged 20-50 years	

After the first allocation the subjects under-went pre-intervention assessments after 12 hour fast in the morning; basal metabolic rate (BMR), body composition (InBody), anthropometry (height, weight, calculated BMI, waist circumference), blood samples (Total-C, HDL-C, LDL-C, TriGly, FFA, fGluc, Insulin, HOMA-IR, HOMA-IS and HOMA-b), physical activity questionnaire to determine the Physical Activity class (Appendix 2), 10m walking test, physical examination by physician and VO_2 max – test. The subjects also filled in food questionnaires, food diaries for 6 days and Physical Activity Diaries from one day each week of the intervention. In addition, during intervention they filled in exercise diaries where they recorded all the exercise they did, regardless of being part of the study intervention or not. In this thesis, the measured results, except BMR and 10m walking test, from the pre- and post-intervention assessments are analysed.

After the pre-intervention measurements subjects of the exercise group participated in Intervention guidance lesson where they were randomly assigned into two subgroups; group 1 (EXW): Exercise following wrist computer guidance (n=21) and group 2 (EXC): Exercise control group following ACSM's 2007 exercise recommendations for adults (n=19). Nordic walking poles were also provided for the subjects and correct technique presented by the member of the research team.

After the intervention guidance lesson exercise-group subjects commenced 6 weeks endurance exercise intervention with Nordic walking. During intervention time (6 weeks) subjects participated in measurements every other week where for EXW-group data from the wrist computers were down-loaded to computer and 10m walking test was done. For EXC-group 10m walking test was done and new Nordic walking intensity determined. After intervention period (6 weeks) subjects participated in the post-intervention assessments which were the same assessments as the pre-intervention assessments.

Weight control (WC) group subjects also participated in Intervention guidance lesson where they were as well randomly assigned into two subgroups; group 1 (WCW): Weight control following wrist computer guidance (n=20) and group 2 (WCC); Weight control control following only provided dietary guidance (n=20). Again, if the subject's BMI exceeded 33, she was automatically assigned to WCC group, due to risk of injury and strain. Both weight control groups received dietary advice from the clinical dietician according to Finnish Nutrition recommendations targeting weight loss (Appendix 3). Subjects in Weight Control groups set them-selves a weight loss target for 6 weeks. Recommended weight loss was 0.5-1kg/week (3-6kg in 6 weeks). Also general exercise guidance according to ACSM's recommendations and tools for permanent weight control (Behaviour management, motivation) were provided. Nordic walking poles were also provided to these subjects, but no correct technique was presented.

After the intervention guidance lesson weight control -group subjects commenced 6 weeks diet intervention with given dietary advice. No diet regime was provided, the subjects were only recommended to follow the provided dietary advice. During intervention time (6 weeks) subjects participated in body composition measurements every other week. From WCW group the data from the wrist computer was down-loaded to computer and new weight fed into the wrist computer. After intervention period (6 weeks) subjects participated in the post-intervention assessments which were the same assessments as the pre-intervention assessments and were performed after 12 hours fast in the morning.

Table 4. Descriptive Information of the Subjects.

	Descriptive information					
	Mean±SD		[a]One-way ANOVA	Mean±SD		[a]One-way ANOVA
	EXW (n=21)	EXC (n=19)	*p-value	WCW (n=20)	WCC (n=20)	*p-value
Age (yrs)	41.9±8.0	42.2±7.4	1.00	42.6±7.2	42.6±5.8	0.99
Height (cm)	166.9±6.8	165.3±5.3	0.98	164.7±6.4	166.3±6.4	0.99
Weight (kg)	78.8±8.8	78.3±7.3	1.00	83.7±10.8	88.1±11.3	0.65
BMI	28.2±2.1	28.6±2.3	1.00	30.8±2.8	31.8±3.4	0.60
WC (cm)	95.2±7.8	97.7±6.5	0.86	99.0±6.7	103.0±11.0	0.43
PA class	4±1.6	4±1.0	1.00	4±1.2	4±1.8	0.58

WC=Waist Circumference, PA=Physical Activity, BMI=Body Mass Index

[a]One-way ANOVA: comparison between groups (EXW vs. EXC, WCW vs. WCC), The level of sig. *p<0.05

5.1.1 Exercise Intervention Following the Wrist Computer Fitness Guidance

The Suunto prototype wrist computer's fitness guidance is based on ACSM's guidelines of training progression for the sedentary low-risk participants. The wrist computer defined the starting fitness level of the subject according to the input fitness level obtained from the VO_2max-test results (Appendix 4). The pre-intervention information about the subject was provided to the wrist computer (height, weight, sex, age, fitness class, maxHR, minHR). The wrist computer then commenced the fitness guidance that the subject implemented, according to the pre-intervention information and ACSM's guidelines (Appendix 5).

5.1.2 Exercise Intervention without the Wrist Computer

Exercise intervention program without the wrist computer guidance is also based on "ASCM's 2007 exercise recommendations for adults" –guidelines. Program was progressive in intensity. Duration and frequency were modified according to intensity (Appendix 6). The walking speed the subjects used in km/h^{-1} (intensity) and $\%HR_{max}$ were determined every other week on the treadmill by the subject and the member of the research team without the walking poles. Subjects were not informed about the $\%HR_{max}$, only the intensity in speed (km/h^{-1}) was told and the subject was recommended to keep that speed during exercise for the next two weeks. New guidance for duration and frequency of the exercise was also provided to the subject.

5.1.3 Weight Control Following the Wrist Computer Weight Guidance

The Weight Control group following wrist computer weight guidance (WCW) followed the guidance from the wrist computer. The set exercise program targeted weight loss (-3kg). The pre-intervention weight was provided to the wrist computer, among with other personal information (height, sex, age, fitness class, maxHR, minHR). Subjects visited the laboratory every other week and InBody-assessments were performed after 12 hour fast, new weight provided for the watch and data down-loaded from the watch to computer.

5.1.4 Weight Control without the Wrist Computer

The Weight Control Control (WCC) group visited the laboratory every other week and InBody-assessments were performed after 12 hour fast. They did not follow any exercise guidance, but were free to exercise if desired.

5.2 Measurements Analysed in this Thesis

All the measurements were performed in the morning, between 7.00-9.00 am after over-night fast, at the pre- and post-intervention. Same equipment was used every time. Research assistants conducted the measurements according the protocol set earlier.

5.2.1 Blood Pressure Measurement

Omron M4-I Intellisense Blood Pressure monitor was used to measure blood pressure (mmHg). Measurements were conducted in prone position and after five (5) minutes rest. Subjects were advised to stay still and not to talk during the measurement.

5.2.2 Body Composition Parameters

Height was measured from the subjects only at the pre-intervention assessments, because it seldom changes. Same measure of length was used with all subjects and the measure was recorded in centimetres (cm).

BIOSPACE InBody 720 Body Composition Analyzer was used to measure body composition (weight (kg), fat percent (%), fat mass (kg), fat free mass (kg), soft lean body mass (kg) and visceral fat area (cm^2)). Subjects were always measured only in minimal clothing (underwear). All jewellery was removed. Subjects were advised to stay still and not to talk during the measurement.

Body Mass Index (BMI) was then calculated by dividing body weight (kg) by height (m) squared (kg/m^2). Waist circumference was measured in centimetres (cm) using tape measure and placing the tape measure at the level of the iliac crest.

5.2.3 Blood Analyses

Blood tests were drawn from the subject's antecubital vein by a trained laboratory technician or a nurse and the samples were transported to the laboratory of University of Jyväskylä where they were analysed by a trained laboratory technician. Blood serum was used to assay all the analyses. Fasting glucose (fGluc, mmol/l), High-density lipoprotein cholesterol (HDL-C, mmol/l), low-density lipoprotein cholesterol (LDL-C, mmol/l), Total cholesterol (Total-C, mmol/l) and Triglycerides (TriGly, mmol/l) were analysed using Konelab 20 XTi Thermo Fisher Scientific (Vantaa, Finland) Analyser. Free fatty acids (FFA, µmol/l) were analysed using Konelab 20 XTi Thermo Scientific (Espoo, Finland) Analyser. Insulin (mlU/l) was analysed using Immulite 1000 Siemens Medical Solution Diagnostic (LA, USA) Analyser.

Homeostatic model assessment of insulin resistance (HOMA-IR) and homeostatic model assessment of insulin secretion (HOMA-β, β-cell function) results were calculated using the equations. HOMA-IR index was calculated using the following equation: glucose (mmol/l)*Insulin (mU/l)/22.5 and HOMA-β index was calculated using following equation: 20*Insulin (mU/l)/glucose (mmol/l)-3.5.

5.2.4 VO_2 max –test Protocol, Heart Rate Monitoring, Fitness Class and Physical Activity Class

The subjects under went the symptom-limited bicycle ergo-meter tests (VO_2max – test) at the pre- and post-intervention assessments (after 6 weeks). A physical examination by physician was performed before the test and the physician was present during testing. ECG (electro-cardio-graph) was taken before, during and after the test. VO_2max –test was used to assess maximal aerobic performance and maximal oxygen uptake (ml/kg/min).

