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**The effect of a workplace physical activity intervention program
on musculoskeletal pain and related symptoms in different
body regions in Portuguese workers**

Academic dissertation submitted with the purpose of obtaining a doctoral degree included in the doctoral course in Physical Activity and Health designed by the Research Centre in Physical Activity, Health and Leisure, Faculty of Sports, University of Porto, according to the Law 74/2006 from March 24th.

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Resumo

Os avanços tecnológicos após a revolução industrial tiveram uma influência decisiva na vida e na saúde do ser humano. Os riscos de uma vida sedentária são amplamente conhecidos. A promoção de saúde no local de trabalho concentra-se em fatores que influenciam a saúde e a produtividade dos trabalhadores. A atividade física (AF) em todas as suas configurações (por exemplo, trabalho e lazer) tem sido utilizada como forma de promoção da saúde. De facto, nos últimos 20 anos, o número de programas de promoção da saúde em ambientes de trabalho tem vindo a crescer. Este crescimento pode ser atribuído ao aumento da consciência por parte da entidade empregadora das vantagens de existir programas de promoção de saúde disponíveis para os funcionários. Neste contexto, iniciativas eficazes e bem documentadas para redução de peso, melhoria da capacidade física e redução da dor músculo esquelética são portanto indispensáveis. Intervenções de AF para melhorar a força muscular, flexibilidade, controlo postural e coordenação pode ser particularmente relevante para a prevenção da deterioração osteoarticular nos trabalhadores. O presente estudo deriva de um projeto de estudo sobre atividade física no local de trabalho, que tem como objetivo diminuir a dor músculo-esquelética e sintomas relacionados, aumentar a capacidade para o trabalho e diminuir o absentismo entre os trabalhadores. O estudo de intervenção foi realizado entre novembro de 2010 e setembro de 2011, numa empresa multinacional com fábricas em Portugal. Os 11 meses do estudo incluíram a avaliação preliminar, a seleção do grupo experimental (GE) e controle (GC) e executar o programa de intervenção, com duração de 6 meses. As avaliações foram realizadas no início e no final da intervenção. O número total de funcionários da empresa é aproximadamente 1000, no entanto, apenas 220 foram autorizadas pelo conselho de administração para participar neste estudo para a produção para não ser afetada negativamente. Estes funcionários são caracterizados por executarem um trabalho com tarefas repetitivas, com força moderada e uma grande parte da jornada laboral é executada de pé. Todos os participantes eram trabalhadores a tempo inteiro (40h/semana) e tinham sido contratados pelo menos há seis meses. Assim, 212 concordaram em participar (88 homens, 124 mulheres) na avaliação inicial. Setenta pessoas (33%) concordaram em ser distribuídos aleatoriamente nos grupos de controlo e no experimental. Ficaram distribuídos assim distribuídos, 39 participantes no grupo experimental e 31 participantes no grupo de controlo. O objetivo deste estudo foi verificar o efeito de um programa de intervenção de atividade física no local de trabalho na dor músculo-esquelética e sintomas relacionados em diferentes regiões do corpo em trabalhadores portugueses.

KEYWORDS: ATIVIDADE FISICA; DOR MUSCULO-ESQUELETICA; LOCAL DE TRABALHO; ESTUDO DE INTERVENÇÃO, TRABALHADORES

Abstract

The technological advances after the industrial revolution had a decisive influence in the way of life and human's health. The hazards of a sedentary lifestyle are widely acknowledged. Workplace health promotion (WHP), focuses on factors that influence the health and productivity of workers. Physical activity in all settings (e.g., occupational and leisure time) has been considered to provide similar health-promoting benefits. Indeed, in the last 20 years, the number of health promotion programs in workplace settings has continued to grow. This growth can be attributed to the increased awareness of the advantages of having quality health promotion programs available for employees. In this context, effective, well-documented initiatives for reducing weight, improving physical capacity, and reducing musculoskeletal pain among workers are, therefore, needed. PA interventions to improve muscle strength, stretch and improve postural control such as coordination training may be particularly relevant for preventing osteoarticular deterioration in workers.

The present study derives from a research project on Physical Activity at the workplace, which is aimed to decrease physical disability, indicated by musculoskeletal pain and related symptoms, increase work ability, and decrease sickness absence among workers with high physical work demands.

The intervention study was conducted between November 2010 and September 2011, in a multinational manufacturing company with offices in Portugal. The 11 months of the study included preliminary evaluation, selection of the experimental (EG) and the control group (CG), and executing the intervention program that lasted six months. Evaluations were performed at baseline and at the end of the intervention. The total number of employees in the company is around 1000; however, only 220 were allowed by the administration board to participate in this study for the production flow to not be adversely affected. These employees are characterized by having repetitive work with moderate force demanding tasks and a large amount of standing. Moreover, all the participants were full-time workers (40h/week) and had been employed in the company for at least six months. Thus, 212 agreed to participate (88 men; 124 women) in baseline evaluations. In this study population gender did not play a significant role. Seventy of those (33%) agreed to be randomly assigned to EG or CG. There were thirty-nine participants in the EG and 31 participants in the CG.

The aim of this study was to verify the effect of a workplace physical activity intervention program on musculoskeletal pain and related symptoms in different body regions in Portuguese workers.

KEYWORDS: PHYSICAL ACTIVITY; MUSCULOSKELETAL PAIN; WORKPLACE; INTERVENTION STUDY, WORKERS

List of abbreviations

PA - Physical Activity

MSD – Musculoskeletal Disorders

WHO - World Health Organization

BLS - Bureau Labour Statistics

BMI - Body Mass Index

INE - National Institute of Statistics

NMQ - Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms

IPAQ – International Physical Activity Questionnaire

WHP - Workplace health promotion

ICF - International Classification of Functioning, Disability and Health

EG – Experimental Group

CG - Control Group

BF - Body Fat

General Introduction

According to new estimates by the International Labour Office, the number of job-related accidents and illnesses, which annually claim more than two million lives, appears to be rising due to the rapid industrialization in some developing countries. The most common workplace illnesses are cancers from exposure to hazardous substances, musculoskeletal diseases, respiratory diseases, hearing loss, circulatory diseases and communicable diseases caused by exposure to pathogens (WHO, 2001).

In accordance with to the *European Foundation of Living and Working Conditions*, Portugal is the third country in European Union with more absenteeism causing by musculoskeletal disorders (MSDs) and related symptoms (Giaccone & Bucalossi, 2008).

The *World Health Organization* (WHO) characterizes the injuries related to work as multifactorial diseases because they involve a broad range of different causes and risk factors, such as, ergonomics, work organization, workplace environment, physical, psychological and social changes (WHO, 1995).

Musculoskeletal health represents not only specific disorders, but also the continuum of normal and abnormal age-related physiological modifications in muscle, bone, and joint function, in addition to fitness-related performance capacity concerning strength, mobility, and bend over muscle mass. MSDs are injuries or dysfunctions affecting muscles, bones, nerves, tendons, ligaments, joints, cartilages and spinal discs. MSDs include sprains, strains, tears and connective tissue injuries (Bureau of Labor Statistics Occupational Safety and Health, 2002, 2012).

Epidemiological studies show a multifactorial model of risk for MSDs (Ramadan & Ferreira, 2006), highlighting the contributions of:

1. risk factors associated with work or occupational risk factors, often little valued by organizations and responsible for health workers (Ramadan & Ferreira, 2006);
2. risk factors relating to the individual or individual susceptibility, also called co-risk factors (Ramadan & Ferreira, 2006);

3. risk factors organizational/psychosocial context of work, although they are also professionals risk factors, are often put in perspective as separate "classics" factors professionals (Serranheira, 2007).

Individual factors include gender, age, anthropometric characteristics (weight, height, among other), health status, diseases (e.g., cardiovascular diseases, diabetes, among other) and unhealthy lifestyles (e.g., smoking, alcohol intake, among other). It is noteworthy that behind the risk that anthropometric characteristics, particularly weight status, have on the development of MSDs, they are also associated with several other complex diseases (e.g., type 2 diabetes, hypertension, cardiovascular diseases). In some instances, obesity and workplace risks (e.g., organizational factors and hazardous exposures) may be related (Paul A. Schulte et al., 2007).

Some studies demonstrate that excessive body weight is related with an increased risk for musculoskeletal pain (Han T.S. et al., 1997), sick leave and early retirement from the workforce, causing high socioeconomic costs (Christensen et al., 2011; Tunceli, 2006; Verweij, 2011). Obesity is also associated with negative consequences in working populations, including more frequent absenteeism, workplace injury and disability pension claims, and higher health care costs (Jennifer et al., 2012).

Employers may be motivated to make changes due to concerns about quality or cost of employee health care (Osilla K., 2012), and worksites may be in a unique position to develop resources and promote social support among co-workers for obesity preventive behaviours (Samuel TW, 2003). Environmental changes that make conceptual sense for obesity prevention include targeting food service (i.e. availability of energy-dense foods, portion sizes, cost), the physical environment (e.g. opportunities for exercise), and information distributed to increase knowledge of behaviours related to obesity risk (French SA, 2001; Hill J.O. et al., 2003).

Exercise and multidisciplinary interventions have a positive effect on the prevention of some MSDs, and comprehensive treatment interventions seem to have an effect on sick leave, costs and prevention of new episodes of MSDs (Tveito et al., 2004).

In this context, effective, well-documented initiatives for reducing weight, improving physical capacity, and reducing musculoskeletal pain among

workers are, therefore, needed (Christensen et al., 2011; Miranda, 2001; Tunceli, 2006). In 2003, a comprehensive study focusing on the economic return of Work Health Program (WHP) concluded that health workplace programs may achieve up to a 25-30% reduction in medical and absenteeism costs in an average period of about 3.6 years (WHO, 2008).

PA interventions to improve muscle strength, stretch and improve postural control such as coordination training may be particularly relevant for preventing osteoarticular deterioration in workers (Marie B. Jorgensen et al., 2011).

There is some evidence for the effectiveness of Physical Activity (PA) programs with focused on strengthening exercises in reducing work-related MSDs. There is also a growing interest in, and use of, stretching exercises to reduce the risk of work-related MSDs. However, little is known about the specific outcomes of stretching programs (Costa & Ramos V., 2008).

Companies invest in employee health based on the acknowledged that the health problems of employees have direct costs related to the treatment of the injury, but also with the consequent decrease of productivity the company's during the absence of the worker. Furthermore, it is common when the employee returns to work, does not produce as before and retires early (Mhurchu, 2010).

The prevention of MSDs may be established by a set of procedures that consistently reduce the likelihood of job/role and working conditions/environment act as factors favourable to this set of disorders (Serranheira, 2007). Two of the strategies used in the prevention of MSDs are the ergonomic and (PA), each contributing in fundamental ways.

In this context, labour PA has specific objectives for individuals and employers, which are:

- For the individual - to improve functionality, physical endurance, muscle strength, joint mobility and self-image, to reduce localized pain, depression and social isolation; to correct poor posture, increase bone density, self-esteem, maintain autonomy, relieve stress.
- For the employer – to increase productivity; to improve the institutional image, and to reduce turnover, absenteeism and medical costs. It appears that there are advantages in adopting active lifestyles, both at individual and professional/employment (Conn et al., 2009).

It can be said that the PA is a positive factor that may trigger the resolution of some of the current companies' problems (Pronk & Kottke, 2009).

Purpose of the Study

The general purpose of this study was to verify the effect of a workplace PA intervention program on musculoskeletal pain and related symptoms in different body regions in Portuguese workers.

To reach this general objective, specific goals were drawn which led to the following original papers:

Paper I – Moreira-Silva, I.; Teixeira, Pedro M.; Santos, R.; Abreu, S.; Moreira, C.; Mota J.

A Systematic Review and Meta-analysis of the effect of Workplace Physical Activity Programs in musculoskeletal pain. [submitted – under review]

Paper II – Moreira-Silva, I; Santos, R., Abreu, S. & Mota, J. (2013)

Associations between Body Mass Index and musculoskeletal pain and related symptoms in Different Body Regions among Workers [SAGE OPEN 2013 3: 1-6]

Paper III - Moreira-Silva, I; Santos, R., Abreu, S. & Mota, J. (2013)

The effect of a Physical Activity program on decreasing physical disability indicated by musculoskeletal pain and related symptoms among workers: a pilot study. [International Journal of Occupational Safety and Ergonomics - Epub ahead of print]

The present dissertation is organized into four chapters. Chapter 1 provides a broad theoretical background. Chapter 2 is the experimental work, which includes the papers published or submitted to peer-reviewed scientific journals. An overall discussion is presented in Chapter 3, and in Chapter 4, the main

conclusions of the present thesis and perspectives for future research are presented.

Chapter 1

Background

According to the *European Foundation of Living and Working Conditions*, Portugal is the third country in European Union with more absenteeism causing by MSDs and related symptoms (Giaccone & Bucalossi, 2008). According to Serranheira (2007), the limited data available in Portugal reported by the National Centre for Protection Against Occupational Hazards, reveals a gradual increase in the number of cases of MSDs and the consequent increase in absenteeism and also the use of Portuguese health care system and health insurance companies by workers.

The technological advances after the industrial revolution had a decisive influence in the way of life and human's health. For instance, the division of labour in sectors and the consequent "obligation" of the worker to perform tasks repetitively during the work day or stay for long periods of time in a posture that causes pain or physical discomfort. Then appears the MSDs, covering an extensive range of diseases which have been mentioned in the working world (Serranheira, 2007).

The WHO characterizes the injuries related to work has multifactorial diseases because they involve a broad range of different causes and risk factors, such as, ergonomics, work organization, workplace environment, physical, psychological and social changes (WHO, 1995).

Workplace hazards continue to have a large burden on society in terms of morbidity, mortality, and financial and social costs which provides justification to health work promotion (Paul A. Schulte et al., 2007).

It is also known that MSD's related to work are a major cause of disability in working age individuals (Christensen et al., 2011; Verweij, 2009). In this context, musculoskeletal health represents not only specific disorders, but also the continuum of normal and abnormal age-related physiological modifications in muscle, bone, and joint function, in addition to fitness-related performance capacity concerning strength, mobility, and bend over muscle mass. MSDs are injuries or dysfunctions affecting muscles, bones, nerves, tendons, ligaments, joints, cartilages and spinal discs. MSDs include sprains, strains, tears and

connective tissue injuries (Bureau of Labor Statistics Occupational Safety and Health, 2002, 2012).

The MSDs include medical conditions which are characterized by symptoms that often include localized pain or radiating, paresthesias a feeling of heaviness, fatigue (or discomfort) located given body segment and feeling or complete loss of strength (Kuorinka, 1987). In some clinical situations that evolve chronicity may also arise edema and allodynia (Serranheira, 2007).