Before, during and after tests, beat-by-beat heart rate was recorded using beta-ready fitness line device (Suunto Oy, Vantaa, Finland) together with ECG and respiratory gas analyser device. Respiratory gases and ventilation was measured using V_{max} (VIASYS Healthcare Inc. USA). Fitness class was defined from the chart according to Shvartz and Reibold from the result of the VO_2max-test (ml/kg/min) (Appendix 4).

Following the VO_2max-test each subject's heart rate was monitored for 24 hours with beta-ready fitness line device and this data was downloaded to the computer and analysed using Firstbeat software. During this 24-hour period, the subjects also recorded their physical activity on a physical activity diary. These results are not analysed in this thesis.

Physical Activity class was obtained from subjects by a questionnaire at the pre- and post-intervention assessments using same questionnaire. Physical activity classes were graded in 14 different stages, where activity class 0 was "no activity at all" and activity class 10 was "I exercise daily (>15hours/week)" (Appendix 2).

5.2.5 Prevalence of Metabolic Syndrome

Metabolic Syndrome (MetS) was defined using NCEP ATP III criteria (table 2). For subject to be classified as having MetS, they needed to have elevated waist circumference (≥88 cm) and 2 or more of the criteria described in table 2.

6. STATISTICAL ANALYSES

SPSS 15.0 for Windows was used to carry out statistical analyses. The data was analysed from the subjects who completed the study (n=80). This number includes those 6 subjects who completed the study, apart from the post-intervention VO_2max-test due to illness or other factors (Appendix 1).

A one-way analysis of variance (ANOVA) was performed to all variables to examine any possible between-group differences at the pre-intervention. Paired samples t-test was performed to all variables to examine the degree of difference between repeated measures. Between groups differences (EXW-EXC and WCW-WCC) were examined with General Linear Model repeated measures. Significance for all tests was set at $p<0.05$. Data is presented as means±standard deviation (SD), p-values and change percentage, unless otherwise specified. Fasting glucose (fGluc), insulin, HOMA-IR and HOMA-β variables were not normally distributed and were thus logarithmically transformed.

To examine the prevalence of the metabolic syndrome at the pre- and post-intervention assessments (means and paired samples t-test) the criteria of NCEP ATP III (table 2) was used. The data was read through and if conditions for metabolic syndrome were satisfied (waist circumference >88cm and ≥2 of the other criteria) at the pre- or post-intervention assessments, subjects were marked with number 1 and if the conditions were not satisfied, subjects were marked with number 0.

7. RESULTS

There were no significant differences between two exercise groups (EXW-EXC) or between two weight control groups (WCW-WCC) at the pre-intervention measurements in any of the variables (one-way ANOVA). However, certain significant differences at the pre-intervention were observed in following variabes:

- Weight (EXW/EXC-WCC p=0.02)
- BMI (EXW-WCC p=0.001 and EXC-WCC p=0.002)
- Fat Mass (kg) (EXW-WCC p=0.01 and EXC-WCC p=0.04)
- Fat percent (EXW-WCC p=0.03)
- Visceral fat area (EXW-WCC p=0.02)
- Waist circumference (EXW-WCC p=0.03)
- TriGly (EXC-WCC p=0.04),
- Insulin levels (EXC-WCC p=0.01)
- HOMA-IR (EXC-WCC p=0.03)

Because of these between group differences at the pre-intervention measurements, only exercise groups (EXW-EXC) and weight control groups (WCW-WCC) were compared with General Linear Model repeated measures.

7.1 Blood Pressure

There were no significant changes observed in any of the groups in systolic or diastolic blood pressure. The decrease in diastolic blood pressure in WCW group was almost significant (p=0.07). There were significant differences observed in between group comparison only between WCW and WCC groups in diastolic blood pressure (p=0.05). Diastolic blood pressure decreased more in WCW group (3.8%) compared to WCC group (1.2%). The results of the paired samples t-test are presented in Table 5a (Exercise groups) and Table 5b (Weight Control groups). The between group comparison results are presented in Table 5c.

Table 5a. Blood pressure results for Exercise groups.

Blood Pressure (mmHg) EX					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
BP Syst	EXW	19	128±10.5	128±18.6	0.99
	EXC	18	124±8.1	126±11.4	0.22
BP Diast	EXW	19	81±7.7	80±11.0	0.74
	EXC	18	80±6.6	79±7.1	0.57

Paired samples t-test, The level of sig. p<0.05

Table 5b. Blood pressure results for Weight Control groups.

Blood Pressure (mmHg) WC					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
BP Syst	WCW	20	126±9.9	130±15.0	0.22
	WCC	20	131±14.3	133±12.6	0.66
BP Diast	WCW	20	79±6.9	76±9.0	0.07
	WCC	20	83±8.5	82±8.9	0.56

Paired samples t-test, The level of sig. $p<0.05$

Table 5c. Between group comparison, blood pressure.

Blood Pressure (mmHg)				
	Between group Comparison, [a]p-value (*GLM)			
	EXW vs. EXC (n)	Change % post-pre (EXW/EXC)	WCW vs. WCC (n)	Change % post-pre (WCW/WCC)
BP Syst	0.43 (19/18)	0/1.6	0.29 (20/20)	3.2/1.5
BP Diast	0.87 (19/18)	-1.2/-1.3	0.05* (20/20)	-3.8/-1.2

*GLM=General Linear Model, repeated measures

[a]The level of sig. $p<0.05$

7.2 Body Composition Parameters

Significant decrease in weight was observed only in WCC group ($p<0.001$). All the other groups did not significantly lose weight. The same significance was observed in BMI. The only significant decrease was in WCC group ($p<0.001$). For waist circumference, EXW group significantly decreased waist circumference ($p=0.01$). There was no change in any of the other groups.

Fat percent did not decrease in any of the groups, in contrast to Fat Free Mass and Soft Lean Body Mass which both decreased significantly in WCW ($p=0.01$) and WCC ($p=0.03$) groups. There were no changes in either of the exercise groups. Fat Mass and Visceral Fat Are (VFA) decreased significantly only in WCC group ($p=0.03$). In between group comparison there were no significant differences observed between EXW-EXC and WCW-WCC groups. WCC group decreased VFA almost significantly ($p=0.07$) compared to WCW group. The results of the paired samples t-test are presented in Table 6a (Exercise groups) and Table 6b (Weight Control groups). The between group comparison results are presented in Table 6c.

Table 6a. Body Composition results for Exercise groups.

Body Composition (EX)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
Weight (kg)	EXW	21	78.8±8.8	78.5±8.6	0.38
	EXC	19	78.3±7.3	78.0±7.3	0.42
BMI	EXW	20	28.3±2.1	28.2±2.2	0.76
	EXC	19	28.6±2.3	28.6±2.1	0.67
WC (cm)	EXW	21	95.2±7.8	93.9±6.8	0.01*
	EXC	19	97.7±6.5	96.9±6.5	0.08
Fat%	EXW	20	34.5±5.4	35.0±5.1	0.11
	EXC	19	37.2±4.9	37.4±4.4	0.67
VFA (cm^2)	EXW	20	113.8±19.9	113.1±20.7	0.56
	EXC	19	122.2±17.9	119.0±16.4	0.11
Fat Mass (kg)	EXW	20	27.3±6.3	27.6±5.9	0.33
	EXC	19	29.3±5.8	29.3±5.4	0.88
Fat Free Mass (kg)	EXW	20	51.4±6.1	51.0±6.4	0.08
	EXC	19	48.9±3.8	48.7±4.1	0.46
Soft Lean Mass (kg)	EXW	20	48.4±5.7	48.0±6.0	0.08

	EXC	19	46.1±3.6	45.9±3.9	0.49

VFA=Visceral Fat Area, WC=Waist Circumference

Paired samples t-test, The level of sig. $p<0.05$

Table 6b. Body Composition results for Weight Control groups.

Body Composition (WC)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
Weight (kg)	WCW	20	83.7±10.8	82.9±10.9	0.07
	WCC	20	88.1±11.3	86.6±10.6	0.001**
BMI	WCW	23	30.5±2.8	30.3±2.8	0.25
	WCC	25	31.8±3.4	31.4±3.3	0.002**
WC (cm)	WCW	20	99.0±6.7	98.0±7.9	0.09
	WCC	20	103.0±11.0	102.1±10.8	0.19
Fat%	WCW	23	38.3±4.1	38.4±3.9	0.64
	WCC	25	39.6±6.6	39.4±6.6	0.36
VFA (cm^2)	WCW	23	121.4±21.6	119.1±21.3	0.11
	WCC	25	132.3±19.3	129.6±18.4	0.03*

Fat Mass (kg)	WCW	23	31.9±6.45	31.8±6.5	0.69
	WCC	25	35.2±8.6	34.5±8.2	0.03*
Fat Free Mass (kg)	WCW	23	51.0±5.8	50.3±5.5	0.01*
	WCC	25	52.7±6.4	52.3±6.6	0.03*
Soft Lean Mass (kg)	WCW	23	48.1±5.4	47.4±5.2	0.01*
	WCC	25	49.7±6.0	49.2±6.2	0.03*

VFA=Visceral Fat Area, WC=Waist Circumference

Paired samples t-test, The level of sig. $p<0.05$

Table 6c. Between group comparison, body composition.

Body Composition				
	Between group Comparison, [a]p-value (*GLM)			
	EXW vs. EXC (n)	Change % post-pre (EXW/EXC)	WCW vs. WCC (n)	Change % post-pre (WCW/WCC)
Weight (kg)	0.84 (21/19)	-0.3/-0.3	0.24 (20/20)	-1.0/-1.7
BMI	0.57 (20/19)	-0.1/-0.2	0.36 (23/25)	-0.7/-1.4
WC (cm)	0.21 (21/19)	-1.4/-0.9	0.17 (20/20)	-1.0/-0.9
Fat%	0.12 (20/19)	1.5/0.4	0.45 (23/25)	0.4/-0.6
VFA (cm^2)	0.24 (20/19)	-0.6/-2.6	0.07 (23/25)	-1.9/-2.0
Fat Mass (kg)	0.34 (20/19)	1.1/-0.2	0.18 (23/25)	-0.5/-2.0
Fat Free Mass (kg)	0.16 (20/19)	-0.9/-0.5	0.30 (23/25)	-1.4/-0.9
Soft Lean Mass (kg)	0.16 (20/19)	-0.9/-0.4	0.30 (23/25)	-1.4/-1.0

*GLM=General Linear Model, repeated measures

[a]The level of sig. $p<0.05$

7.3 Blood Results

7.3.1 Blood Lipid Profile

Total Cholesterol (Total-C) increased significantly in EXC ($p<0.001$) and WCW ($p<0.001$) groups. There was no significant decrease in total-C in any of the groups. When groups were compared no significant between group differences were observed in EXW-EXC and WCW-WCC groups. Significant increase in HDL-C was not observed in any of the groups, unlike in LDL-C levels, where significant increase was observed in almost all the groups, EXW ($p=0.002$), EXC ($p<0.001$) and WCW ($p=0.001$). There was also a significant difference in between groups comparison between EXW-EXC groups ($p=0.03$). LDL-C levels increased more in EXC group (24.2%) compared to EXW group (10.3%).

Triglyceride (TriGly) levels increased significantly in EXC group ($p=0.04$), but there were no significant changes in any other groups. In between group comparison, no significant differences were observed. Significant decrease in Free Fatty Acids (FFA) were observed in EXW ($p=0.001$) and EXC ($p=0.001$). In between group comparison the difference between EXW-EXC groups was almost significant ($p=0.06$). FFA decreased slightly more in EXC group (34.6%) compared to EXW group (33.8%). The results of the paired samples t-test are presented in Table 7a (Exercise groups) and Table 7b (Weight Control groups). The between group comparison results are presented in Table 7c.

Table 7a. Blood Lipid Profile results for Exercise groups.

Blood Lipid Profile (EX)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
Total C (mmol/l)	EXW	21	5.1±1.1	5.3±0.8	0.202
	EXC	19	4.5±0.3	5.3±0.5	<0.001**
HDL-C (mmol/l)	EXW	21	1.5±0.4	1.6±0.5	0.45
	EXC	19	1.6±0.3	1.6±0.4	0.87
LDL-C (mmol/l)	EXW	20	3.1±0.7	3.3±0.6	0.002**
	EXC	19	2.5±0.4	3.1±0.7	<0.001**
TriGly (mmol/l)	EXW	21	1.5±0.7	1.3±0.5	0.17
	EXC	19	1.1±0.4	1.4±0.6	0.04*
FFA (µmol/l)	EXW	21	413.5±202.0	273.6±88.3	0.001**
	EXC	19	510.3±192.4	333.6±107.7	0.001**

Paired samples t-test , The level of sig. p<0.05

Table 7b. Blood Lipid Profile results for Weight Control groups.

Blood Lipid Profile (WC)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
Total C (mmol/l)	WCW	20	5.4±1.1	6.0±1.3	<0.001**
	WCC	20	5.1±0.8	5.4±0.9	0.18
HDL-C (mmol/l)	WCW	19	1.5±0.3	1.5±0.4	0.30
	WCC	20	1.4±0.3	1.4±0.3	0.70
LDL-C (mmol/l)	WCW	19	3.0±0.6	3.5±0.8	0.001**
	WCC	20	3.0±0.6	3.3±0.8	0.12
TriGly (mmol/l)	WCW	19	1.4±0.6	1.6±0.9	0.17
	WCC	20	1.5±1.0	1.5±0.8	1.0
FFA (μmol/l)	WCW	19	482.5±140.7	428.9±159.2	0.22
	WCC	20	465.5±187.9	416.2±172.1	0.26

Paired samples t-test, The level of sig. $p<0.05$

Table 7c. Between group comparison, Blood Lipid Profile.

Blood Lipid Profile				
Between group Comparison, [a]p-value (*GLM)				
	EXW vs. EXC (n)	Change % post-pre (EXW/EXC)	WCW vs. WCC (n)	Change % post-pre (WCW/WCC)
Total C (mmol/l)	0.19 (21/19)	3.9/15.9	0.18 (20/20)	11.4/4.1
HDL-C (mmol/l)	0.90 (21/19)	2.0/0	0.45 (19/20)	-2.7/-1.4
LDL-C (mmol/l)	0.03** (20/19)	10.3/24.2	0.66 (19/20)	18.6/7.6
TriGly (mmol/l)	0.42 (21/19)	-13.1/21.6	0.98 (19/20)	15.5/0
FFA (µmol/l)	0.06 (21/19)	-33.8/-34.6	0.74 (19/20)	-11.1/-10.6

*GLM=General Linear Model, repeated measures

[a]The level of sig. $p<0.05$

7.3.2 Glucose Metabolism

There was significant decrease in serum fasting glucose levels (fGluc) in EXW ($p<0.001$) and EXC ($p=0.01$) groups. No changes were observed in either of the weight control groups. Insulin levels decreased significantly only in EXW group ($p=0.01$).

Insulin Resistance Index (HOMA-IR) decreased significantly in all groups, EXW ($p<0.001$), EXC ($p=0.01$), WCW ($p=0.001$) and WCC ($p=0.05$). Insulin Secretion Index (HOMA-β) increased significantly in three groups, EXW ($p=0.002$), EXC ($p=0.004$) and WCW ($p=0.001$). There were no significant differences observed in between group comparison. The results of the paired samples t-test are presented in

Table 8a (Exercise groups) and Table 8b (Weight Control groups). The between group comparison results are presented in Table 8c.

Table 8a. Glucose Metabolism results for Exercise groups.

Glucose Metabolism (EX)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
Insulin* (mIU/l)	EXW	20	8.6±5.0	6.6±3.0	0.01*
	EXC	19	6.6±3.3	6.1±2.8	0.51
f-Gluc* (mmol/l)	EXW	21	5.3±0.5	4.7±0.5	<0.001**
	EXC	17	6.0±3.5	5.5±3.6	0.01*
HOMA-IR*	EXW	16	2.1±1.2	1.1±0.6	<0.001**
	EXC	17	1.6±0.8	1.1±0.4	0.01*
HOMA-β*	EXW	11	0.4±0.7	2.0±1.3	0.002**
	EXC	14	0.8±0.6	1.9±1.1	0.004**

Paired samples t-test, The level of sig. p<0.05

*p-value counted from Ln

Table 8b. Glucose Metabolism results for Weight Control groups.

Glucose Metabolism (WC)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
Insulin* (mIU/l)	WCW	19	9.3±6.4	8.9±6.9	0.27
	WCC	20	10.8±6.8	9.6±5.5	0.31
f-Gluc* (mmol/l)	WCW	20	5.2±0.5	5.3±0.5	0.34
	WCC	19	5.4±0.7	5.5±0.9	0.94
HOMA-IR*	WCW	19	1.9±1.1	1.3±0.8	0.001**
	WCC	19	2.5±1.7	1.8±1.1	0.05*
HOMA-β*	WCW	12	0.3±0.8	1.6±1.0	0.001**
	WCC	8	0.7±0.9	1.1±1.9	0.62

Paired samples t-test, The level of sig. p<0.05

*p-value counted from Ln

Table 8c. Between group comparison, Glucose Metabolism.