MSDs include pathologic cases, such as, back and neck pain, carpal tunnel syndrome, hernia, or musculoskeletal system and connective tissue diseases or disorders. Some of the latter can be tendinitis, when the event or exposure leading to the injury or illness is physical reaction/bending, climbing, crawling, reaching, twisting, overexertion or movement repetition (Bureau of Labor Statistics Occupational Safety and Health, 2002, 2012).

Concerning musculoskeletal functioning and pain symptoms among the working population the prevalence of subjective complaints is high in the Nordic European countries: 35% reported low back pain, , 32% neck pain, 22% pain in the upper back and 21% pain in their feet and 3% reported pain in the arms/shoulders (Eriksen et al., 1998). According to the National Institute of Statistics (INE) of Portugal, back and neck pain are the main health problems (18.9%) concerning musculoskeletal functioning and pain symptoms among the working population. There are some other body regions reported such as feet (8.6%) and the arms and hands (6.8%). It is also estimated that musculoskeletal problems amounted 35.3% of the workers' health related problems (Instituto Nacional de Estatística, 2012).

Neck and back pain problems are experienced by a majority of people in industrialized countries; only a relatively small number go on to develop long term pain and disability. However, the 5% to 10% who developed persistent problems reported for the mainstream of the expenses in the form of health care utilization and compensation for lost work, as well as, for considerable suffering due to the pain and reduced function (Sjögren, 2006).

According to the Bureau Labour Statistics (BLS), sprains and strains, most often involving the back, accounted for 43% of injuries and illnesses were resulting in over 600 thousands days away from work. When sprains and strains, bruises and contusions, cuts and lacerations, and fractures are

combined, they accounted for nearly two-thirds of the cases with days away from work (Bureau of Labor Statistics Occupational Safety and Health, 2002).

In this context, it is imperative to evaluate injuries, functionality and health of working individuals. This evaluation can be done by questionnaires, physical diagnostic tests and diagnostic laboratory tests. It is very common for clinical assessment and researches the use of self-administered questionnaires. The accessibility and constant use of valid and reliable questionnaires in different languages facilitates the compilation of reliable data in international multicentre studies. The *Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms* (NMQ) is one of the most commonly used questionnaires to assess MSD's. NMQ consists of 27 binary choice questions (yes or no). The questionnaire has three questions correlating to nine anatomic regions (neck, shoulders, wrists/hands, upper back, low back, hips/thighs, knees, ankles/feet). The first question is "had some troubles or pain in the last 12 months", the second is "in the last 12 months felt some limitation caused by work in the daily activities", and the third is "had some troubles or pain in the last 7 days". According to the original author of the questionnaire, for "troubles" we must understand pain, discomfort or aching (Kuorinka, 1987). In the sense of facilitating the identification of the corporal areas, the questionnaire also includes a corporal diagram detaching all of the involved corporal areas (Kuorinka, 1987).

The WHO created a form of assessing Human functionality, disability and health designated "The International Classification of Functioning, Disability and Health", recognized more commonly known as ICF. This is a classification of health and health-related domains. These domains are classified from body, individual and societal perspectives by means of two lists: a list of body functions and structure, and a list of domains of activity and participation. Since an individual's functioning and disability occurs in a context, the ICF also includes a list of environmental factors, as it can be see it in the figure 2 (WHO, 2001):

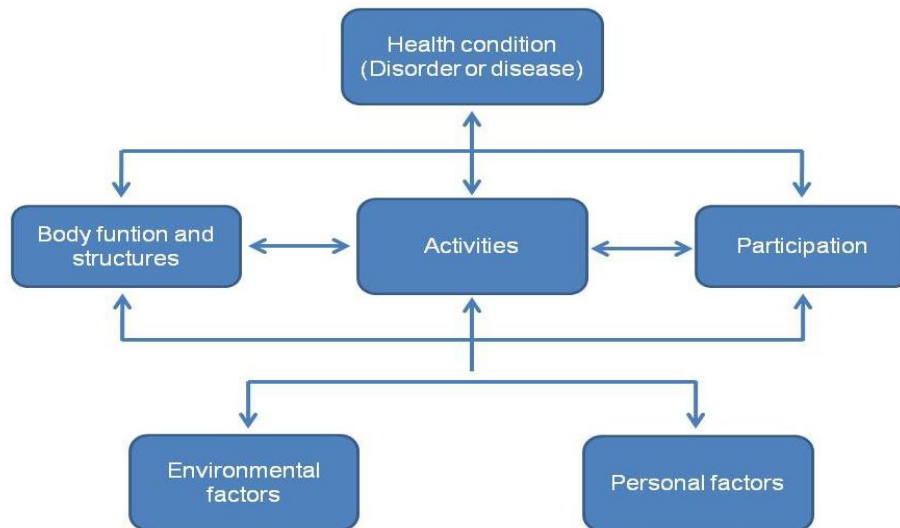


Figure 1 - International classification of Functioning Disability and Health (ICF) model (Adapted from WHO)

Epidemiological studies show a multifactorial model of risk for MSDs (Ramadan & Ferreira, 2006; Serranheira, 2007), highlighting the contributions of:

1. risk factors associated with work or occupational risk factors, often little valued by organizations and responsible for health workers;
2. risk factors relating to the individual or individual susceptibility, also called co-risk factors;
3. risk factors organizational/psychosocial context of work, although they are also professional risk factors, are often put in perspective as separate "classic" professional factors.

Thus, labour risk factors like strength application and carrying heavy loads, shocks and impacts, repetitive movements, static postures or repeated in the limit range of motion, contact with vibrating tools, extreme temperature (particularly, cold), oversteering movements and high repetition or forces can overload the tissues and exceed their threshold of tolerable stress, resulting in MSDs. Maintenance of static exertion for prolonged time compresses veins and capillaries inside the muscles, may cause micro-lesions due to the absence of oxygenation and nutrition. All of these factors can cause imbalance, fatigue, discomfort and pain due to disruption of tissues (Costa & Ramos V., 2008)

In addition, organizational/psychosocial factors such as rhythms of intense work, monotony of tasks, time pressure, style of leadership, performance

evaluation, productivity requirements, working by objectives should be also considered (Serranheira, 2007).

Finally, the individual factors like gender, age, anthropometric characteristics (weight, height, among other), health status, diseases (e.g., cardiovascular diseases, diabetes, among other) and unhealthy lifestyles (e.g., smoking, alcohol intake, may also be involved in the risk of MSD's). It is noteworthy that behind the risk that anthropometric characteristics, particularly weight status, have on the development of MSDs, they are also associated with several complex diseases (e.g., type 2 diabetes, hypertension, cardiovascular diseases). In some instances, obesity and workplace risks (e.g., organizational factors and hazardous exposures) may be related (Paul A. Schulte et al., 2007).

Obesity can be defined as an excess of body fat, at the same time as overweight is an excess of body mass. (WHO, 1995).

Body Mass Index (BMI) is frequent used in epidemiological studies as an indicator of overweight and obesity and it is calculated from weight and height [weight (kg)/height² (m)]. Body weight is also correlated with muscle and lean mass, BMI tends to be correlated with muscle and lean mass, as well, and may be correlated with height (Flegal & Ogden, 2011). Accordingly, two people with the same amount of body fat can have quite different BMIs (Lobstein et al., 2004).

Other measures often used in epidemiological studies include the measurement of weight-for-height, waist circumference and skinfold thicken. Skinfold thickness uses simple equipment and has the ability to determine total body fat and regional fat distribution. However, in very obese individuals, measurement of skinfold thickness is more difficult (WHO, 1995). Bioelectrical impedance analysis is not strictly a direct measure of body composition, being based on the principle that, relative to water, lean tissue has a higher electrical conductivity and lower impedance than fatty tissue because of its electrolyte content. Bioelectrical impedance has been shown to be better correlated with body fat than BMI (Tyrrell et al., 2001).

More accurate and precise methods are available to directly measure total body fat, including underwater weighing, magnetic resonance imaging, computerized tomography, dual energy x-ray absorptiometry and air-displacement plethysmography, but these methods cannot be feasibly applied in large epidemiological studies because they are complex, time-consuming and expensive. In contrast, such methods are used predominantly for research and in tertiary care settings, and as a 'gold standard' to validate indirect measures of body fatness.

Obesity arises from complex social and biological phenomenon, but is often perceived as the result of an individual's behaviour. Overweight and obesity are one of the world's most challenging public health problems (WHO, 2003). The prevalence of overweight has reached epidemic proportions in most Western countries, including Portugal (Carreira et al., 2012). In Portugal, about two thirds of the adult population aged 18 and older, are overweight or obese (Sardinha et al., 2012). Overweight and obesity rates are high among employed adults and have shown a consistent increase over the past few decades (Dam et al., 2006; Snijder et al., 2004). They are well documented to be associated with major chronic illnesses, including hypertension, diabetes, arthritis, heart diseases, cancer and all causing mortality (Christensen et al., 2011; Dam et al., 2006; Jennifer et al., 2012). Several studies have linked obesity with MSDs, the repetitive work can contribute significantly to the increase of MSDs especially in obese workers (Christensen et al., 2011; Miranda, 2001; Tunceli, 2006; Verweij, 2009) ((Paul A. Schulte et al., 2007): According to the study of Verweij, 2009, that consisted of an individual and an environmental component. The individual component included recommendations for occupational physicians on how to promote PA and healthy dietary behaviour based on principles of motivational interviewing. The environmental component contained an obesogenic environment assessment tool. The guideline was evaluated in a randomised controlled trial among 20 occupational physicians. Occupational physicians in the intervention group apply the guideline to eligible workers during 6 months. Occupational physicians in the control group provide care as usual. Measurements take place at baseline and 6, 12, and 18 months thereafter. Primary outcome measures included waist circumference, daily PA and dietary behaviour. Secondary

outcome measures included sedentary behaviour, determinants of behaviour change, body weight and body mass index, cardiovascular disease risk profile, and quality of life. Additionally, productivity, absenteeism, and cost-effectiveness were assessed. In this study the authors concluded that improving workers' daily physical activity and dietary behaviour may prevent weight gain and subsequently improves workers' health, increases productivity, and reduces absenteeism (Verweij, 2009).

Obesity is associated with negative consequences in working populations, including more frequent absenteeism, workplace injury and disability pension claims, and higher health care costs (Jennifer et al., 2012). Some studies demonstrate that excessive body weight was related with the increase the risk for musculoskeletal pain (Han T.S. et al., 1997), sick leave and early retirement from the workforce, causing high socioeconomic costs (Christensen et al., 2011; Tunceli, 2006; Verweij, 2011).

It is known that employed adults spend approximately half of waking time at work, therefore worksites provide a logical setting in which the environment might be reshaped to promote healthier behaviours and improve weight control. Employers may be motivated to make changes due to concerns about quality or cost of employee health care (Osilla K., 2012), and worksites may be in a unique position to develop resources and promote social support among co-workers for obesity preventive behaviours (Samuel TW, 2003). Environmental changes that make conceptual sense for obesity prevention include targeting food service (i.e. availability of energy-dense foods, portion sizes, cost), the physical environment (e.g. opportunities for exercise), and information distributed to increase knowledge of behaviours related to obesity risk (French SA, 2001; Hill J.O. et al., 2003).

It seems imperative from public health perspective, based on effective well-documented initiatives for reducing weight that improving physical capacity and reducing musculoskeletal pain among health care workers are therefore needed.

In adults, the hazards of a lifestyle with low PA levels are widely acknowledged. (Gilson et al., 2009).

Physical Activity Guideline for all adults emphasise that adults should do at least 150 minutes (2 hours and 30 minutes) a week of moderate-intensity, or 75 minutes (1 hour and 15 minutes) a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate- and vigorous-intensity aerobic activity. Aerobic activity should be performed in episodes of at least 10 minutes, and preferably, it should be spread throughout the week.

For additional and more extensive health benefits, adults should increase their aerobic physical activity to 300 minutes (5 hours) a week of moderate-intensity, or 150 minutes a week of vigorous-intensity aerobic physical activity, or an equivalent combination of moderate-and vigorous-intensity activity. Additional health benefits are gained by engaging in physical activity beyond this amount.

Adults should also do muscle-strengthening activities that are moderate or high intensity and involve all major muscle groups on 2 or more days a week, as these activities provide additional health benefits (Centers for Disease Control and Prevention, 2013; U.S. Department of Health & Human Services, 2008).

In occupational environment physical load is influenced by the task, environment, tools and devices, and by personal characteristics. Awkward, repeated and prolonged postures, overstretching movements, high repetition or forces can overload the tissues and exceed their threshold of tolerable stress, resulting in musculoskeletal pain and related symptoms (Costa & Ramos V., 2008).

Workplace health promotion (WHP) focuses on factors that influence the health and productivity of workers (Goetzel RZ, 2008). PA in all settings (e.g., occupational and leisure time) has been considered to provide similar health-promoting benefits (Andreas Holtermann, 2010). In sequence to analyse the relationships between these factors, it is important to define some concepts. PA is defined as any physical movement produced by a contraction of skeletal muscle that substantially increases energy expenditure.

Portugal, among 15 member states of the European Union was the country with the lowest prevalence of PA in leisure time (40.7%) (Martinez-Gonzalez MA et al., 2001) and the sixth country with the highest prevalence of “high physical activity” (33.1%) when also considering professional, domestic,

and transport domains (Sjostrom M. et al., 2006) Nevertheless, according to public physical activity recommendations for adults (Baptista et al., 2012).

The total energy expenditure in activity includes the resting metabolic rate and the cost of the activity itself. The dose of PA, or exercise, is described by frequency, duration, intensity and type of activity. Frequency is described as the number of activity sessions per time period (e.g., day or week). Duration refers to the number of minutes of activity in each session. Intensity describes, in relative or absolute terms, the measured or estimated efforts associated with the PA (Howley, 2001; Sjögren et al., 2006).

Acute effects to responses of PA or exercise refer to health related changes that occur during and in the hours after PA. Chronic effects associated with PA or exercise occurs over time due to changes in the structures or functions of various body systems, independent of acute effects or responses. Acute responses to exercise and chronic adaptations to exercise cannot be viewed in isolation because the frequent repetition of isolated sessions with transient responses produces more permanent adaptations (i.e., chronic effect or responses) (Sjögren et al., 2006).

International recommendations for health-promoting PA do not distinguish between occupational and leisure-time PA (Centers for Disease Control and Prevention, 2013; Frenk-Poli, 2011).

Workplace health programs have demonstrated improvements in the leading global risk factors for chronic disease, which has led to their increasing role in chronic disease prevention (Osilla K., 2012). Indeed, in the last 20 years, the number of health promotion programs in workplace settings has continued to grow (Yujie Wang, 2010). This growth can be attributed to the increased awareness of the advantages of having quality health promotion programs available for employees (Yujie Wang, 2010). Companies believe that these programs can reduce employee health care and disability costs, staff renewal rate, aid in recruiting new workers, enhance the company image and improve employee productivity (WHO, 2008). Skilled employees who are well compensated, have pleasant work environments, and enjoy their work can still have low productivity when they are absent from work because of poor health (WHO, 2008).

Musculoskeletal symptoms rates are high among employed adults and have shown a consistent increase over the past few decade (Dam et al., 2006; Miranda, 2001).

Exercise and multidisciplinary interventions have a positive effect on the prevention of some MSDs, and comprehensive treatment interventions have an effect on sick leave, costs and prevention of new episodes of MSDs (Tveito et al., 2004).

In this context, effective, well-documented initiatives for reducing weight, improving physical capacity, and reducing musculoskeletal pain among workers are, therefore, needed (Christensen et al., 2011; Miranda, 2001; Tunceli, 2006). In 2003, a comprehensive study focusing on the economic return of WHP concluded that health workplace programs achieve a 25-30% reduction in medical and absenteeism costs in an average period of about 3.6 years (WHO, 2008).

Several interventions are proposed to reduce work-related MSDs rate, including work adjustments, re-engineering type modifications, training in ergonomic principles, exercise programs and smoking cessation campaigns (Costa & Ramos V., 2008).

PA interventions to improve muscle strength, stretch and improve postural control such as coordination training may be particularly relevant for preventing osteoarticular deterioration in workers (Marie B. Jorgensen et al., 2011).

There is some evidence for the effectiveness of PA programs with centre of attention on strengthening exercises in reducing work-related MSDs. There is also a growing interest in, and use of, stretching exercises to reduce the risk of work-related MSDs. However, little is known about the specific outcomes of stretching programs (Costa & Ramos V., 2008).

Companies invest in employee health by finds that the health problems of employees had costs directly related to the treatment of the injury, but also with the consequent decrease in productivity of the company during the absence. Furthermore, it is common when the employee return to work, does not produce as before and retires early (Mhurchu, 2010).

The prevention of MSDs is, among other aspects by establishing a set of procedures that consistently reduce the likelihood of job/role and working

conditions/environment act as factors favourable to this set of disorders (Serranheira, 2007).

Two of the strategies used in the prevention of MSDs are the ergonomic and PA, each contributing in fundamental ways.

In this context, labour PA has specific objectives for individuals and employers, which are:

- For the individual - improve functionality, physical endurance, muscle strength, joint mobility and self-image, reduce localized pain, depression and social isolation, correct poor posture, increase bone density, self-esteem, maintain autonomy, relieve stress.
- For the employer - increase productivity, improve the institutional image, and reduce turnover, absenteeism and medical costs.

It appears that there are advantages in adopting active lifestyles, both at individual and professional/employment (Conn et al., 2009).

It can be said that the PA is a positive factor to be relevant in resolving some issues currently experienced by companies.

There are several protocols in the literature for labour PA programs, according to Pronk & Kottke (2009) may consist of stretching and flexibility exercises, 10-minute sessions daily supervised in the workplace, before, during or after the workday (Pronk & Kottke, 2009)

Several studies of efficacy of PA programs in the workplace were considered. Were examined articles with comparison groups that assessed PA, health-related behaviours, healthcare cost, and absenteeism articles were included if they had a control or other comparison group and evaluated outcomes of comprehensive worksite wellness programs (ie, multiple wellness components focused on health promotion or disease prevention).

Were extracted type of intervention, setting, and research design from each study. Programs and worksites were classified by type, size, and industry.

In some studies such as Kietrys, 2005 investigated the effectiveness of PA programs in the workplace with respect to work-related outcomes. This randomized control trial assessed adherence, pain and satisfaction after 4 weeks of at-work exercise. Subjects ($n = 72$) were randomized into 3 groups: resistance exercise, stretching, and control. Exercise frequency was similar

across the 3 groups (median = 1.5 times per day). There was a significant difference between groups on the assessment item related to discomfort. The resistance and stretching group differed from the control group with regard to their perception that the exercises were helpful in reducing discomfort in the back and neck ($p < 0.001$). With this study the authors concluded that most subjects found the resistance and the stretching exercises easy to do, performed them 1 to 2 times daily, and reduced discomfort (David M. Kietrysa et al., 2005).

Table 1 shows the characteristics of the 20 intervention studies that examined the association between PA programs and musculoskeletal pain. All studies explored this association and reported local pain as their outcome measure, while few reported regular breaks (van den Heuvel et al., 2003) and trapezius myalgia (Ahlgren et al., 2001; Andersen, Jørgensen, et al., 2008), sum dissatisfaction with work related (Horneij et al., 2001) and/or absenteeism (Kellett et al., 1991; Mongini et al., 2008; Tveito & Eriksen, 2009) as their outcome. Nineteen of the 20 studies reported a protective association, while 1 reported no significant association between PA and/or health programs and musculoskeletal pain (Tveito & Eriksen, 2009) .

Table 1 – Characteristics and outcome measures of intervention studies examining the association between PA programs and musculoskeletal pain.

References	Study details	Intervention details	Outcome measures	Main findings
Donchin, M. et al., (1990)	N=142 hospital employees Mean age: CAL=45.2; BS=48.0; CONTROL=44.9 years Duration of the intervention=1 year	Participants were randomly assigned to one of the 3 groups: a calisthenics program (CAL) for 3 months with 2 times/week sessions of flexion exercises, a back school program (5 sessions) and the control group.	Annual rate of recurrent low back pain (LBP) Trunk forward flexion and abdominal muscle strength	A monthly surveillance for the whole year showed a mean of 4.5 "painful months" in the CAL group versus 7.3, and 7.4 months in the school back and control group, respectively. The superiority of the CAL group was achieved partly because of the significant increase in trunk flexion and to initial increment in abdominal muscle strength.
Kellett, K. et al., (1991)	Exercise group: n =58 Control group: n =53 Mean age = 41 years old (intervention group); 42 years old (control group) Duration of the intervention= 18months	Exercise program: Coordination exercises were included throughout the session. The session ended with a "warm-down" and specific stretching exercises. Additional exercise and Cardiovascular fitness, 1 hour per week during working period for six months.	Back pain Cardiovascular fitness	This study has shown that a weekly exercise program has resulted in a reduction of sick leave for people with relatively short (<50 days) episodes of back pain. The majority of patients who develop chronic back pain have previously had repeated short episodes of back pain. This study demonstrated that it is possible to reduce sick leave by 50%; therefore, it is probable that the number of patients developing chronic back pain can also be reduced.
Grønningseter, H. et al. (1992)	N=76 Age range= 25-67 years old Duration of the intervention= 10 weeks	Self-report questionnaires concerning job stress, job satisfaction and trait anxiety. The procedure was repeated for the POST test in December, following the train were filled out by each subject alone and returned the day after. An aerobic training session, lasting for 55 minutes, was given two times/day (The programmes aimed at improving physical capacity, muscle strength, flexibility, and relaxation of neck, back and shoulder muscles. Level and intensity were modified to meet the capability of each individual and the particular group. The exercise was dynamic and rhythmical at moderate intensity.) Stress Management Training. A cognitive behavioural stress management programme was offered to the second group, concurrently during the day, with the same frequency and duration as the physical exercise programme (55 mind3 per week). The control group was not offered any programme during the study, but was promised participation in an exercise programme after three months.	Aerobic capacity Well-being Muscle pain Job Satisfaction	Aerobic exercise resulted in significantly increased aerobic capacity. Improved feelings of well-being and significantly decreased complaints of muscle pain. Inliers were no changes in anxiety and job stress reports. But job satisfaction was significantly reduced. Stress management training resulted in improved coping ability. No significant changes in somatic or psychological health. No unspecific treatment effects were observed across groups

Table 1 – continued.

References	Study details	Intervention details	Outcome measures	Main findings
Gundewall, B. et al., (1993)	N=58 nurses Age range: 18-58 years old Duration of the intervention=13 months	The subjects were randomized into 2 groups: 1 group was allowed to exercise during working hours to improve back muscle strength, endurance and coordination (during 13 months) The control group did not participate in the exercise program and received no further advice or information.	Back muscle strength Back muscle endurance Coordination Low Back Pain recorded as the number of days with complaints Number of working days lost due to work-related back problems	After 13 months the intervention group had increased back muscle strength. The back pain complaints and intensity of back pain in the training group also decreases. Every hour spent by a physiotherapist on the training group reduced the work absence among participants by 1.3 days, resulting in a cost/benefit ratio greater than 10.
Genaid, M et al., (1995)	N= 28 Age: not reported Duration of the intervention=4 weeks	Each employee was instructed as follows: (1) determining the frequency and length of each break based on your perceived discomfort; (2) Stop working when you perceive discomfort in any body part, then resume work when you feel reasonable recovery from the previous working cycle; (3) During the breaks, you will be asked to perform a set of stretching exercises and following ergonomic guideline: frequent and short breaks help reduce the discomfort perceived during the course of the workday.	Discomfort perceived on the job Musculoskeletal capability	Active micro breaks significantly reduced the level of discomfort perceived by employees during the course of the working day. The subjective ratings of perceived discomfort correlated significantly with anthropometric, strength and background information. The physical characteristics of meatpacking employees were significantly lower than those reported in the literature for employees engaged in manual handling tasks.
Haldorsen, E. et al., (1998;)	n=459 Mean age = 43 years old Duration of the intervention= 4 weeks	Patients were recruited through the National Insurance System. After a pre-test by an independent physiotherapist the patients were allocated at random to the intervention group (n=312) or the control group (n=157). The MMBCT program lasted for 4 weeks. The control group returned to their general practitioners, without any feedback or advice on therapy from the project. At the one year follow-up the MMBCT group had not returned to work at a higher rate than the control group receiving ordinary treatment available through their general practitioners.	Musculoskeletal pain	The MMBCT group had improved their ergonomic behaviour, work potential, life quality, physical, and psychological health.

Table 1 – continued.

References	Study details	Intervention details	Outcome measures	Main findings
Lundblad, I. et al, (1999)	N= 97 female industrial workers Mean age = 33 ±9 years old Duration of the intervention= 16 weeks	The Group-based Physiotherapy Intervention (PT-group) was based upon the clinical practice of the physiotherapists at the occupational health service. The intervention was performed for 50 minutes twice a week in groups of 5 to 8 subjects during the 16 weeks of intervention. The Feldenkrais Intervention (F-group) had as aims the increased body awareness, coordination, and control. The Feldenkrais intervention includes a certain pedagogic approach, which has been labelled somatic education that emphasises learning based on the experience of the individual subject. In consequence, the terms "instructor" and "student" are used instead of "therapist" and "patient." The intervention was done individually four times and in a group (7 to 8 subjects per group) 12 times. In the Control Regime (C-group) no intervention was made for the subjects randomized to this group.	Complaints from: Neck Shoulders (prevalence, pain intensity, sick leave, and disability in leisure and work roles)	The intervention was associated with significant positive changes in the complaints from the neck and shoulders (i.e., the neck-shoulders-index) while tendencies to worsening was found for the C-group. Neck and shoulders complaints in the previous 7 days decreased significantly in the F-group. The PT- and C-groups generally had higher prevalence of complaint for the other prevalence periods. Neck complaints in the previous 7 days increased in the two other groups, while shoulder complaints in the previous 7 days were unchanged. The changes in sick leave were not significantly different across groups but in the intervention groups, sick leave tended to decrease while the opposite tendency was found in the C-group. The study showed significant positive changes in complaints after the intervention but not after the physiotherapy intervention
Linton, S. et al (2001)	n=253 Aged to 35-45 years old Duration of the intervention= 30 days. 1 year follow-up	Participants had experienced four or more episodes of relatively intense spinal pain during the past year but had not been out of work more than 30 days. Participants were randomly assigned to either a cognitive behavioural group intervention or a treatment as usual comparison group. The experimental group received a standardized six-session program, provided by a trained therapist according to a manual.	Neck pain Back pain	Despite the strong natural recovery rate for back pain, the cognitive-behavioural intervention produced a significant preventive effect with regard to disability.
Ahlgren, C. et al, (2001)	n= 102 women Mean age = 38 years Duration of the intervention= one-hour sessions, three times a week for ten weeks.	Women were randomized to strength, endurance, co-ordination and non-training groups. Strength training group Endurance training group. Co-ordination training group Non-training group. All group activities were performed during working hours, except for subjects in shift work for which training sessions could occur during leisure time. All training sessions started with a 15-min warming up, followed by 40 min of specific exercises. Strength and endurance training sessions ended with stretching of exercised muscles while training sessions for the body awareness group ended with a 5 min verbal summary of individual experiences.	Trapezius myalgia	The study indicates that regular exercises with strength, endurance or co-ordination training of neck/shoulder muscles might alleviate pain for women with work-related trapezius myalgia.

Table 1 – continued.

References	Study details	Intervention details	Outcome measures	Main findings
Horneij, E. et al, (2001)	n = 282 Aged to 24-60 years old Duration of follow-up= 12 and 18 months.	Female nursing aides and assistant nurses working in the home-care services, were randomly assigned to one of three groups for: (1) individually designed physical training programme (exercises were individually adapted and individual goals were formulated), (2) work-place stress management, (3) control group (participants were requested to live as usual)	Musculoskeletal disorders Neck, shoulder and back pain Pain-drawing	The results revealed no significant differences between the three groups. However, improvements in low back pain were registered within both intervention groups for up to 18 months. Perceived physical exertion at work was reduced in the physical training group. Improvements in neck and shoulder pain did not differ within the three groups. Dissatisfaction with work-related, psychosocial factors was generally increased in all groups.
Larson, K. et al, (2002)	n=249 Mean age 21 years old Duration of the intervention = 10 months	Were randomized into two groups. After randomization, 65 conscripts dropped out for administrative reasons, leaving 249 conscripts to participate fully in the study. Data were collected through questionnaires at the start of military duty and after 10 months. All conscripts in the intervention group had one 40-minute theoretical lesson on back problems and ergonomics and had to perform passive prone extensions of the back daily during the rest of their military duty. The control group had no intervention.	Back problems	It's possible reduce the prevalence rate of back problems and the use of health care services during military service, at a low cost, using passive prone extensions of the back motivated by a back school approach, including the theory of the disc as a pain generator and ergonomic instructions.
Heuvel, V. et al, (2003)	n= 268 Aged to 18 and 50 years old Duration of the intervention= 8-week	Computer workers with complaints in the neck or an upper limb from 22 office locations were randomized into a control group, one intervention group stimulated to take extra breaks and one intervention group stimulated by a software program to perform exercises during the extra breaks during an 8-week period.	Neck and upper-limb disorders Sick leave Productivity	The use of a software program stimulating workers to take regular breaks contributes to perceived recovery from neck or upper-limb complaints. There seems to be no additional effects from performing physical exercises during these breaks.
Maul, I. et al, (2005)	n= 183 Mean age = 38±8 years old (intervention group) and 39±10 years old (control group) Duration of the intervention= three months	183 hospital employees with chronic low back pain (LBP) were randomly assigned either to back school (Comparison group), or three months supervised physical training including a back school (exercise group). Various measurements of functional ability were performed and subjects completed questionnaires on self-rated pain, disability, and general well-being before treatment, immediately after intervention, and at 6 months follow-up. At one-year and at ten-years follow-up participants evaluated treatment effectiveness.	Low back pain.	Supervised physical training effectively improved functional capacity and decreased LBP and disability up to one-year follow-up. The subject's positive evaluation of the treatment effect at ten-year follow-up suggests a long-term benefit of training.