	Glucose Metabolism			
	Between group Comparison, [a]p-value (*GLM)			
	EXW vs. EXC (n)	Change % post-pre (EXW/EXC)	WCW vs. WCC (n)	Change % post-pre (WCW/WCC)
Insulin (mIU/l)**	0.28 (20/19)	-24.1/-7.6	0.21 (19/20)	-5.3/-11.0
f-Gluc (mmol/l)**	0.93 (21/17)	-11.0/-8.3	0.53 (20/19)	2.3/3.4
HOMA-IR**	0.79 (16/17)	-45.9/-30.9	0.21 (19/19)	-31.6/-27.2
HOMA-β**	0.67 (11/14)	-	0.87 (12/8)	-

*GLM=General Linear Model, repeated measures

[a]The level of sig. p<0.05

**p-value counted from Ln

7.4 Physical Activity and Fitness

Physical Activity class significantly increased in all groups during the intervention, EXW and EXC (p<0.001), WCW (p=0.004) and WCC (p=0.001). In the following variables (VO_2max, Fitness class, HRmax, minHR) no significant changes were observed in any of the groups. In between group comparison, significant difference was observed between EXW-EXC groups (p=0.03) in minHR. It decreased more in EXW group (1.9%) compared to EXC group (no change). The results of the paired samples t-test are presented in Table 9a (Exercise groups) and Table 9b (Weight Control groups). The between group comparison results are presented in Table 9c.

Table 9a. Physical Activity and Fitness results for Exercise groups.

Physical Fitness (EX)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
PA Class	EXW	19	4±1.6	6±1.1	<0.001**
	EXC	18	3±0.8	5±1.4	<0.001**
VO2max (ml/kg/min)	EXW	20	32.8±5.2	32.6±6.2	0.78
	EXC	19	31.6±4.7	32.4±4.2	0.31
HRmax (bpm)	EXW	20	179±15.2	178±14.0	0.18
	EXC	18	182±11.2	181±12.9	0.51
MinHR (bpm)	EXW	11	53±4.6	52±4.4	0.17
	EXC	13	56±5.8	56±3.8	0.79
Fitness Class	EXW	20	4±1.3	4±1.4	0.83
	EXC	19	4±1.3	4±1.3	0.15

PA class=Physical Activity Class, bpm=beats per minute

Paired samples t-test, The level of sig. p<0.05

Table 9b. Physical Activity and Fitness results for Weight Control groups.

Physical Fitness (WC)					
			Pre	Post	Paired t-test
		n	Mean±SD	Mean±SD	p-value
PA Class	WCW	19	4±1.2	6±1.5	0.004**
	WCC	20	4±1.8	5±1.9	0.001**
VO2max (ml/kg/min)	WCW	16	30.7±4.5	31.7±4.5	0.45
	WCC	19	30.1±6.3	31.5±5.0	0.11
HRmax (bpm)	WCW	17	177±6.8	176±6.7	0.11
	WCC	19	177±10.2	179±10.0	0.40
MinHR (bpm)	WCW	14	56±6.4	54±56.0	0.47
	WCC	13	52±7.0	53±7.9	0.72
Fitness Class	WCW	17	4±1.4	4±1.2	0.43
	WCC	19	4±1.6	4±1.4	0.07

PA class=Physical Activity Class, bpm=beats per minute

Paired samples t-test, The level of sig. $p<0.05$

Table 9c. Between group comparison, Physical Activity and Fitness.

Physical Activity and Fitness				
	Between group Comparison, [a]p-value (*GLM)			
	EXW vs. EXC (n)	Change % post-pre (EXW/EXC)	WCW vs. WCC (n)	Change % post-pre (WCW/WCC)
PA Class	0.20 (19/18)	50/67	0.23 (19/20)	50/25
VO2max (ml/kg/min)	0.62 (20/19)	-0.6/2.6	0.77 (16/19)	3.3/4.5
HRmax (bpm)	0.51 (20/18)	-0.6/-0.6	0.56 (17/19)	-0.6/1.1
MinHR (bpm)	0.03* (11/13)	-1.9/0	0.33 (14/13)	-3.6/1.9
Fitness Class	0.79 (20/19)	0/0	0.81 (17/19)	0/0

*GLM=General Linear Model, repeated measures

[a]The level of sig. $p<0.05$

7.5 Metabolic Syndrome

The prevalence of Metabolic Syndrome decreased significantly only in EXW group ($p=0.04$). No significant decrease in prevalence of MetS was observed in any of the other groups. In between group comparison, no significant differences were observed between EXW-EXC and WCW-WCC groups. The results of the paired samples t-test are presented in Table 10a for both groups and the between group comparison results are presented in Table 10b.

Table 10a. The prevalence of Metabolic Syndrome (MetS)

	Metabolic Syndrome (MetS)					
	Pre			Post		Paired t-test
	n	no MetS	MetS	no MetS	MetS	p-value
EXW	21	11	10	15	6	0.04*
EXC	19	15	4	13	6	0.33
WCW	20	13	7	12	8	0.33
WCC	20	11	9	10	10	0.67

Paired samples t-test, The level of sig. $p<0.05$

Table 10b. Between group comparison, Prevalence of the Metabolic Syndrome (MetS).

	Metabolic Syndrome (MetS)	
	Between group Comparison, [a]p-value (*GLM)	
	EXW vs. EXC	WCW vs. WCC
N	21/19	20/20
MetS	0.38	0.50

*GLM=General Linear Model, repeated measures

[a]The level of sig. $p<0.05$

8. DISCUSSION

The main goal of this study was to investigate the possible effects of short-term aerobic exercise and diet intervention with the added motivational factor (wrist computer) or general exercise/diet guidance on body composition, blood lipid profile and glucose metabolism, and furthermore, on the risk factors of metabolic syndrome on 20-50 year old overweight/obese women, who were previously inactive. Two specific objectives were addressed. First, to determine if there is a difference in body composition, blood lipid profile and glucose metabolism between the added motivational factor groups and control groups after short-term aerobic exercise and diet intervention. Second, to determine, what is the prevalence of the metabolic syndrome at the pre- and post-intervention measurements in Exercise and Weight Control groups and furthermore, do the groups with the added motivational factor differ from control groups after short-term aerobic exercise and diet intervention.

We hypothesised that aerobic exercise and diet guidance have positive effects on health by improving body composition, blood lipid profile and glucose metabolism, as well as, reducing the risk factors of metabolic syndrome. In addition, the added motivational factor groups benefit more than general exercise or diet guidance groups.

The results of the study show that aerobic exercise resulted in positive effects on Free Fatty Acids (FFA) (Tables 7a and 7b) and glucose metabolism (Tables 8a and 8b) without therapeutic weight loss and when practised short-term. With higher intensity exercise even further positive effects were gained on waist circumference and prevalence of the metabolic syndrome. Exercise, however, did not cause significant decreases in body weight, BMI or other factors of body composition (Table 6a). Only dietary modifications had an effect on body composition parameters (Table 6b).

It is difficult to determine if the added motivational factor (wrist computer) resulted in any further health benefits than general exercise recommendations for adults. It can be hypothesised, that the intensity of the exercise program on the wrist computer (fitness guidance, based on ACSM's guidelines of training progression for the sedentary low-risk participants, appendix 5) was higher than on the "ACSM's 2007 exercise recommendations for adults" –guidelines (Appendix 6), thus, the further health benefits. It may also be that ladies in the EXW group were more motivated to exercise due to the wrist computer than in the EXC group. In the WC groups the possible benefits of the added motivational factor are even more difficult to determine due to the different intervention protocols of the groups.

8.1 Blood Pressure

As mentioned earlier, there were no significant changes in systolic or diastolic blood pressure in any of the studied groups which is unexpected result. The decrease in diastolic blood pressure in WCW group (3.8%) was greater than in WCC group (1.2%) and the between group comparison was significant. It can be hypothesised that the diet modification and exercise together resulted in greater decrease in diastolic blood pressure than either one on their own. The effect of exercise alone, without diet modifications, is often not enough to decrease blood pressure in people with hypertension. Exercise alone usually results larger reduction in blood pressure for hypertensive than normotensive individuals (Fogelholm et al. 2006). It has been presented, however, that walking is an effective form of exercise for reducing blood pressure in women. Contrary to the results of this study, the reductions in blood pressure have been evident after just 4 weeks of walking and with a variety of walking protocols (Albright & Thompson 2006).

8.2 Body Composition Parameters

Significant decreases in weight and BMI were observed only in WCC group (Table 6b). All the other groups, except WCC group, followed some kind of exercise guidance during 6-weeks intervention, which might have had an effect on body weight through increased muscle mass or fluid retention. Although, Fat Free Mass and Soft Lean Body Mass only increased significantly in WCW and WCC groups. It may very well be that subjects in the groups which did not achieve weight loss (EXW, EXC, WCW) consumed more calories due to increased feeling of hunger after exercise. The fat oxidation after exercise is determined by whether the calories burned during the exercise are replaced or not. If the energy intake (eating) increases to compensate the energy burned during exercise, the daily fat oxidation will not increase and fat mass will be maintained (Melanson et al. 2009).