Table 1 – continued.

References	Study details	Intervention details	Outcome measures	Main findings
Sjogrena, T. et al, (2005)	n=53 (43 women and 10 men) Mean age = 47.1 years old Duration of the intervention= 15 weeks	The cross-over design consisted of physical exercise intervention (15 weeks) and no intervention (15 weeks). The subjects (n=53) were office workers who reported headache (n=41) symptoms in the neck (n=37) or shoulders (n=41), which had restricted their daily activities during the last 12 months. Pain symptoms were measured using the Borg CR10 scale and muscular strength with a 5RM test.	Headache Intensity of symptoms in the neck and shoulders Extension and flexion strength of the upper extremities	Physical exercise intervention resulted in a slight, but statistically significant, decrease in the intensity of headache and neck symptoms, as well as an increase in the extension strength of the upper extremities. The intervention had no effect on the intensity of shoulder symptoms or the flexion strength of the upper extremities. Specific exercise may be clinically important to alleviate headache and neck symptoms.
Sjogrena, T. et al, (2006)	n = 36 Mean age = 47.1 years old Duration of the intervention= 15 weeks	The subjects were office workers, who self-reported low back symptoms, which restricted their daily activities during the last 12 months. Low back symptoms were measured using the Borg CR10 scale. The cross-overdesign consisted of one intervention period of light resistance training and guidance and no training and no guidance of 15 weeks duration.	Intensity of low back symptoms	The active component of the intervention, light resistance training, resulted in a slight, but statistically significant, decrease in the intensity of low back symptoms ($p = 0.020$). At the average training time of 5 minutes per working day (25 min/week) the average decrease during the 15-week period. A physical exercise intervention, which included daily light resistance training, conducted during the working day affected low back symptoms in a positive direction among symptomatic office workers.
Andersen, L. et al, (2008)	n=48 Aged to 45-49 years old Duration of the intervention=10 weeks	Were recruited subjects from 7 workplaces characterized by monotonous jobs (e.g., computer-intensive work). Forty-eight employed women with chronic neck muscle pain (defined as a clinical diagnosis of trapezius myalgia). Participants were randomly assigned to 10 weeks of specific strength training locally for the affected muscle, general fitness training performed as leg bicycling with relaxed shoulders, or a reference intervention without physical activity.	Neck muscle pain	A decrease of 35 mm ($_79\%$; $P < 0.001$) in the worst VAS pain score over a 10-week period was seen with specific strength training, whereas an acute and transient decrease in pain (5 mm; $P < 0.05$) was found with general fitness training. Specific strength training had high clinical relevance and led to marked prolonged relief in neck muscle pain. General fitness training showed only a small yet statistically significant acute pain reduction.

Table 1 – continued.

References	Study details	Intervention details	Outcome measures	Main findings
Andersen, L., et al, (2008)	Were done 3 groups: specific resistance training (SRT, n = 180), all-round physical exercise (APE, n = 187), and reference intervention (REF, n = 182) Aged to 45-49 years old Duration of the intervention= 1 year	Physical tests were performed and questionnaires answered at pre-, mid- and post intervention. The main outcome measures were compliance, changes in maximal muscle strength, and changes in intensity of neck/shoulder pain (scale 0–9) in those with and without pain at baseline.	Neck/shoulder pain in office workers	Compliance was highest in SRT but generally decreased over time. SRT and APE caused increased shoulder elevation strength, were more effective than REF to decrease neck pain among those with symptoms at baseline, and prevent development of shoulder pain in those without symptoms at baseline.
Mongini, F., et al (2008)	n = 192 study group and 192 control group Aged to 35-53 years old Duration of the intervention= 8months	Study group: educational and physical programme. The primary end-point was the change in frequency of headache and neck and shoulder pain expressed as the number of days per month with Pain. The number of days of analgesic drug consumption was also recorded. Diaries completed for the whole 8 months were available for 169 subjects in the study group and 175 controls.	Neck and shoulder pain	This study suggests that an educational and physical programme reduces headache and neck and shoulder pain in a working community.
(Tveito & Eriksen, 2009)	n = 40 Age= not reported Duration of the intervention= 9 months	The intervention group participated in an Integrated Health Programme twice weekly during working hours. The programme consisted of physical exercise, stress management training, health information and an examination of the participants' workplace. The control group was offered the same intervention after the project was finished.	Reduce sick leave Subjective health complaints	There were no statistically significant effects on sick leave or health related quality of life. The intervention group reported fewer neck complaints compared to the control group, but otherwise there were no effects on subjective health complaints. The subjective effects were large and highly statistically significant, the intervention group reporting improvement in health, physical fitness, muscle pain, stress management, maintenance of health and work situation. The Integrated Health Programme was not effective in reducing sick leave and subjective health complaints, but may be of use to employers wanting to increase employee job satisfaction and well-being.

Table 1 – continued.

References	Study details	Intervention details	Outcome measures	Main findings
Hartnel, N. et al.(2012)	n = 59 Mean age 44.8 years old Duration of the intervention= 8 weeks	Participants were recruited from a British local government authority and randomized into a yoga group who received one 50 min Dru Yoga session each week for 8 weeks and a 20 min DVD for home practice and a control group who received no intervention. Baseline and end-programme measurements of self-reported stress, back pain and psychological well-being were assessed with the Perceived Stress Scale, Roland Morris Disability Questionnaire and the Positive and Negative Affect Scale.	Stress Back pain at work	The results indicate that a workplace yoga intervention can reduce perceived stress and back pain and improve psychological well-being. Larger randomized controlled trials are needed to determine the broader efficacy of yoga for improving workplace productivity and reducing sickness absence.
CAL- calisthenics program; BS- Back school; LBP- low back pain; MMCBT multimodal cognitive behavioural treatment; SRT - specific resistance training; APE- all-round physical exercise; REF- reference intervention;				

Chapter 2

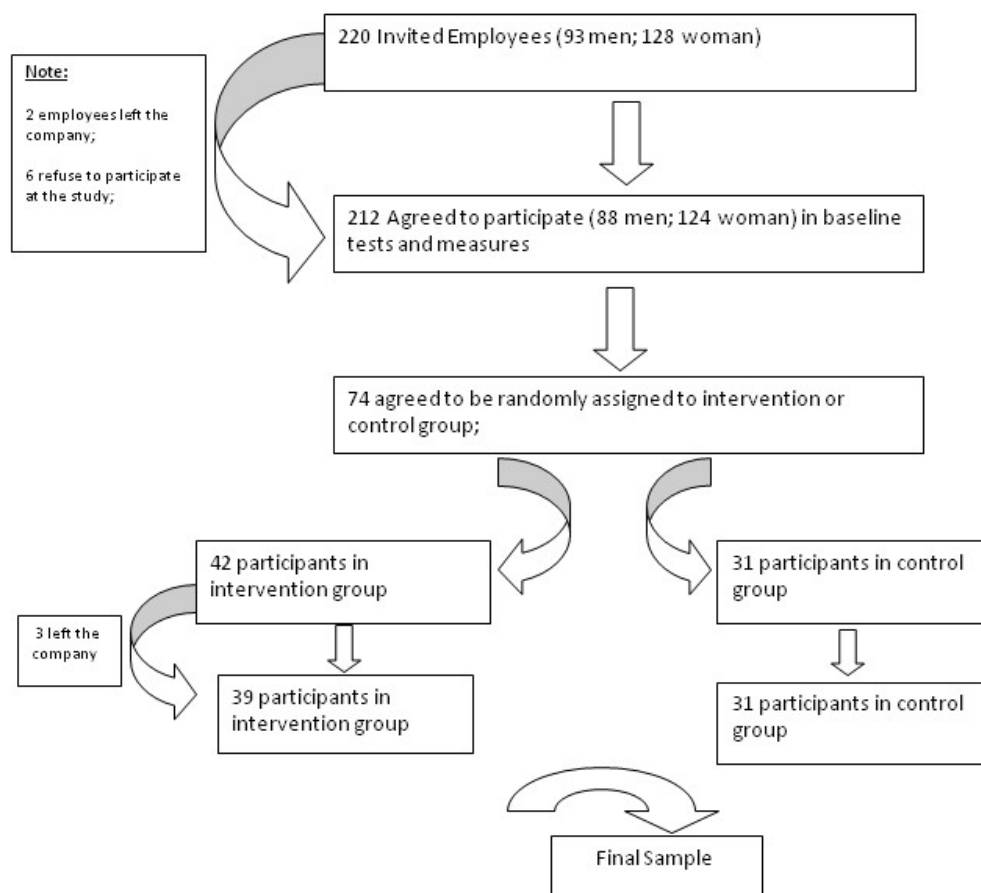
Experimental work

This study began by carrying out several introductory The present study derives from a research project on Physical Activity at the workplace, which is aimed to decrease physical disability, indicated by musculoskeletal pain and related symptoms, increase work ability, and decrease sickness absence among workers with high physical work demands.

The intervention study was conducted between November 2010 and September 2011, in a multinational manufacturing company with offices in Portugal. The 11 months of the study included preliminary evaluation, selection of the experimental (EG) and the control group (CG), and executing the intervention program that lasted six months. Evaluations were performed at baseline and at the end of the intervention.

Meetings regarding the project with the administration board, the medical department, the production department, the human resources department, and the workers. The total number of employees in the company is around 1000; however, only 220 were allowed by the administration board to participate in this study for the production flow to not be adversely affected. These employees are characterized by having repetitive work with moderate force demanding tasks and a large amount of standing. Moreover, all the participants were full-time workers (40h/week) and had been employed in the company for at least six months.

Thus, at the beginning of this intervention, 220 employees were invited (93 men; 128 women) to participate. From those, 212 agreed to participate (88 men; 124 women) in baseline evaluations. In this study population gender did not play a significant role. Seventy of those (33%) agreed to be randomly assigned to EG or CG. There were thirty-nine participants in the EG and 31 participants in the CG, as can be observed in the flowchart (Figure 2).



Groups were created based on the management of working teams, day and evening/night shifts. This approach was chosen to avoid contamination between the intervention and the reference group. The aim was to increase compliance and to facilitate the necessary practical arrangement at the workplace. It was, therefore, decided to integrate the intervention into work time. A cluster formation of the groups was performed to assure equal allocation in the intervention. The randomization was done by an external research group, which had no knowledge of the work place or the participants. All participants in this study were informed of its goals and provided written informed consent to participate. The study was approved by the Faculty of Sport, University of Porto Ethics Committee; it was conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies.

Intervention program

The intervention lasted six months. The training sessions were given during work time. The EG consisted of one training group with their own

instructor. The aim was to create a close-knit team spirit, which would hopefully help prevent dropouts. The same instructor gave all the trainings during the six months.

The physical training consisted of 10-15 minutes of physical exercise training three times a week and focused on stretching exercises to decrease some muscular tension in some body regions, specifically the hands, wrists, elbows, shoulders, neck, dorsal, and lumbar regions in order to maintain physical capacity. Other exercises of general strength were also included and consisted of exercises for abdominal and lower extremities (i.e., thigh, hip, knees, ankle, and feet). Participants took home strength and stretching training program, picturing these exercises and were encouraged to perform them at home. In addition to the brief training sessions, participants were orally encouraged in all training sessions to initiate aerobic leisure time exercises such as biking, walking, running, or attending different sports in the local area.

Anthropometric measures

Body height was measured to the nearest millimeter in bare or stocking feet with the participant standing upright against a stadiometer (Holtain Ltd., Crymmych, Pembrokeshire, UK). Weight was measured to the nearest 0.10 kg, lightly dressed using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan). BMI was calculated from the ratio between body weight (kg) and body height (m^2). Participants were categorized as non-overweight, overweight and obese, applying the cut-off points suggested by the World Health Organization (WHO, 2000).

Percentage of body fat (%BF) was measured using a bio impedance scale (Tanita Inner Scan BC 532, Tokyo, Japan), which was set to 'standard' while body frame and the participant's age, height and gender were entered.

Waist circumference was measured twice, with a non-elastic metal anthropometric tape, midway between the lower rib margin and the iliac crest at the end of normal expiration (Lohman TG, 1988). The average of the two measures was used for analysis. If the two measurements differed by more than one cm, a third measurement was taken and the two closest measurements were averaged.

Blood pressure

Blood pressure was measured in a seated position after 10 minutes of rest with an electronic blood pressure monitoring device (OSZ 5 Easy Welch Allyn) on the left arm. Three measurements were done one minute apart and an average calculated (Stevens VJ et al., 2001).

Socio-demographic variables

Participants answered a questionnaire that assessed several socio-demographic variables (age, marital status, etc.).

Physical activity

Physical activity was assessed using the short version of the International Physical Activity Questionnaire (IPAQ) (Craig et al., 2003). Validity and reliability data from 12 countries (including Portugal) show IPAQ has comparable validity and reliability to CSA monitor and to other self-reported measures of PA (International Physical Activity Questionnaire, 2005). According to the Guidelines for data Processing and Analysis of the IPAQ, total PA was expressed as metabolic equivalent (MET) minutes/week by weighting the reported minutes per week in each activity category by the metabolic equivalent specific to each activity (Total PA = 3.3 MET x walking minutes x walking days + 4.0 MET x moderate-intensity activity minutes x moderate days + 8.0 MET x vigorous-intensity activity minutes x vigorous-intensity days). Physical activity was expressed as minutes per week by summing the time spent in moderate physical activity and vigorous physical activity (MVPA).

Musculoskeletal disorders and related symptoms

Musculoskeletal pain and related symptoms was assessed by the *Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms*. (NMQ) (Kuorinka, 1987), supplemented with questions about localized pain intensity. This questionnaire has been validated to the Portuguese population (Mesquita C. et al., 2010). The NMQ consists of 27 binary choice questions (yes or no). The questionnaire has three questions correlating to nine anatomic regions (neck, shoulders, wrists/hands, lumbar region, dorsal region, hips/thighs, knees, and ankles/feet). The first is “had some troubles or pain in the last 12 months,” the second is “in the last 12

months felt some limitation caused by work in the daily activities,” and the third is “had some troubles or pain in the last 7 days.” In the sense of facilitating the identification of the corporal areas, the questionnaire also includes a corporal diagram detaching all of the involved corporal areas(Kuorinka, 1987). The pain intensity in the “last 7 days,” included the numeric pain scale (scale 0-10).

Paper 1 – Moreira-Silva, I.; Teixeira, Pedro M.; Santos, R.; Abreu, S.; Moreira, C.; Mota J.

A Systematic Review and Meta-analysis of the effect of Workplace Physical Activity Programs in musculoskeletal pain. [submitted – under review]

The effects of Workplace Physical Activity Programs in musculoskeletal pain: A systematic review and meta-analysis

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Keywords: physical activity; musculoskeletal pain; workers; Systematic Review and Meta-analysis

Abstract

Objectives: To review the effectiveness of Physical Activity (PA) interventions in the workplace to reduce musculoskeletal pain in employees and assess the effect size of these programs with meta-analysis.

Methods: Four databases (PubMed, EBSCO, Web of Science, and Cochrane) were searched for trials among employees for the period of January 1990 and March 2013, which included comparison groups that assessed physical activity programs, musculoskeletal pain and health-related behaviours. We examined articles with comparison groups that assessed Physical Activity programs, musculoskeletal pain and health-related behaviours.

Results: The meta-analysis estimates of standardised mean differences (Hedges g) present significant evidence of pain decrease in intervention groups in studies of general pain $g = -.40$ with a 95% Confidence Interval ranging from -0.78 to -0.02 and in neck and shoulder pain $g = -.37$ with a 95% Confidence

Interval ranging from -0.63 to -0.12. The few studies covering low back pain and arms, elbows, wrists, hands or fingers pain do not present sufficient statistical significant evidence.

Conclusion: There is consistent evidence that workplace PA interventions significantly reduce general musculoskeletal pain and neck and shoulders pain. More studies are required to provide clarification of the effectiveness of work related PA interventions in arms, elbows, wrists, hands or fingers and low back pain.

INTRODUCTION

Technological advances after the Industrial Revolution had a decisive influence on the way of life and human health. The division of labour in sectors and the consequent "obligation" of the worker to perform a task repetitively during the work day or stay for long periods of time in a posture causes pain, physical discomfort and musculoskeletal disorders (MSDs). The *World Health Organization* (WHO) characterizes the injuries related to work as multifactorial diseases because they involve a broad of different causes and risk factors, such as: ergonomics, work organization, workplace environment, physical, psychological and social changes (WHO, 1995).

MSDs are injuries or dysfunctions affecting muscles, bones, nerves, tendons, ligaments, joints, cartilages and spinal discs; which include sprains, strains, tears and connective tissue injuries (Bureau of Labor Statistics Occupational Safety and Health, 2002, 2012). In this context musculoskeletal health represents not only specific disorders, but also the continuum of normal and abnormal age-related physiological modifications in muscle, bone, and joint function, in addition to fitness-related performance capacity concerning strength, mobility, and bend over muscle mass.

Concerning musculoskeletal functioning and pain symptoms among the working population the prevalence of subjective complaints is high in the Nordic European countries: 35% reported low back pain, 3% reported pain in the arms/shoulders, 32% reported neck pain, 22% reported pain in the upper back and 21% reported pain in their feet (Eriksen, Svendsrod, Ursin, & Ursin, 1998).

From a public health point of view workplace health promotion (WHP) initiatives are a very important concern (Goetzel RZ, 2008). WHP are designed to promote health by reducing health risks and actively preventing the beginning of disease. They typically include interventions and programs designed to decrease stress, high blood pressure and cholesterol, excess of body weight, smoking and alcohol consumption, improve nutrition, and increase physical activity (PA) and fitness levels. Some of them also offer cancer screening, health risk appraisals, cooking classes and a variety of health education activities. Reviews of the effectiveness of many of these interventions have shown mainly positive results (Ashe, 2012; David M. Kietrysa, Jill S. Galperb, & Vernoc, 2005). Moreover, WHP have demonstrated improvements in the leading global risk factors for chronic disease, which has led to their increasing role in chronic disease prevention (Osilla, 2012). Indeed, in the last 20 years, the number of health promotion programs in workplace settings has continued to grow (Yujie Wang, 2010). This growth can be attributed to the increased awareness of the advantages of having quality health promotion programs available for employees (Yujie Wang, 2010). Therefore companies consider that these programs can reduce employee health care costs, disability, and staff renewal rate; aid in recruiting new workers; enhance the company image; and improve employee productivity (WHO, 2008). Skilled employees who are well compensated, have pleasant work environments, and enjoy their work can still have very low productivity when they are absent from work because of poor health (WHO, 2008).

In the literature there are some well-documented effective initiatives that included diet programs for reducing weight and PA programs for improving physical capacity and reduce musculoskeletal pain among workers (Christensen et al., 2011; Miranda, 2001; Tunceli, 2006). PA interventions improve muscle strength, stretching and postural control such as coordination training which may be particularly relevant for preventing osteoarticular deterioration and musculoskeletal pain in workers (Marie B Jorgensen & Andreas Holtermann, 2011).

PA and multidisciplinary interventions (e.g. diet and ergonomics) seem to have a positive effect on the prevention of some MSDs, and comprehensive treatment interventions seem have an effect on sick leave, costs and

prevention of new episodes of pain and physical discomfort and consequently MSDs (David M. Kietrysa et al., 2005; Gerr et al., 2005; Torill H. Tveito, 2004). It appears that there are advantages in adopting active lifestyles, both at individual and professional/employment (Conn, Hafdahl, Cooper, Brown, & Lusk, 2009).

Generally, health promotion programs are having some success in reducing employee health risks, but changing human lifestyles is really an arduous assignment. (Steven G. Aldana, 2001).

PA intervention programs may have a positive impact both in the perspective of the employee and in the perspective of the employer. Therefore, it is necessary to analyse the effects these programs may have in real workplace settings. Several studies have been developed focusing on workplace interventions based on different health promotion strategies. PA interventions in workplaces may have specific objectives for individuals and employers, namely:

- For the individual - improve functionality, physical endurance, muscle strength, joint mobility and self-image, reduce localized pain, depression and social isolation, correct poor posture, increase bone density, self-esteem, maintain autonomy, relieve stress.
- For the employer - increase productivity, improve the institutional image, and reduce turnover, absenteeism and medical costs.

In this context, the aim of this study was to systematically review the effectiveness of PA interventions in the workplace to reduce musculoskeletal pain in employees and assess the effect size of these programs with meta-analysis.

METHODS

Data Sources and Searches

A literature search was conducted in April 2013 in the following databases: PubMed, EBSCO, Web of Science, and Cochrane for the period of 1990 to 2013. Additionally, articles were identified through reference searches of recent literature reviews. The articles with comparison groups that aimed to decrease

musculoskeletal pain through PA programs were examined. The key words used were (“physical activity”) AND (“work”) AND (“pain”) AND (“trial” OR “random*”). Additionally, the references of some review articles were considered to identify potential interesting studies not found in the electronic search. Citations were entered into the reference management software EndNote, version X6 (Thomson Reuters, Carlsbad, CA, USA).

Study Selection

The titles and abstracts of studies identified in the electronic searches (1675 reports) were examined by two authors (IS and PMT) in order to remove duplicates and irrelevant reports. The first screening based on available full access and duplicates text criteria resulted in 1345 records. Following the criteria for inclusion were titles and abstracts. Four investigators (IMS, PMT, SA and CM) independently evaluated articles for inclusion based on title and abstract review, and then full text review. A fourth investigator (RS or JM) served as tie breaker in case of discrepancy. Studies were included if they had a control or other comparison group and evaluated outcomes of comprehensive worksite wellness programs (i.e., multiple wellness components focused on health promotion or disease and pain prevention). We excluded opinion and theory articles, articles without a comparison group and those written in non-English language. Next, the authors independently reviewed the full-text of 26 reports to identify eligible studies for a meta-analysis.

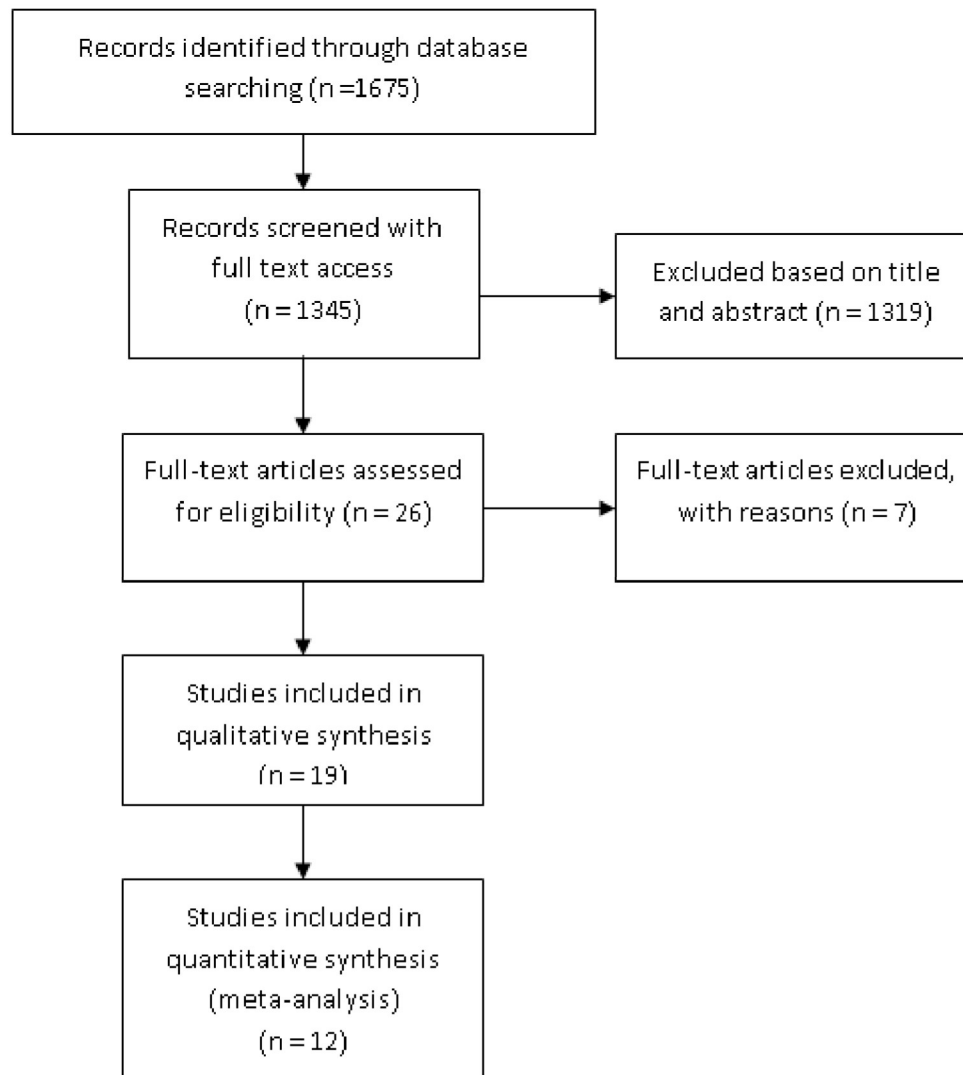


Figure 1: Flowchart of the studies included in the meta-analysis

Data extraction and Quality Assessment

Data extraction was completed using a coding frame to record information on a range of details. We extracted type of intervention, setting, and research design from each study. Programs and worksites were classified by musculoskeletal pain type outcome. The major categories of variables coded included source characteristics (e.g. country, publication year), study design (e.g. number of participants, follow-up length, randomization, and intent-to-treat analysis), sample characteristics (e.g. gender, age, health and/or functional status), intervention (e.g. type, frequency and duration of the interventions), variables and outcome measures (mean differences and standard deviations). The methodological quality of the studies was assessed an adaptation of the Cochrane risk of bias assessment tool (Higgins & Green, 2009). We

categorized the quality of the design in relation to controlled trials with random assignment, prospective studies with non-randomly assigned comparison groups, and observational designs with internal comparison groups (e.g., participants vs. nonparticipants). Assessment of risk of bias in included studies namely: sequence generation, allocation concealment, blinding, incomplete outcome data, and selective outcome reporting is presented in table 1. 'Yes' indicates low risk of bias, 'No' indicates high risk of bias and 'Not Reported' indicates unclear or unknown risk of bias.

Continuous Data

All the outcomes were reported using meaningful scales in all studies; however, they did not use the same scale for the measurement of pain perceptions. Therefore, the chosen effect size (ES) was Hedges g for a standardized mean difference. We combined trials reporting mean final values with trials reporting mean changes. When studies reported both final and change we used the change score to compute g . Accordingly, g was calculated from studies that used independent groups as the difference between treatment group vs. comparison group final value means or the difference between absolute change-from-baseline values. A negative g reflects more favorable outcome scores for intervention groups than for the control group. In some studies, standard deviation was obtained from the standard error (SE) by multiplying SE by the square root of the sample size; confidence intervals for means were also used to calculate standard deviations using studies with multiple treatment groups. Reported results regarding missing individual participants were not imputed, and thus we included data for only those participants whose results were known.