Some individuals lost significant amounts of weight during six weeks intervention. Others failed to lose weight or even gained weight during the intervention despite of the efforts. The previous study demonstrated that overweight and obese women usually have positive attitude towards exercise and dieting as well as towards the health benefits they result in.

The systematic review of Stefanic (1999) concluded that diet alone can result the same results in weight loss than diet and exercise together. The most powerful component of weight loss in short-term appears to be calorie intake. Even with large amounts of daily aerobic exercise, no significant reductions in weight loss over diet alone were observed (Brill et al. 2002).

There were no significant changes observed in fat percent in any of the groups. Fat mass and VFA decreased significantly only in WCC group. WCC group did not significantly decrease waist circumference even though VFA decreased. Waist circumference was significantly decreased in EXW group only.

Similar results were obtained by Brill et al. (2002) and Murphy et al. (2002). They both reported significant decreases in waist circumference, but not in total body weight in pre-menopausal overweight women, who take up walking as exercise. The fact that waist circumference decreased significantly in EXW group and not in WCC group, emphasises the importance of exercise in reducing abdominal adiposity and reducing the risk factors of the metabolic syndrome above other groups in this study.

Williams (2005) stated, that higher levels of moderate-intensity walking were related to lower levels of BMI and waist circumference. He also reported, that decreases in adiposity per kilometre per week walked seems to be greater among obese than lean women. It has been established, that physical activity can reduce age-related weight gain. Physically active women also have less age-related adiposity than sedentary women (Williams 2005). In his study, Williams (2005) established that the association between physical activity and adiposity (waist circumference) is restricted to vigorous rather than moderate-intensity exercise.

The InBody- measurements were standardized in terms of 12 hours fast and minimal clothing, but not in terms of menstrual cycle or menopause. This might have had an effect on fluid balance and through that to fat percent. One confounding factor might also be that all the subjects were shift workers and some of them came to the measurements straight after their night shift. Even though they had been fasting during their shift, sleeping pattern was different than normal and they had been on their feet all night.

8.3 Blood Lipid Profile

Total Cholesterol (Total-C) levels increased significantly in EXC and WCW groups, but not in EXW or WCC groups. There was no significant decrease observed in any of the groups in Total-C levels. LDL-C levels increased significantly in almost all the groups, EXW, EXC and WCW, which explains the increase in Total-C levels in EXC and WCW groups. Significant difference in between group comparison was observed between EXW-EXC groups. LDL-C levels increased more in EXC group (24.2%) compared to EXW group (10.3%). TriGly levels increased significantly in EXC group. Significant decrease in FFA was observed in EXW and EXC groups.

Study results about the effects of walking on women’s blood lipid profile vary. Some studies show that favourable effects can occur on blood lipid profile with walking in as little as 6 weeks, but other studies have failed to show any effects even with longer interventions. The reasons for the lack of consistency are not yet clear. It has been hypothesised, that diet and baseline blood lipid profile could be the possible factors. Also the different kind of walking protocols in different studies may contribute to this lack of consistency (Albright & Thompson 2006). In the meta-analysis of Carrol & Dudfield (2004) the finding was that exercise alone may not be sufficient to achieve improvements in dyslipidemia associated with the metabolic syndrome. Fogelholm et al. (2006) concluded that reduction in LDL-C appears to be dependent on weight loss.

The fact is that when glucose molecules are not available in blood or in muscles, human body starts to use lipid molecules for energy production which in turn increases the amount of lipid molecules in blood (Vuori 1994). In this study, total-C levels increased significantly in EXC and WCW groups and LDL-C levels in EXW, EXC and WCW groups as well as TriGly-levels in EXC group. All these groups exercised with different intensities. It may well be that subjects in these groups did not consume enough calories from carbohydrates in their daily diet and low-calorie intake with increased energy consumption from exercise may alter the lipid metabolism.

Parks et al. (1999) concluded that low-saturated fat diets increase the levels of circulating triglycerides and simple sugars, like fructose in fruit, stimulate lipogenesis and increase LDL-C production. It is evident that insulin stimulates lipogenesis (Chen et al. 1995). If too many fruits per day are consumed on the expense of other foods, too much fructose is obtained which might have been the case in this study. Examining through all the food diaries filled in by the subjects of this study is beyond the scope of this paper, so this conclusion is only hypothetical.

The study of Karpe (1997) stated that insulin resistance increases the production of triglycerides and LDL-C and decreases the clearance of LDL-C particles from blood. Parks et al. (1999) demonstrated in their study, that effects of low-fat diet on blood lipid profile can be confounded by hyperinsulinemia in mildly overweight subjects.

The Bruneck Study (Bonora et al. 1998) which was a population-based study (n=888, 40-79 years, male and female), reported that the vast majority of subjects with multiple metabolic disorders also had insulin resistance. Furthermore, the prevalence of insulin resistance was 65.9% in IGT subjects, 83.9% in NIDDM subjects, 53.5% in hypercholesterolemia subjects, 84.2% in hypertriglyceridemia subjects, 88.1% in subjects with low HDL-C and 58.0% in hypertension subjects. Based on the results of the Bruneck Study, they concluded that hypertriglyceridemia and low HDL-C almost never occurred on their own, but always associated with insulin resistance. In hypercholesterolemia and hypertension insulin resistance is less frequent (Bonora et al. 1998).

8.4 Glucose Metabolism

The most significant findings of the study were observed in glucose metabolism. There was a significant decrease in fGluc levels in EXW and EXC groups. In EXW group the decrease from the pre-intervention to the post-intervention was 11% and in EXC group 8.3%. In weight control groups, fGluc was slightly increased, but not significantly. Insulin levels decreased significantly only in EXW group. Decrease was 24.1% from the pre-intervention to the post-intervention.

Insulin Resistance Index, HOMA-IR decreased significantly in all the groups. The decrease in HOMA-IR Index from the pre-intervention to the post-intervention was 45.9% in EXW group, 30.9% in EXC group, 31.6% in WCW group and 27.2% in WCC group. Insulin Secretion Index, HOMA-β increased significantly in EXW, EXC and WCW groups.

It has been established that acute and chronic walking results in positive effects in insulin resistance and glucose tolerance for diabetics and nondiabetics (Albright & Thompson 2006). Walking provides an acute effect by increasing insulin sensitivity. Braun et al. (1995) reported no differences between the effects of the exercise intensity on insulin sensitivity. However, there was clear effect of a single walking session on decreasing insulin resistance in women (Braun et al. 1995).

Swartz et al. (2003) established positive changes in glucose tolerance after 8-weeks walking intervention period in overweight and obese sedentary women who had family history of T2D. These significant decreases occurred without any significant weight loss or changes in diet. The study of Ross et al. (2000) disclosed that decrease in VFA alone, even without significant weight loss, is related to improvements in glucose tolerance and insulin sensitivity. This supports the result obtained from this study, where VFA and HOMA-IR were both reduced in WCC group. Furthermore, Goodpaster et al. (1999) reported that diet-induced decreases in VFA are related to improvements in insulin resistance in obese men and women.

It has been established, that HOMA-IR and HOMA-β indexes derived from basal levels of fasting insulin and glucose are associated with increased risk of T2D on postmenopausal women. These associations are independent of BMI and waist-to-hip-ratio as well as other risk factors of T2D (Song et al. 2007).

8.5 Physical Activity and Fitness

Physical activity class significantly increased in all the groups. In between group comparison, a significant difference between EXW-EXC groups was observed in minHR. It decreased more in EXW group (1.9%) compared to EXC group (no change). This difference in the decrease on minHR could have resulted in the higher exercise intensity of EXW group.

All the subjects were shift workers and some of them came to the measurements after one or more night shifts. Even though they had been sleeping during the day, sleeping pattern was different than normal. Working shifts, especially nights, affects the recovery from exercise. Sickness also has an effect on recovery and physical fitness. During intervention period many of the subjects were ill (appendix 1), thus did not exercise according to the program. This might have had an effect on their physical fitness and on the VO_2max results at the post intervention assessments. Some individuals increased significantly their post-intervention VO_2max results and fitness class.

At the pre-intervention assessments the subjects had differences in their physical activity class. Some of them did no exercise at all and some exercised 2-3 times per week. The intervention time in this study was only 6 weeks which is too short to result in any improvements in physical fitness for those subjects who already participate in some physical activity. For those who were inactive, 6 weeks might result in some improvements in physical fitness.

One weakness of this study design is that fitness level and VO_2max were determined with the symptom-limited bicycle ergo-meter test. The form of exercise in the intervention was Nordic walking. When form of exercise is walking, assessing fitness level with bicycle test is not appropriate, due to the different muscles and range of motion used to perform the task. The more appropriate determination of VO_2max and fitness level would have been for example the UKK-walking test.