First Author and Publication Year	Was the study population adequately described? (i.e. were the important characteristics of the randomized participants described, e.g. age, gender?)	Was there intention to treat analysis used? (i.e. were all participants who were randomized included in follow-up and analysis?)	Were the participants allocated using random number tables, coin flip, computer generation?(RCT)	Was the randomization process concealed from the investigators?	Was an estimated effect size reported? (e.g. mean difference)	Was precision of effect size estimated? (confidence intervals)	Were summary data presented in sufficient detail to permit alternative analysis or replication?
Ahlgren, 2001*	Y	N	N	NA	N	N	Y
Andersen, 2008*	Y	Y	Y	Y	NR	N	Y
Donchin, 1990	Y	Y	NA	Y	Y	N	N
Genaidy, 1995	Y	Y	NR	Y	N	N	Y
Gronningsaeter, 1992*	Y	Y	NA	Y	Y	N	Y
Gundewall, 1993	Y	Y	NA	Y	Y	N	Y
Haldorsen, 1998	Y	Y	NR	Y	NR	Y	Y
Hartfiel, 2012	Y	Y	NR	Y	NR	Y	Y
Horneij, 2001*	Y	Y	NR	Y	Y	N	Y
Kellett, 1990*	Y	Y	NR	Y	NR	N	Y
Larsen, 2002	Y	Y	NR	Y	NR	N	Y
Linton, 2000	Y	Y	Y	Y	Y	N	Y
Lundblad, 1999*	Y	Y	NR	Y	N	N	Y
Maul, 2005*	Y	Y	Y	Y	NR	N	Y
Mongini, 2008*	Y	Y	NA	NA	N	Y	Y
Sjögren, 2005*	Y	Y	NR	Y	NR	N	Y
Sjögren, 2006*	Y	Y	NR	Y	NR	N	Y
Tveito, 2008*	Y	Y	NR	Y	Y	Y	Y
Van den Heuvel SG, 2003*	Y	Y	Y	Y	Y	Y	Y

Y – yes; N- no; NR – not reported; NA – not applicable

* Included in meta-analysis

Table 1- Characteristics of the studies

Data synthesis and Analysis

The selected studies for the meta-analysis differ in the combinations of participants and in the implementations of interventions and for that reason there may be different effect sizes underlying different studies. Consequently, the outcomes were analysed using a random-effects meta-analysis. We calculated a weighted mean, where the weight assigned to each study is the

inverse of that study's variance. Study weights were assigned with the goal of minimizing both sources of variance, which are more balanced under the random-effects model than under the fixed-effect model. Furthermore, large studies are assigned less relative weight, and small studies are assigned more relative weight as compared with the fixed-effect model. Statistical significance of the results was considered with 95% confidence intervals (CIs). All analyses were conducted with Review Manager (*RevMan*) software Version 5.2.5. (Copenhagen: The Nordic Cochrane Centre).

Assessment of heterogeneity

In order to express informative heterogeneity indices, a measure of both the magnitude and of uncertainty were presented. The measure of uncertainty is given the p value of the Q statistic. Magnitude is represented by both the degree of true variation (the between-studies variance) on the scale of the effect measure T^2 and the degree of inconsistency I^2 that represents the ratio of true heterogeneity to total observed variation. The I^2 statistic expresses the result as a ratio of the proportion of the observed variance that reflects real differences in effect size. Generally, values of 25%, 50% and 75% are considered to be indicative of small, moderate and large amounts of inconsistency, respectively (Higgins & Green, 2009).

RESULTS

The meta-analysis estimate of the standardised mean difference in the studies that consider a measure of general pain is significant in a 95% confidence interval (i.e. -0.78,-0.02). Also, studies that consider measures of neck and shoulder pain present significant evidence of pain decrease in intervention groups (i.e. -0.63,-0.12). The studies covering low back pain and arms, elbows, wrists, hands or fingers pain do not present sufficient statistical evidence ($p>0.05$).

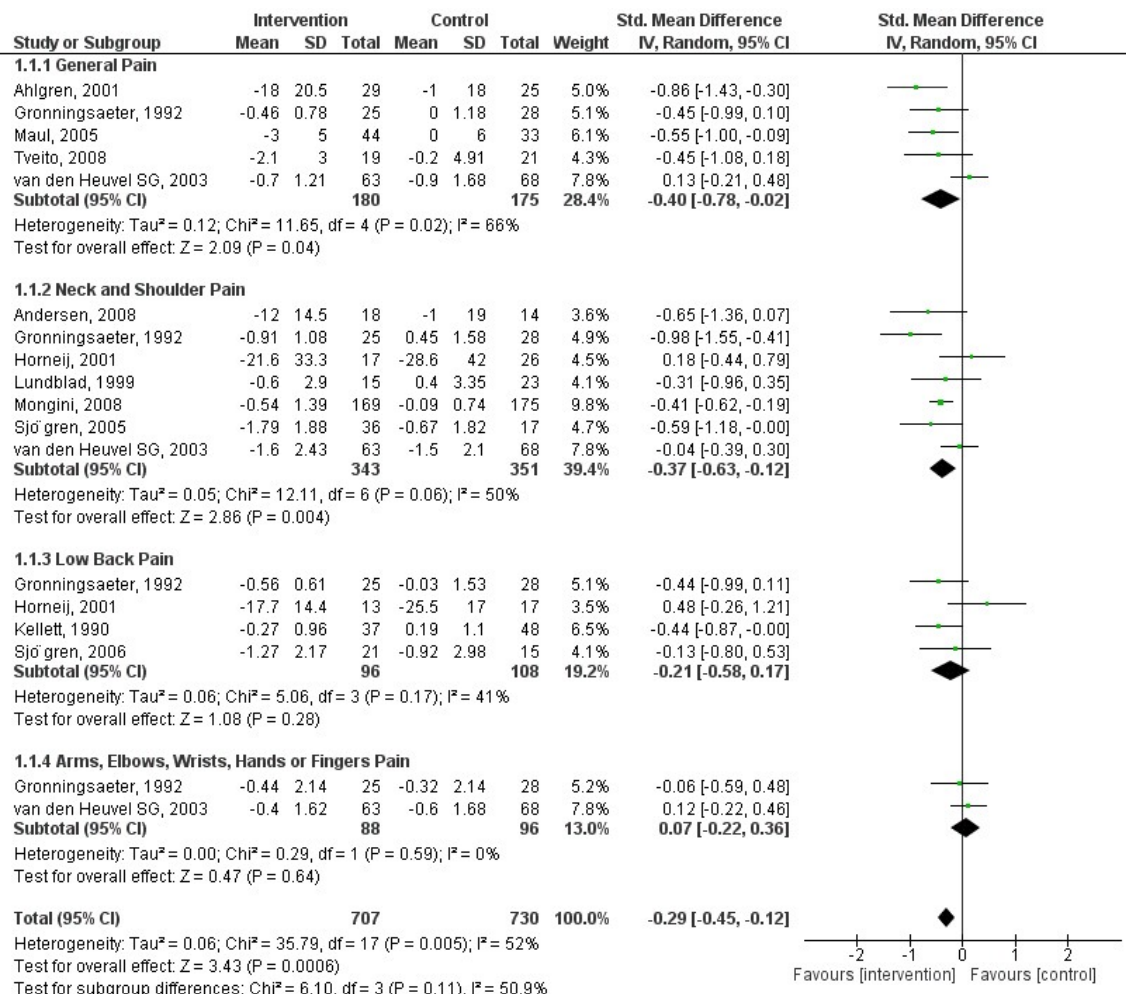


Figure 2: Forest plots PA Intervention programs and Pain

Discussion

In a meta-analysis of twelve studies the findings suggested that there is moderate quality of evidence that workplace PA interventions significantly reduce general musculoskeletal pain and neck and shoulders pain. Additionally, there is low quality of evidence that workplace PA interventions significantly reduce low back and arms, elbows, wrists and hands/fingers pain. These results can be related with the lack of studies. Globally, these results provide evidence favouring PA intervention programs, in labour context, in diminishing self-reported musculoskeletal pain. These findings emphasize the ongoing interest for research in this area and the rationale for this review.

PA and multidisciplinary interventions (e.g. diet and ergonomics) seem to have a positive effect on the prevention of some MSDs, and comprehensive treatment interventions seem have an effect on sick leave, costs and prevention

of new episodes of pain and physical discomfort and consequently MSDs (David M. Kietrysa et al., 2005; Gerr et al., 2005; Torill H. Tveito, 2004). It appears that there are advantages in adopting active lifestyles, both at individual and professional/employment (Conn et al., 2009).

PA intervention is a helpful feature to consider when dealing with some issues currently experienced by companies. However, some evidence suggests that PA interventions in the workplace may not have a significant positive impact in bio psychosocial factors particularly, in reducing musculoskeletal disorders and associated symptoms (i.e. pain). Such results may be influenced by small sample studies and other constraints associated with the implementation of controlled trials to assess health interventions in workplaces. In this context, this review may contribute to evidence based practice of the prevention of MSDs.

Implications for practice

This meta-analytic review showed that interventions focusing on improving workplace PA are moderately effective in reducing musculoskeletal pain of employees.

These effects can be generalized to the worksite setting. However, we were not able to assess differences among subgroups of employees. Nevertheless, the prevention must be considered. The effect of musculoskeletal pain prevention on a population level may be substantial, but the influence and perceptible benefits on the health of generally persons is quite small. For one person to have advantage, many people have to change their behaviour. (Verweij, 2011). Moreover, a public health policy report in the Netherlands determined that a broad implementation of PA in combination with dietary interventions may realistically reduce the prevalence rate of overweight by 1–3 percentage points and the prevalence of inactivity by 1–2 percentage points over 5 years. In this line, it was estimated that 15 000 to 41 000 diabetes cases, 17 000 to 40 000 heart disease cases, and 43 000 to 100 000 musculoskeletal disorders can be prevented during the next 20 years (Wendel-Vos GCW et al., 2005);(Verweij, 2011).

Consequently, these studies support the use of PA interventions, to prevent musculoskeletal pain among workers.

Implications for researchers

The efficacy of workplace PA interventions in achieving small reductions of musculoskeletal pain that was showed in this study seems reasonably credible, and more convincing than in previous reviews. Moreover, when more studies are available, we may find more PA components that contribute to reducing musculoskeletal pain. In addition, better evidence is needed to understand the impact of incentives for program participation, behaviour change, and risk factor reduction. Investigations should also examine the impact of interventions on important worksite-related outcomes that influence worker productivity, including absenteeism, stress levels, and job satisfaction.

Future studies will need to be based on strong evaluation designs, sufficient follow-up, detailed report randomization procedures, blinding procedures, co-intervention and intention-to-treat analysis, in order to gain insight in methodological quality.

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Declarations of interest

The authors declare that no conflict of interest was present.

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Paper II – Moreira-Silva, I; Santos, R., Abreu, S. & Mota, J. (2013)

Associations between Body Mass Index and musculoskeletal pain and related symptoms in Different Body Regions among Workers [SAGE OPEN 2013 3: 1-6]

Associations Between Body Mass Index and Musculoskeletal Pain and Related Symptoms in Different Body Regions Among Workers

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Abstract

Obesity rates are high among employed adults and have shown a consistent increase over the past few decades. Musculoskeletal disorders related to work are a major cause of disability in working individuals. The objective of this study was to verify the associations between weight status and musculoskeletal pain and related symptoms in different body regions among workers. The sample comprised 203 factory workers. Anthropometric measures were assessed with standardized protocols and body mass index (BMI) was calculated. Participants were classified as nonoverweight (BMI ≤ 24.9 kg/m²) or overweight/obese (BMI ≥ 25 kg/m²). Musculoskeletal pain and related symptoms was assessed with the Nordic Questionnaire of Osteoarticular Symptoms. The association of BMI and musculoskeletal pain and related symptoms was analyzed with logistic regression. Overweight/obese participants were more likely to have musculoskeletal pain and related symptoms in the shoulders (odds ratio [OR] = 2.129, $p = .023$). Our results emphasize the need of worksite interventions to promote healthy weight as a way to prevent musculoskeletal pain and related symptoms.

Keywords

musculoskeletal disorders, worksite, body mass index

Introduction

Overweight and obesity are one of the world's most challenging public health problems (World Health Organization [WHO], 2003). The prevalence of overweight has reached epidemic proportions in most Western countries, including Portugal (Carreira, Pereira, Azevedo, & Lunet, 2012).

Overweight and obesity rates are high among employed adults and have shown a consistent increase over the past few decades (Snijder, Visser, Dekker, & Seidell, 2004; van Dam, Willet, Manson, & Hu, 2006). Overweight and obesity are well documented to be associated with major chronic illnesses, including hypertension, diabetes, arthritis, heart diseases, cancer, and all cause mortality (Christensen et al., 2011; Linde et al., 2012; van Dam et al., 2006). Excessive body weight has also been shown to increase the risk for musculoskeletal pain (Han, Schouten, Lean, & Seidell, 1997), sick leave, and early retirement from the workforce, causing high socioeconomic costs (Christensen et al., 2011; Tunceli & Williams, 2006; Verweij, Coffeng, van Mechelen, & Proper, 2011). Obesity is associated with negative consequences in working populations, including more frequent absenteeism, workplace injury and disability pension claims, and higher health care costs (Linde et al., 2012).

It is also known that musculoskeletal disorders related to work are a major cause of disability in working-age individuals (Christensen et al., 2011; Verweij, Proper, Weel, Hulshof, & van Mechelen, 2009). Several studies have linked obesity with musculoskeletal disorders and the repetitive work (Christensen et al., 2011; Miranda, Viikari-Juntura, Martikainen, Takala, & Riihimäki, 2001; Tunceli & Williams, 2006).

As employed adults spend approximately half their waking time at work, worksites provide a logical setting in which the environment might be reshaped to promote healthier behaviors and improve weight control. Employers may be motivated to make changes due to concerns about quality or cost of employee health care (Osilla, 2012), and worksites may be in a unique position to develop resources and promote

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social support among coworkers for obesity preventive behaviors (Samuel, Raleigh, Hower, & Schwartz, 2003). Environmental changes that make conceptual sense for obesity prevention include targeting food service (i.e., availability of energy-dense foods, portion sizes, cost), the physical environment (e.g., opportunities for exercise), and information distributed to increase knowledge of behaviors related to obesity risk (French, Story, & Jeffery, 2001; Hill, Wyatt, Reed, & Peters, 2003).

According to public health perspective, effective well-documented initiatives for reducing weight, improving physical capacity, and reducing musculoskeletal pain among health care workers are therefore needed. Moreover, there is lack of evidence about the association between weight status and musculoskeletal injury in different body regions.

The aim of this study was to verify the associations between weight status and musculoskeletal pain and related symptoms in different body regions among workers.

Method

Study Design and Sampling

The present study derives from a larger research project on Physical Activity at Worksites, which is aimed to decrease physical disability, indicated by musculoskeletal disorders and related symptoms; increase work ability; and decrease sickness absence among workers with high physical work demands.

This study was conducted from November 2010 to September 2011, in a multinational manufacturing appliances company with office in Portugal. These 11 months included preliminary evaluation, selection of experimental group (EG) and control group (CG), the intervention program that lasts 6 months along with tests performed at baseline and at the end of the intervention.

For the purpose of this study, we only use the baseline data and limited the analysis to the variables under the scope of this study.

This study began by carrying out several introductory meetings about the project: the administration board, the medical department, production department, human resources department, as well as, the workers.