8.6 Prevalence of Metabolic Syndrome

The prevalence of metabolic syndrome decreased significantly only in EXW group. It appears that exercise training reduces and reverses the risk factors of the MetS on overweight or obese persons. At least three RCTs (Stewart et al. 2005, Tjønna et al. 2008, Kemmler et al. 2009) reported decrease in the prevalence of the MetS after 16-weeks to 12-months exercise training interventions. The intensity of the exercise performed played an important role in improving cardiovascular fitness and reducing and reversing the risk factors of the MetS. It seems, that modest amount of moderate intensity exercise significantly affected many of the parameters of the MetS, but higher amount of vigorous intensity exercise had even greater and widespread effects (Stewart et al. 2005, Johnson et al. 2007, Irving et al. 2008, Tjønna et al. 2008, Kemmler et al. 2009).

The importance of the intensity of the exercise training has been shown by many scientific studies (Stewart et al. 2005, Johnson et al. 2007, Irving et al. 2008, Tjønna et al. 2008). Higher amount of high-intensity exercise per week results greater and more widespread effects than moderate amount of moderate-intensity exercise.

Stewart et al. (2005), Johnson et al. (2007) and Irving et al. (2008), all presented that dose-response relationship is applicable in improving and reversing body composition and the risk factors of the MetS on overweight and obese persons.

These results obtained in the present study were similar to the results of the studies reviewed by Carroll and Dudfield (2004) in their review article. They presented in their review that physical inactivity and low cardiorespiratory fitness are associated with MetS. Supervised, long-term, moderate to moderately vigorous intensity exercise training improved low HDL-C and high TG levels in overweight and obese adults with risk factors of MetS even without therapeutic weight loss. According to the review, exercise training also decreased blood pressure and was effective treatment for insulin resistance on overweight and obese persons.

Carroll and Dudfield (2004) also concluded in their review that regular, long-term exercise training is associated with modestly decreased abdominal adiposity tissue and blood pressure, improved insulin action and improved insulin regulation as well as dyslipidemia profile, by raising HDL-C and lowering TG on overweight/obese persons, even without clinically significant weigh loss. These changes might be modest, but they are clinically relevant and may prevent or delay the onset of T2D.

The conclusions were similar in the review of Churilla and Zoeller (2008). Longitudinal studies generally provide strong association between regular physical activity and lower prevalence of MetS. Regular, moderate-intensity aerobic exercise was recommended as primary exercise form, combined with strength training. They also stated that dose-response relationship is present and greater intensity may bring greater health benefits.

Gaesser (2007) and Lakka and Laaksonen (2007) both found that regular exercise prevents T2D, CVD and premature mortality among overweight/obese persons. Moderate-intensity aerobic exercise, 30 min daily was recommended as the primary form of exercise; furthermore, additional health benefits can be obtained by increasing the amount and the intensity of aerobic exercise and combining it with strength training.

Johnson et al. (2007) mentioned that females usually have more favourable risk profile at the baseline than males. It their study prevalence of the MetS at the baseline was 40% (69/171) and 46% of these subjects diagnosed with MetS were male and 34% female even if the same criteria of MetS was used.

Kemmler et al. (2009) performed their study as a randomised controlled trial, in which participants (n=65) were randomised into two groups, exercise group and control group. Intervention lasted for 12 months. Exercise group had high-intensity aerobic and resistance training intervention and unlike in the other RCTs, control group was not entirely inactive, but followed low-intensity physical activity and relaxation program 60 min once a week, which was designed so that it would not effect the end points of the study. They argued that it is more acceptable to the participants of the control group to carry out some exercise training program, because exercise training studies cannot be blinded. However, they reported positive effects on the prevalence of the MetS among the control group and the test group. Many parameters of the MetS slightly improved in the control group, including WC, TG and HDL-C. Systolic and diastolic blood pressure significantly reduced also in the control group. These results indicate that any amount and any intensity exercise is better than none for overweight or obese adults with metabolic risk factors.

The amount recommended in 2008 Physical Activity guidelines for Americans and in The Finnish Current Care guidelines (U.S. Department of Health and Human Services 2008, 21-22, Liikunta 2008) appears to be enough for preventing and reducing the risk factors of the MetS on overweight and obese persons, but higher amount of more vigorous exercise was shown to have even greater effects (Johnson et al. 2007).

8.7 Future Research

Future research should focus on how professionals could motivate middle-aged overweight and obese women to exercise. The use of different motivational factors, for example, heartbeat monitors, wrist computers and pedometers can motivate some people to exercise. It is evident however, that with structured exercise programs, the exercise is regimented and can be difficult to conduct for many. Less regimented exercise, for example, with pedometer-monitored walking, may lead to better compliance and results. This allows people to fit the exercise into their daily life in longer (>30 min/session) or shorter (10 min/session) bouts (Albright & Thompson 2006).

In the study of Swartz et al. (2003), they tested the usage of pedometer-monitored walking and stated, that the 10,000 steps per day was enough to result in positive effects on glucose tolerance and blood pressure on overweight women. According to Swartz et al. (2003) this result demonstrates that exercise can be accumulated from shorter (10 min/session) bouts throughout the day to gain the same health benefits as with longer exercise sessions and even without weight loss.

Strength of this study is that the data obtained is comprehensive and the number of the subjects is sufficient. The data will be processed in various ways and many articles will be written. It would be beneficial to analyse the obtained data on the correlation between insulin resistance and metabolic abnormalities. As referred earlier in this paper, these two conditions are very often clustered together. Furthermore, the different intervention designs in this study provide a large scale of designs to compare the effects of diet and exercise. Unfortunately, this comparison cannot be made due to between group (EX-WC) differences at the baseline. This is due to the way of randomisation, which was made to protect the most obese subjects from the risk of strain and injuries due to intense exercise.

8.8 Conclusions

It can be concluded that exercise, even with light intensity and practised short-term is beneficial and can be recommended to gain health benefits, without therapeutic weight loss or changes in diet. For reducing the risk factors of metabolic syndrome exercise is more effective than diet. With higher intensity exercise further health benefits are gained.

Adults, regardless of body size or shape, should be encouraged to exercise at least the minimum amount of 30 minutes, which can be accumulated from shorter 10 minutes bouts (Swartz et al. 2003), 5 times per week, moderate-intensity exercise to gain the obesity-independent health benefits of physical activity (Haskell et al. 2007). Furthermore, it is important to develop ways to motivate overweight/obese people to exercise. The case may be that usually overweight and obese people would like to lose weight but are ashamed to participate in group sessions or go to the gym. Motivational factors or wrist computers, similar to the one used in this study can present an opportunity for these people to exercise. The program in the wrist computer can be modified for individual needs and fitness levels. Intensity, duration and frequency of the exercise are programmed and structured and the exercise is regimented which makes it more beneficial and effective. These motivational factors should target gaining health benefits rather than weight loss like the results of this study suggests.

Photo: Marko Kauko

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REFERENCES

Aikuisten lihavuus. Käypä hoito – suositus. Suomalaisen Lääkäriseuran Duodecimin ja Suomen Ortopediayhdistyksen asettama työryhmä. [www-document] 19.03.2006 [Referred 19.04.2010] http://www.kaypahoito.fi/web/kh/suositukset/naytaartikkeli/tunnus/hoi24010#s12

Alberti KGMM, Zimmet P, Shaw J. Metabolic syndrome – a new world-wide definition. A consensus statement from the International Diabetes Federation. Diabet Med 2006;23:469-80.

Albright C, Thompson D. The effectiveness of walking in preventing cardiovascular disease in women: A review of the current literature. J womens health 2006;15(3):271-80.

American College of Sports Medicine (ACSM). ACSM's guidelines for exercise testing and prescription. 7th ed. USA, 2006.

Braun B, Zimmerman MB, Kretchmer N. Effects of exercise intensity on insulin sensitivity in women with non-insulin-dependent diabetes mellitus. J Appl Physiol 1995;78:300-06.

Brill JB, Perry AC, Parker L, Robinson A, Burnett K. Dose-response effect of walking exercise on weight loss. How much is enough? Int J Obes 2002;26:1484-93.

Bonora E, Kiechl S, Willeit J, Oberhollenzer F, Egger G, Targher G, Alberiche M, Bonadonna RC, Muggeo M. Prevalence of insulin resistance in metabolic disorders. The Bruneck Study. Diabetes 1998;47:1643-49.

Carroll S, Dudfield M. What is the relationship between exercise and metabolic abnormalities? A review of the metabolic syndrome. Sports Med 2004;34(6):371-18.

Cerny FJ, Burton HW. Exercise Physiology for Health Care Professionals. USA: Human Kinetics, 2001.

Chen I, Coulston AM, Zhou MY, Hollenbeck CB, Reaven GM. Why do low-fat high-carbohydrate diets accentuate postprandial lipemia in patients with NIDDM? Diabetes Care 1995;18:10-6.

Churilla JR, Zoeller RF Jr. Physical activity: Physical activity and the metabolic syndrome: A review of the evidence. Am J Lifes Med 2008;2(2):118-25.

Church TS, Earnest CP, Morss GM. Field testing of physiological responses associated with Nordic walking. Physiology. RQES. 2002;73(3):296-300.

Eriksson JG. Diabetes. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3rd ed. Helsinki: Duodecim, 2005:438-51.

Executive summary of the Third Report of The National Cholesterol Education Program (NCEP) Expert Panel on detection, evaluation, and treatment of high blood cholesterol In Adults (Adult Treatment Panel III). NIH Publication [www-document] 2001 [Referred 12.05.2009] http://www.nhlbi.nih.gov/guidelines/cholesterol/atp3xsum.pdf

Fogelholm M. Syö ja liiku mielelläsi. Juva: WSOY, 1999.

Fogelholm M, Kaukua J. Lihavuus. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3rd ed. Helsinki: Duodecim, 2005:423-37.

Fogelholm M, Stallknecht B, Van Baak M. ECSS position statement: Exercise and obesity. European J Sport Sci 2006;6(1):15-4.

Gaesser GA. Exercise for prevention and treatment of cardiovascular disease, type 2 diabetes and metabolic syndrome. Curr Diab Rep 2007;7(1):14-9.

Goodpaster BH, Kelley DE, Wing RR, Meier A, Thaete FL. Effects of weight loss on regional fat distribution and insulin sensitivity in obesity. Diabetes 1999;48:839-47.

Haskell WL, Lee IM, Pate RR, Powell KE, Blair SN, Franklin BA, Macera CA, Heath GW, Thompson PD, Bauman A. Physical activity and public health: Updated recommendation for adults from the American College of Sport Medicine and the American Heart Association. Med Sci Sports Exerc 2007;39(8):1423-34.

Heinonen OJ. Liikunnan vaikutus kliinis-kemiallisiin suureisiin. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3rd ed. Helsinki: Duodecim, 2005:130-43.

International Diabetes Federation. IDF Worldwide Definition of the Metabolic Syndrome. [www-document] March 2009 [refered 01.03.2009] http://www.idf.org/metabolic_syndrome

Irving BA, Davis CK, Brock DW, Weltman JY, Swift D, Barrett EJ, Gaesser GA, Weltman A. Effect of exercise training intensity on abdominal visceral fat and body composition. Med Sci Sports Exerc 2008;40(11):1863-72.

Jensen-Urstad M, Jensen-Urstad K. Cardiovascular and peripheral vessel diseases. In Kjaer M, Krogsgaard M, Magnusson P, Engebretsen L, Roos H, Takala T, Savio L-Y W. (eds.) Textbook of sportmedicine: Basic science and clinical aspects of sports injury and physical activity. Blackwell Science, 2003:1-7,397-09.

Johnson JL, Slentz CA, Houmard JA, Samsa GP, Duscha BD, Aiken LB, McCartney JS, Tanner CJ, Kraus WE. Exercise training amount and intensity effects on metabolic syndrome (from studies of a targeted risk reduction intervention through defined exercise). Am J Cardiol 2007;100(12):1759-66.

Karpe F. Mechanisms of postprandial hyperlipidemia remnants and coronary artery disease. Diabet Med 1997;14:S60-6.

Kemmler W, Von Stengel S, Engelke K, kalender WA. Exercise decreases the risk of metabolic syndrome in elderly females. Med Sci Sports Exerc 2009;41(2):297-05.

Keskinen K. Fyysinen kunto ja sen testaaminen. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3 rd ed. Helsinki: Duodecim, 2005:102-19.

Kukkonen-Harjula K, Hiilloskorpi H, Mänttäri A, Pasanen M, Parkkari J, Suni J, Fogelholm M, Laukkanen R. Self-guided brisk walking training with or without poles: randomized-controlled trial in middle-aged women. Scand J Med Sci Sports 2007;17:316-23.

Kukkonen-Harjula K, Rauramaa R. Kohonnut verenpaine. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3 rd ed. Helsinki: Duodecim, 2005:413-21.

Laaksonen D, Uusitupa M. Liikunta, energiankulutus ja ravitsemus. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3 rd ed. Helsinki: Duodecim, 2005:60-76.

Lakka TA, Laaksonen DE. Physical activity in prevention and treatment of the metabolic syndrome. Appl Physiol Nutr Metab 2007;32:76-88.

Liikunta. Käypä hoito – suositus. Suomalaisen Lääkäriseuran Duodecimin ja Suomen Ortopediayhdistyksen asettama työryhmä. [www-document] 9.10.2008 [Referred 01.03.2009]http://www.kaypahoito.fi/kotisivut/sivut.koti?p_sivusto=6&p_navi=36507&p_sivu=36211

Melanson EL, Gozansky WS, Barry DW, MacLean PS, Grunwald GK, Hill JO. When energy balance is maintained, exercise does not induce negative fat balance in lean sedentary, obese sedentary, or lean endurance-trained individuals. J Appl Physiol 2009;107:1847-56.

Murphy M, Nevill A, Neville C, Biddle S, Hardman A. Accumulating brisk walking for fitness, cardiovascular risk and psychological health. Med Sci Sports Exerc 2002;34(9):1468-74.

Ohkawara K, Tanaka S, Miyachi M, Ishikawa-Takata K, Tabata I. A dose-response relation between aerobic exercise and visceral fat reduction: systematic review of clinical trials. Int J Obes 2007;31:1786-97.

Quinn A, Doody C, O'Shea D. The effect of a physical activity education programme on physical activity, fitness, quality of life and attitudes to exercise in obese females. J Sci Med Sport 2008;11:469-72.

Parks EJ, Krauss RM, Christiansen MP, Neese RA, Hellerstein MK. Effects of a low-fat, high-carbohydrate diet on VLDL-triglyceride assembly, production, and clearance. J Clin Invest 1999;104:1087-96.

Rauramaa A. Liikunnan vaikutukset elinjärjestelmittäin. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3 rd ed. Helsinki: Duodecim, 2005:30-54.

Ross R, Dagnone D, Jones PJH, Smith H, Paddags A, Hudson R, Janssen I. Reduction in obesity and related comorbid conditions after diet-induced weight loss and exercise-induced weight loss in men. Ann Intern Med 2000;133(2):92-103.

Shvartz E, Reibold RC. Aerobic fitness norms for males and females aged 6 to 75 years: a review. Aviat Space Environ Med 1990;61:3-11.

Song Y, Manson JAE, Tinker L, Howard B, Kuller LH, Nathan L, Rifai N, Liu S. Insulin sensitivity and insulin secretion determined by homeostasis model assessment (HOMA) and risk of diabetes in a multiethnic cohort of women: The women's health initiative observational study. Diabet care 2007; 30(7):1747-52.

Stefanic ML. Physical activity for preventing and treating obesity-related dyslipoproteinemias. Med Sci sports Exerc 1999;31:S609-18.

Stewart KJ, Bacher AC, Turner K, Lim JG, Hees PS, Shapiro EP, Tayback M, Ouyang P. Exercise and risk factors associated with metabolic syndrome in older adults. Am J Prev Med 2005;28(1):9-18.

Swartz AM, Strath SJ, Basset DR, Moore JB, Redwine BA, Groër M, Thompson D. Increasing daily walking improves glucose tolerance in overweight women. Prev Med 2003;37:356-62.

Tjønna AE, Lee SJ, Rognmo ø, Stølen TO, Bye A, Haram PM, Loennechen JP, Al-Share QY, Skogvoll E, Slørdahl SA, Kemi OJ, Najjar SM, Wisløff U. Aerobic interval training versus continuous moderate exercise as a treatment for the metabolic syndrome. Circulation 2008;118:346-54.

U.S. Department of Health and Human Services (HHS). Physical Activity guidelines for Americans. [www-document] 2008 [Referred January 2009] www.health.gov/paguidelines

Uusitalo A. Keskeisverenkierron patofysiologiaa. In Sovijärvi A, Uusitalo A, Länsimies E, Vuori I. (eds.) Kliininen fysiologia. 1st ed. Jyväskylä: Duodecim, 1994:117-23.

Vuori I. Metabolinen oireyhtymä. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3rd ed. Helsinki: Duodecim, 2005:452-59.

Vuori I. Normaali energia-aineenvaihdunta levossa ja kuormituksessa. In Sovijärvi A, Uusitalo A, Länsimies E, Vuori I. (eds.) Kliininen fysiologia. 1st ed. Jyväskylä: Duodecim, 1994:244-50.

Vuori I. and Andersen L-B. Exercise as disease prevention. In Kjaer M, Krogsgaard M, Magnusson P, Engebretsen L, Roos H, Takala T, Savio L-Y W. (eds.) Textbook of sportmedicine: Basic science and clinical aspects of sports injury and physical activity. Blackwell Science, 2003:315-36.

Vuori I, Kesäniemi V. Sepelvaltimotauti ja sydämen vajaatoiminta. In Vuori I, Taimela S, Kujala U. (eds.) Liikuntalääketiede. 3rd ed. Helsinki: Duodecim, 2005:348-69.