At the beginning of this intervention, 221 employees were invited (93 men; 128 women) to participate, from those, 212 agreed to participate (88 men; 124 women) in baseline tests and measures. The employees who did not participate did not significantly differ from those who agreed to participate, with regard to age, gender, and body mass index (BMI; $p > .05$, for all). Some participants were not included in our analysis ($n = 9$) because their weight and height information was missing. Therefore, the final sample comprised 203 participants (82 men; 121 women).

All the participants were full-time workers (40 hr/week) and employed in the company for at least 6 months.

All participants in this study were informed of its goals and provided written informed consent to participate. The study was approved by the Faculty of Sport, University of Porto Ethics Committee; it was conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies.

Anthropometry Measures

Body height was measured to the nearest millimeter in bare or stocking feet with the participant standing upright against a stadiometer (Holtain Ltd., Crymmych, Pembrokeshire, United Kingdom). Weight was measured to the nearest 0.10 kg, lightly dressed using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan). BMI was calculated from the ratio between body weight (kg) and body height (m^2). Participants were categorized as nonoverweight, overweight, and obese, applying the cutoff points suggested by the WHO (2000).

Percentage of body fat (% BF) was estimated using a bio impedance scale (Tanita Inner Scan BC 532, Tokyo, Japan), which was set to "standard" for body frame, and the participant's age, height, and gender were entered.

Waist circumference was measured twice, with a nonelastic metal anthropometric tape, midway between the lower rib margin and the iliac crest at the end of normal expiration (Lohman, Roche, & Martorell, 1988). The average of the two measures was used for analysis. If the two measurements differed by more than 1 cm, a third measurement was taken and the two closest measurements were averaged.

Sociodemographic Variables

Participants answered a questionnaire that assessed several sociodemographic variables (age, marital status, etc.). Participants were divided according to their job position in factory, that is, "white-collars" (skilled occupations) and "blue-collars" (unskilled and manual jobs).

Musculoskeletal Disorders and Related Symptoms

Musculoskeletal pain and related symptoms were assessed by Nordic Questionnaire of Musculoskeletal Disorders (NMQ; Kuorinka et al., 1987), supplemented with questions about localized pain intensity. This questionnaire has been validated to the Portuguese population (Mesquita, Ribeiro, & Moreira, 2010). The NMQ consists of 27 binary choice questions (yes or no). The questionnaire has three questions correlating to nine anatomic regions (neck, shoulders, wrists/hands, lumbar region, dorsal region, hips/thighs, knees, ankles/feet)—"had some troubles or pain in the last 12 months," "in the last 12 months felt some limitation caused by work in the daily activities," and "had some troubles or pain in the last 7 days." In the sense of facilitating the

Table 1. Descriptive Characteristics of the Participants, by Weight Status.

	Total sample (n = 203)	Nonoverweight (n = 80)	Overweight/obese (n = 123)	p value ^{a,b}
Age (years)	37.62 (± 8.27)	34.9 (± 8.2)	39.4 (± 8.0)	<.001
Weight (kg)	73.3 (± 14.7)	62.5 (± 8.6)	80.3 (± 13.5)	<.001
Height (m)	1.65 (± 0.10)	1.66 (± 0.10)	1.64 (± 0.10)	.231
BMI (kg/m ²)	25.72 (± 7.05)	22.6 (± 1.8)	29.6 (± 3.6)	<.001
WC	89.6 (± 12.6)	79.9 (± 8.1)	95.8 (± 10.9)	<.001
% BF	26.8 (± 10.1)	21.3 (± 7.7)	30.4 (± 9.9)	<.001
Gender (%)				
Women	59.6	40	59.3	.926
Men	40.4	60	40.7	
Job position (%)				
Blue-collar	70	60	76.4	.013
White-collar	30	40	23.6	

Note: BMI = body mass index; WC = waist circumference; % BF = % body fat. Data are mean (± standard deviation).

^aAnalysis by *t* test for continuous variables.

^bAnalysis by χ^2 for categorical variables.

identification of the corporal areas, the questionnaire also includes a corporal diagram detaching all of the involved corporal areas (Kuorinka et al., 1987). The pain intensity in the “last 7 days” was included in the numeric pain scale (range = 0–10).

Statistical Analysis

Descriptive characteristics of the participants were presented as means ± standard deviation and percentages. The Kolmogorov–Smirnov test was used to assess the assumption of normality. Two-tailed *t* test was performed to compare groups for continuous variables and χ^2 test for categorical variables. The association between weight status and musculoskeletal pain and related symptoms was analyzed with logistic regression adjusted for age, gender, and jobs position. Only the significant results of logistic regression models are presented. The data were analyzed for statistical significance by using the statistical package of social science (SPSS 20.0) software for Mac OXS. A *p* value below .05 was denoted as significant.

Results

In the total sample (*n* = 203), 38.4% was classified as overweight and 22.2% as obese (Table 1). Overweight/obese participants had higher proportion of “blue-collar” jobs compared with nonoverweight participants (76.4% vs. 23.6%, respectively, *p* = .013). No significant differences for age and proportion of gender were seen between weight status.

As depicted in Table 2, the overweight/obese participants reported more frequently musculoskeletal pain and related symptoms in the shoulders (*p* = .007) and wrist/hand in the last 12 months (*p* = .04) compared with their normal weight counterparts.

Logistic regression analysis showed that overweight/obese participants were more likely to have musculoskeletal pain and related symptoms in the last 12 months in the shoulders (odds ratio [OR] = 2.129, *p* = .041; Table 3).

Discussion

In this study, we found that overweight/obese participants reported higher pain intensity only in shoulders and wrist/hand compared with their lean counterparts. The results suggested that overweight/obese participants were more likely to have musculoskeletal pain and related symptoms in the last 12 months in the shoulders. This association was not confounded by age, gender, and jobs position as it remained significant after adjustments.

In this study, a higher proportion (60.6%) of overweight/obesity was seen among workers. Likewise, a cross-sectional study has found overweight/obesity prevalence above 60% among Kuwait Oil Company workers (Al-Asi, 2003). Choi et al. (2010) in a longitudinal study also showed that the prevalence of overweight/obesity increased significantly from 1995–2002 among factory workers. Moreover, overweight and obesity are more prevalent among blue-collar and shift workers than among white-collar and office workers (Karlsson, Knutsson, & Lindahl, 2001; Nakamura, Nakamura, & Tanaka, 2000; Nakamura et al., 1997). In our study, we also found a higher proportion of overweight/obesity in blue-collar workers. Furthermore, obesity may represent an additional risk factor for diseases that result from workplace exposures (Schulte et al., 2007). These findings emphasize that efficient weight loss programs are highly relevant as health promotion for this sector. Indeed, we find an example in a Danish workplace health promotion study with workers. The study consisted in promoting correct ergonomic setup, frequent rest, stretching and strengthening exercises and showed a reduction in a few degrees of the

Table 2. Musculoskeletal pain in different body regions of the target population.

	Total sample	Non-overweight	Overweight/obese	p-value ^{a,b}
Shoulder				
12m (%yes)	76 (36)	23(30.3)	53 (69.7)	0.009
Avoid (%yes)	27 (13)	10(37)	17 (63)	0.677
7days (%yes)	31 (15)	9 (29)	22 (71)	0.117
Pain intensity ^c	1.04 ± 2.32	1.53±2.71	2.46 ± 3.12	0.025
Elbow				
12m (%yes)	36 (17.2)	12(33.3)	24 (66.7)	0.27
Avoid (%yes)	14 (6.8)	5 (35.7)	9 (64.3)	0.781
7days (%yes)	12 (5.8)	2 (16.7)	10 (83.3)	0.08
Pain intensity ^c	0.95 ± 2.11	0.88±2.17	1.00 ± 3.12	0.700
Knee				
12m (%yes)	53 (25.4)	19(35.8)	34 (64.2)	0.335
Avoid (%yes)	20 (9.7)	6 (30)	14 (70)	0.341
7days (%yes)	14 (6.8)	7(50)	7 (50)	0.587
Pain intensity ^c	1.25 ± 2.32	1.03 ± 2.04	1.41 ± 2.51	0.233
Wrist/Hand				
12m (%yes)	88 (42.1)	30 (34.1)	58 (65.9)	0.04
Avoid (%yes)	41 (19.8)	13 (31.7)	28 (68.3)	0.158
7days (%yes)	35 (16.8)	14 (40)	21 (60)	0.852
Pain intensity ^c	2.08 ± 2.87	1.51 ± 2.49	2.14 ± 3.04	0.016
Ankle/feet				
12m (%yes)	55 (26.3)	21 (38.28)	34 (61.8)	0.53
Avoid (%yes)	28 (13.5)	13 (46.4)	15 (53.6)	0.684
7days (%yes)	23 (11.1)	9 (39.1)	14 (60.9)	0.852
Pain intensity ^c	1.38 ± 2.59	1.24 ± 2.40	1.48 ± 2.73	0.513
Dorsal region				
12m (%yes)	24 (11.5)	125 (62.5)	9 (37.5)	0.05
Avoid (%yes)	8 (3.8)	7 (87.5)	1 (12.5)	0.01
7days (%yes)	7 (3.3)	4 (57.1)	3 (42.9)	0.46
Pain intensity ^c	0.55 ± 1.56	0.81±1.91	0.36 ± 1.24	0.054
Lumbar region				
12m (%yes)	100 (48.1)	41 (41)	59 (59)	0.777
Avoid (%yes)	43 (21)	17 (39.5)	26 (60.5)	0.730
7days (%yes)	39 (19)	15 (57.1)	24 (61.5)	0.719
Pain intensity ^c	2.71 ± 3.19	2.68 ± 3.01	2.73 ± 3.27	0.912
Thigh/Hip				
12m (%yes)	42 (20.1)	13 (31)	29 (69)	0.117
Avoid (%yes)	20 (9.7)	7 (35)	13 (65)	0.635
7days (%yes)	16 (7.8)	3 (18.8)	13 (81.2)	0.06
Pain intensity ^c	1.04 ± 2.33	1.04 ± 2.33	1.22 ± 2.57	0.187
Neck				
12m (%yes)	72 (35.5)	23 (28.8)	49 (39.8)	0.107
Avoid (%yes)	24 (12.1)	9 (11.2)	15 (12.7)	0.757
7days (%yes)	31 (15.6)	9 (11.2)	22 (18.5)	0.167
Pain intensity ^c	1.83 ± 2.85	1.38 ± 2.49	2.14 ± 3.04	0.069

Note: n (%); ^a Data are mean (standard deviation); ^b analysis by t-test for continuous variables; ^c analysis by χ^2 for categorical variables.

12m - concerned the question of NMQ about "had some troubles or pain in the last 12 months" in body regions.

Avoid - concerned the question of NMQ about "in the last 12 months felt some limitation caused by work in the daily activities"

7days - concerned the question of NMQ about "had some troubles or pain in the last 7 days"

physiological and psychological load in the body. In another study, a randomized controlled trial, included 16 school worksites (8 interventions and 8 controls), the intervention schools formed committees to develop and implement health

promotion activities for employees. Anthropometric and self-report data were collected at baseline and at the end of the intervention (2 years later). The primary outcome measures were BMI, waist-hip ratio, physical activity, and fruit

Table 3. Odds Ratios for Pain in the Last 12 Months in Shoulder and Wrist/Hand by Weight Status.

	Shoulder			Wrist/hand		
	OR ^a	95% CI	p value	OR ^a	95% CI	p value
Nonoverweight	1			1		
Overweight/obese	2.129	[1.108, 4.091]	.023	1.651	[0.887, 3.070]	.114

Note: OR = odds ratio; CI = confidence interval.

^aAdjusted for age, gender, and job position.

and vegetable consumption. This participatory intervention resulted in a modest improvement in health status and possible unmeasured secondary gains, such as improved morale and increased productivity (Siegel, Prelip, Erausquin, & Kim, 2010). Thus, some studies highlight the importance of the reduction of body weight in sedentary works, to decrease the risk to related musculoskeletal disorders and occupational-psychosocial stress, and improve life quality (Christensen et al., 2011; Schulte et al., 2007).

In our study, we found a positive association between BMI and musculoskeletal pain and related symptoms in last 12 months in the shoulder and in the wrist/hand. Several studies observed a positive association between overweight/obesity and increased risk of musculoskeletal disorders, sickness absence, work disability, cardiovascular disease, and mortality (Schmier, Jones, & Halpern, 2006). It has also been described that obesity appears to have a significant positive association with absenteeism (measured as work loss days; Bungum, Satterwhite, Jackson, & Morrow, 2003; Schulte et al., 2007). Sethi, Sandhu, and Imbanathan (2011), in 301 workers with different jobs and shifts in an engineering plant, found a significant association ($p < .001$) between high BMI and increased scores of musculoskeletal discomfort and occupational stress. The authors of the latter study also reported a higher incidence of overweight and obesity in these workers compared with the national average for similar age classes; therefore meetings were organized at the plant on awareness and information on correct lifestyle and diet targeted for shift workers. Bihari, Kesavachandran, Pangtey, Srivastava, and Mathur (2011) also found in cross-sectional study that the risk of musculoskeletal pain among overweight/obese individuals was 1.7-times more as compared with nonoverweight participants.

Some limitations of the present study should be acknowledged. As in every cross-sectional study, conclusions related to cause and effect cannot be drawn. With the use of self-reported musculoskeletal pain and related symptoms, one cannot rule out some reporting bias; however, the questionnaire has been previously tested (Mesquita et al., 2010). BMI may not be a sensitive measure of body fatness when there are some sophisticated methods to accurately measure body fat, such as magnetic resonance imaging or dual-energy X-ray. However, such techniques are not feasible to apply in work environment, because they are complex and

time-consuming. Thus, BMI has been widely used as an index of relative adiposity among adults and in studies of the impact of work on obesity.

Conclusion

In our study, we found that overweight/obesity is positively associated with musculoskeletal pain and related symptoms in shoulders among workers. This study provides the insight to the health professionals about the relationship between BMI and musculoskeletal pain and related symptoms, to formulate well-designed training program to avoid overweight.

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Declaration of Conflicting Interests

The author(s) declared the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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Paper III - Moreira-Silva, I; Santos, R., Abreu, S. & Mota, J. (2013)

The effect of a Physical Activity program on decreasing physical disability indicated by musculoskeletal pain and related symptoms among workers: a pilot study. [International Journal of Occupational Safety and Ergonomics - Epub ahead of print]

The effect of a Physical Activity program on decreasing physical disability indicated by musculoskeletal pain and related symptoms among workers: a pilot study

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Keywords: physical activity; musculoskeletal pain; workers; intervention study

Abstract

The aim of this study was to verify the effect of the Physical Activity (PA) program on musculoskeletal pain and related symptoms in different body regions among workers.