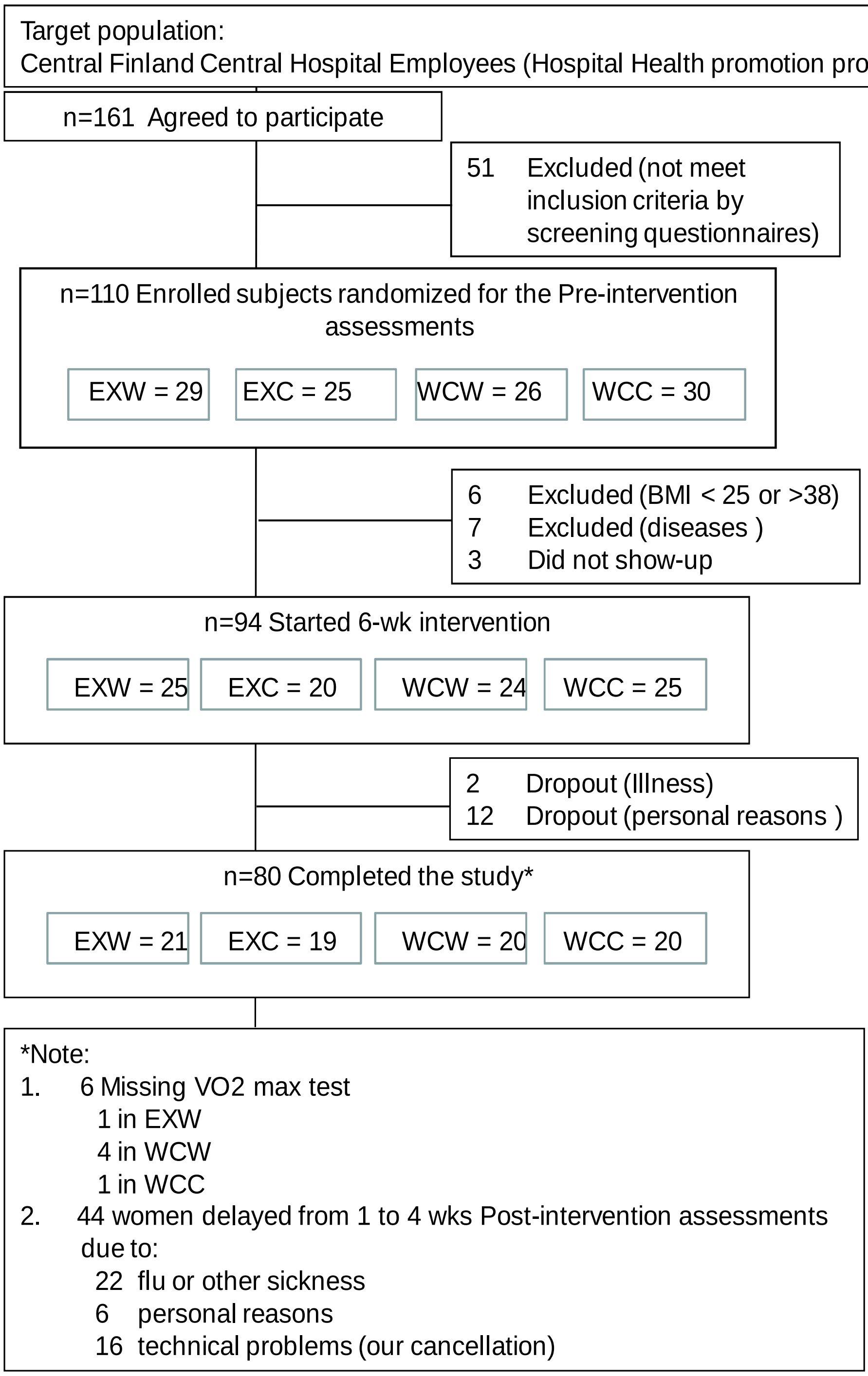
Warburton DER, Whitney Nicol C, Bredin SSD. Health benefits of physical exercise: the evidence. CMAJ 2006;174(6):801-09.

Williams PT. Nonlinear relationship between weekly walking distance and adiposity in 27,596 women. Med Sci Sports Exerc 2005;37(11):1893-01.

Yang X, Telama R, Hirvensalo M, Mattsson N, Viikari JSA, Raitakari OT. The longitudinal effects of physical activity history on metabolic syndrome. Med Sci Sports Exerc 2008;40(8):1424-31.

Appendix 1.

Study profile.



Physical Activity Questionnaire.

Physical Activity class	**Description**
0	No exercise
1	Light exercise (once in two weeks, < 15 min/wk)
2	Light exercise (once in two weeks, < 30 min/wk)
3	Light exercise (once/week, approx. 30 min/wk)
4	Regular exercise (2-3 times/wk, approx. 45 min/wk)
5	Regular exercise (2-3 times/wk, approx. 45-60 min/wk)
6	Regular exercise (2-3 times/wk, approx. 1-3 h/wk)
7	Regular exercise (3-5 times/wk, approx. 3-5 h/wk)
7.5	Regular exercise (3-5 times/wk, approx. 5-7 h/wk)
8	Regular exercise (daily, approx. 7-9 h/wk)
8.5	Regular exercise (daily, approx. 9-11 h/wk)
9	Regular exercise (daily, approx. 11-13 h/wk)
9.5	Regular exercise (daily, approx. 13-15 h/wk)
10	Regular exercise (daily, >15 h/wk)

Finnish Nutrition recommendations for adults targeting weight loss (The Finnish Current Care guidelines, Aikuisten lihavuus 2006).

- Targeting permanent weight loss of 5-10%, 0.5-1kg/week
- Reducing 500-1000 Kcal a day from the diet, so that daily energy intake is approximately 1200-1500 Kcal/day
- Calorie reduction can come from reduced nutrition energy density (less saturated fat and other high energy foods, more fibre rich products, vegetables, fruit ect) or/and eating smaller portion sizes (The plate –model)
- Regular eating rhythm, 5-6 meals/day (every 3-4 hours)
- Products with hidden fat, sucker, salt or white flour are not recommended
- Total Energie Consumption: Carbohydrates 35-58 E%, Protein 15-25 E%, Fat <20 E% (20-30g/d)
- Recommended products: fibre rich foods (whole grain), vegetables, root vegetables, fruits, berries, low fat milk products, low fat meat, fish, chicken, low fat bakery, vegetable oils, light margarine (<40%)
- Recommended drinks: water, sparkling water, light juice, light beverages, coffee, tea (moderate use of alcoholic beverages, favour mild versions)
- Strict fashion diets or regimes are not recommended (Atkins diet)

Classification of VO_2max (maximal oxygen uptake, ml/kg/min) for women according to Shvartz & Reinbold (1990).

Age	1	2	3	4	5	6	7
20-24	< 27	27-31	32-36	37-41	42-46	47-51	>51
25-29	< 26	26-30	31-35	36-40	41-44	45-49	>49
30-34	< 25	25-29	30-33	34-37	38-42	43-46	>46
35-39	< 24	24-27	28-31	32-35	36-40	41-44	>44
40-44	< 22	22-25	26-29	30-33	34-37	38-41	>41
45-49	< 21	21-23	24-27	28-31	32-35	36-38	>38
50-54	< 19	19-22	23-25	26-29	30-32	33-36	>36

Fitness class 1= very poor, 2= poor, 3= fair, 4= average, 5= good, 6= very good and 7= excellent. Cardiovascular fitness compared to individuals of the same gender and age.

Appendix 5.

Exercise intervention following the wrist computer Fitness guidance, ACSM'S guidelines of training progression for the sedentary low-risk* participants (ACSM 2006, table 7-1, 149).

Program Stage	Week	Exercise Frequency (sessions/week)	Exercise Intensity (%HRR)	Exercise Duration (min)
Initial Stage	1	3	40-50	15-20
	2	3-4	40-50	20-25
	3	3-4	50-60	20-25
	4	3-4	50-60	25-30
Improvement Stage	5-7	3-4	60-70	25-30
	8-10	3-4	60-70	30-35
	11-13	3-4	65-75	30-35
	14-16	3-5	65-75	30-35
	17-20	3-5	70-85	35-40
	21-24	3-5	70-85	35-40
Maintenance Stage	24+	3-5	70-85	20-60

*Low-risk: women <55 yrs of age, who are asymptomatic and meet no more than one risk factor threshold (family history of myocardial infarction, coronary revascularization, sudden death, smoking, hypertension, dyslipidemia, impaired fasting glucose, obesity, sedentary lifestyle (ACSM 2006, 22 table 2-2, 27 table 2-4).

Exercise intervention without the wrist computer, ASCM'S 2007 exercise recommendations for adults (ACSM 2006, 139).

	Week 1	**Weeks 2-3**	**Weeks 4-5**	**Week 6**
Intensity ($\%HR_{max}$)	60%	65%	70%	75%
Duration (min/session)	60 min	45 min	35 min	30 min
Frquency (times/week)	3	4	4	3