Methods: The intervention study lasted 6 months. The training sessions were given during work time. The intervention group (TOI) (n=39) participated in 10-15 minutes of physical exercise training three times a week and focused on stretching exercises and general strength. The reference group (TOR) (n=31) were asked to continue their daily activities. Musculoskeletal pain was assessed with the Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms. Evaluations were performed at baseline and at the end of the intervention.

Results: After the intervention, the TOI obtain some significant results regarding a decrease of the intensity of pain in some of the anatomic regions evaluated, such as elbow ($p=0.03$) and dorsal region ($p=0.015$). In comparing the TOR and TOI after the six months of the PA program, we can verify that in the elbow and in the thigh/hip areas, the pain intensity decreased significantly; additionally there is a some evidence to suggest statistically significant results in the neck area ($p=0.063$).

Conclusion: Our intervention seems to have positive benefits on musculoskeletal pain and related symptoms in factory workers.

Introduction

The hazards of a sedentary lifestyle are widely acknowledged. Workplace health promotion (WHP), focuses on factors that influence the health and productivity of workers [1]. Physical activity in all settings (e.g., occupational and leisure time) has been considered to provide similar health-promoting benefits [2] and therefore International recommendations for health-promoting physical activity do not distinguish between occupational and leisure-time physical activity [3].

Workplace health programs have demonstrated improvements in the leading global risk factors for chronic disease, which has led to their increasing role in chronic disease prevention[4]. Indeed, in the last 20 years, the number of health promotion programs in workplace settings has continued to grow [5]. This growth can be attributed to the increased awareness of the advantages of having quality health promotion programs available for employees [5]. Companies believe that these programs can reduce employee health care and disability costs; staff renewal rate; aid in recruiting new workers; enhance the company image; and improve employee productivity [6]. Skilled employees who are well compensated, have pleasant work environments, and enjoy their work can still have low productivity when they are absent from work because of poor health [6].

Musculoskeletal symptoms rates are high among employed adults and have shown a consistent increase over the past few decade [7, 8]. Osteoarticular disorders has also been shown to increase the risk of sick leave and early

retirement, causing high socioeconomic costs [9]. It is also known that work-related musculoskeletal disorders are a major cause of disability in working age individuals [10, 11]. Several studies have shown that repetitive work can contribute significantly to the increase of musculoskeletal disorders in workers and to absenteeism [7, 10, 12].

In 2003, a comprehensive study focusing on the economic return of WHP concluded that workplace programs achieve a 25-30% reduction in medical and absenteeism costs in an average period of about 3.6 years [6].

In this context, effective, well-documented initiatives for reducing weight, improving physical capacity, and reducing musculoskeletal pain among workers are, therefore, needed [7, 10, 12]. PA interventions to improve muscle strength, stretch and improve postural control such as coordination training may be particularly relevant for preventing osteoarticular deterioration in workers [13].

The aim of this study was to verify the effect of a workplace physical activity intervention program on musculoskeletal pain and related symptoms in different body regions in Portuguese workers.

Materials and methods

Study design and sampling

The present study derives from a research project on Physical Activity at the workplace, which is aimed to decrease physical disability, indicated by musculoskeletal pain and related symptoms, increase work ability, and decrease sickness absence among workers with high physical work demands.

The intervention study was conducted between November 2010 and September 2011, in a multinational manufacturing company with offices in Portugal. The 11 months of the study included preliminary evaluation, selection of the intervention (TOI) and the reference group (TOR), and executing the intervention program that lasted six months. Evaluations were performed at baseline and at the end of the intervention.

This study began by carrying out several introductory meetings regarding the project with the administration board, the medical department, the production department, the human resources department, and the workers. The total number of employees in the company is around 1000; however, only 220 were allowed by the administration board to participate in this study for the production flow to not be adversely affected. These employees are characterized by having repetitive work with moderate force demanding tasks and a large amount of standing. Moreover, all the participants were full-time workers (40h/week) and had been employed in the company for at least six months.

Thus, at the beginning of this intervention, 220 employees were invited (93 men; 128 women) to participate. From those, 212 agreed to participate (88 men; 124 women) in baseline evaluations. Seventy of those (33%) agreed to be randomly assigned to TOI or TOR. There were thirty-nine participants in the TOI and 31 participants in the TOR, as can be observed in the flowchart (Figure 1).

Groups were created based on the management of working teams, day and evening/night shifts. This approach was chosen to avoid contamination between the intervention and the reference group. The aim was to increase compliance and to facilitate the necessary practical arrangement at the workplace. It was, therefore, decided to integrate the intervention into work time.

A cluster formation of the groups was performed to assure equal allocation in the intervention. The randomization was done by an external research group, which had no knowledge of the work place or the participants.

All participants in this study were informed of its goals and provided written informed consent to participate. The study was approved by the Faculty of Sport, University of Porto Ethics Committee; it was conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies.

Intervention program

The intervention lasted six months. The training sessions were given during work time. The TOI consisted of one training group with their own instructor. The aim was to create a close-knit team spirit, which would hopefully help

prevent dropouts. The same instructor gave all the trainings during the six months.

The physical training consisted of 10-15 minutes of physical exercise training three times a week and focused on stretching exercises to decrease some muscular tension in some body regions, specifically the hands, wrists, elbows, shoulders, neck, dorsal, and lumbar regions in order to maintain physical capacity. Other exercises of general strength were also included and consisted of exercises for abdominal and lower extremities (i.e., thigh, hip, knees, ankle, and feet). Participants took home strength and stretching training program, picturing these exercises and were encouraged to perform them at home. In addition to the brief training sessions, participants were orally encouraged in all training sessions to initiate aerobic leisure time exercises such as biking, walking, running, or attending different sports in the local area.

Anthropometric measures

Body height was measured to the nearest millimetre in bare or stocking feet with the participant standing upright against a stadiometer (Holtain Ltd., Crymmych, Pembrokeshire, UK). Weight was measured to the nearest 0.10 kg, lightly dressed using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan). BMI was calculated from the ratio between body weight (kg) and body height (m²). Participants were categorized as non-overweight, overweight and obese, applying the cut-off points suggested by the World Health Organization [14].

Percentage of body fat (%BF) was measured using a bio impedance scale (Tanita Inner Scan BC 532, Tokyo, Japan), which was set to 'standard' while body frame and the participant's age, height and gender were entered.

Waist circumference was measured twice, with a non-elastic metal anthropometric tape, midway between the lower rib margin and the iliac crest at the end of normal expiration [15]. The average of the two measures was used for analysis. If the two measurements differed by more than one cm, a third measurement was taken and the two closest measurements were averaged.

Blood pressure

Blood pressure was measured in a seated position after 10 minutes of rest with an electronic blood pressure monitoring device (OSZ 5 Easy Welch Allyn) on the left arm. Three measurements were done one minute apart and an average calculated.

Socio-demographic variables

Participants answered a questionnaire that assessed several socio-demographic variables (age, marital status, etc.).

Physical activity

Physical activity was assessed using the short version of the International Physical Activity Questionnaire (IPAQ) [16]. Validity and reliability data from 12 countries (including Portugal) show IPAQ has comparable validity and reliability to CSA monitor and to other self-reported measures of PA [17]. According to the Guidelines for data Processing and Analysis of the IPAQ, total PA was expressed as metabolic equivalent (MET) minutes/week by weighting the reported minutes per week in each activity category by the metabolic equivalent specific to each activity (Total PA = 3.3 MET x walking minutes x walking days + 4.0 MET x moderate-intensity activity minutes x moderate days + 8.0 MET x vigorous-intensity activity minutes x vigorous-intensity days). Physical activity was expressed as minutes per week by summing the time spent in moderate physical activity and vigorous physical activity (MVPA).

Musculoskeletal disorders and related symptoms

Musculoskeletal pain and related symptoms was assessed by the Standardised Nordic Questionnaires for the Analysis of Musculoskeletal Symptoms. (NMQ)[18], supplemented with questions about localized pain intensity. This questionnaire has been validated to the Portuguese population [19]. The NMQ

consists of 27 binary choice questions (yes or no). The questionnaire has three questions correlating to nine anatomic regions (neck, shoulders, wrists/hands, lumbar region, dorsal region, hips/thighs, knees, and ankles/feet). The first is “had some troubles or pain in the last 12 months,” the second is “in the last 12 months felt some limitation caused by work in the daily activities,” and the third is “had some troubles or pain in the last 7 days.” In the sense of facilitating the identification of the corporal areas, the questionnaire also includes a corporal diagram detaching all of the involved corporal areas[18]. The pain intensity in the “last 7 days,” included the numeric pain scale (scale 0-10).

Statistical analysis

Descriptive characteristics of the participants were presented as means $\pm$ standard deviation and percentages.

The Shapiro-Wilk test was used to assess the assumption of normality. The two-tailed T-test was performed to compare groups for continuous variables and the X2 Test for categorical variables. When the continuous variables were found to not be normally distributed, the Mann-Whitney test was used to determine differences between groups. For repeated measures, the paired-sample T-test was used or the Wilcoxon signed-rank test when appropriate. In addition, McNemar’s test was used to compare paired proportions.

The data was analyzed for statistical significance by using the statistical package of social science (SPSS 20.0) software for Mac OXS. A p value under 0.05 was denoted as significant.

Results

Descriptive characteristics of the TOR and TOI are shown in Table 1. A higher proportion of overweight and obese can be seen in the TOR before and after the intervention ($P < 0.05$, for all). No significant differences were seen in age, weight, height, blood pressure, body fat, and waist circumference across groups.

Concerning physical activity, in the TOR, MVPA decreased after the intervention ($p = 0.002$) and there was not a significant difference in the TOI after

the intervention ($p=0.966$). When we compare the differences in MVPA between groups, we can verify that the TOI group was more active than the TOR, 150(345) vs. 90(135), respectively, $p=0.010$. No differences were observed between groups before the intervention.

Table 2 - Descriptive characteristics of the participants, by Reference (TOR) and Intervention (TOI) groups.

	Reference (TOR)			Intervention (TOI)		
	n=31			n=39		
	T0	T1	P	T0	T1	P
Age (years) ^a	38.8 (8.6)	-	-	38.0 (6.9)	-	0.687 ^e
Weight (kg) ^b	68.7 (17.6)	70.5 (20.4)	0.165 ^d	57.2 (15.2)	67.3 (18.4)	0.194 ^d
Height (m) ^a	1.62 (0.09)	-	-	1.62 (0.09)	-	0.945 ^e
BMI (kg/m ²) ^b	26.4 (3.5)	27.0 (3.8)	0.179 ^d	26.0 (6.8)	25.0 (7.4)	0.194 ^d
Weight status (%)						
Non-overweight	25.8	19.4		46.2	51.3	
Overweight	54.8	54.8	0.102	25.6	17.9	0.739
Obese	19.4	25.8		28.2	30.8	
Body fat (%) ^a	30.17 (9.61)	29.3 (9.8)	0.183 ^c	28.24 (10.97)	27.5 (11.5)	0.514 ^c
Waist circumference (cm)	91.1 (11.8)	92.7 (11.3)	0.212 ^c	90.3 (13.7)	89.5 (12.3)	0.512 ^c
Blood pressure (mmHg) ^a						
Systolic	123.7(14.3)	127.0 (17.1)	0.290 ^c	124.1 (12.5)	122.7 (17.7)	0.477 ^c
Diastolic	75.5(8.8)	75.9 (10.7)	0.755 ^c	75.2 (10.3)	74.7 (11.7)	0.756 ^c
MVPA (min/week) ^b	180(390)	90(135)	0.002 ^d	180(390)	150(345)	0.966 ^d
						0.798 ^f

BMI body mass index; MVPA – moderate and vigorous physical activity; T0 – before intervention; T1 – after the intervention; T0C – before intervention for the control group; T0I - before intervention for the intervention group; T1C - after intervention for the control group; T1I - after intervention for the intervention group.

^a Data are mean (standard deviation); ^b data are median (interquartile range); ^c analysis by Student's t-test for paired variables; ^d analysis by Wilcoxon's test; ^e analysis by Student's t-test for independent variables; ^f analysis by Mann-Whitney's test.

In Table 2 we can verify the musculoskeletal pain in different body regions of the reference and intervention groups before and after the PA program. No differences were seen between groups in musculoskeletal pain and related symptoms in baseline.

The results showed that the TOI participants after the PA intervention felt less limitation caused by work in daily activities in the last 12 months in the neck ($p=0.004$) and the pain intensity decreased after the PA intervention ($p=0.059$). If we compared the differences between the two groups we can verify that the TOI felt less limitation caused by work in daily activities in the last 12 months in the neck ($p=0.063$).

After the intervention, the TOI showed some significant results regarding a decrease of the intensity of pain in some anatomic regions evaluated, such as elbow ($p=0.03$) and dorsal region ($p=0.015$).

Although not statistically significant in this study, there did exist some results that should be examined, because there is a tendency toward a decrease of the intensity of pain in the neck ($p=0.059$), in the wrist/hand ($p=0.083$), and in the lumbar region ($p=0.083$).

If we compared the TOR and TOI after the six months of the PA program, we can demonstrate that in the elbow and thigh/hip regions, the pain intensity decreased significantly, and there is some trend to show statistically significant results in the neck region ($p=0.063$).

Table 2 - Musculoskeletal pain in different body regions of the reference (TOR) and intervention (TOI) group before and after the PA program.

	Reference (TOR)			Intervention (TOI)			P (T0C*T0I) ^{d, e}	P (T1C*T1I) ^{d, e}
	n=31			n=39				
	T0	T1	P ^{b, c}	T0	T1	P ^{b, c}		
Neck								
12m (% yes)	19(61.3)	20(64.5)	1.000	33(56.4)	20(51.3)	0.774	0.681	0.266
Avoid (% yes)	7(22.6)	6(19.4)	1.000	11(28.2)	2(5.1)	0.004	0.593	0.063
7 days (% yes)	9(29.0)	9(29.0)	1.000	11(28.2)	9(23.1)	0.774	0.939	0.571
Pain intensity ^a	2(5)	3(5)	0.727	3(6)	(5)	0.059	0.494	0.128
Shoulder								
12m (% yes)	18(58.1)	23(74.2)	0.267	26(66.7)	28(71.8)	0.774	0.459	0.823
Avoid (% yes)	6(19.4)	5(16.1)	1.000	7(17.9)	8(20.5)	1.000	0.881	0.639
7 days (% yes)	9(29.0)	12(38.7)	0.508	11(28.2)	12(30.8)	1.000	0.939	0.487
Pain intensity ^a	3(6)	3(6)	0.827	4(7)	4(5)	0.269	0.382	0.918
Elbow								
12m (% yes)	9 (29.0)	10(32.3)	1.000	10(25.6)	4(10.3)	0.109	0.751	0.022
Avoid (% yes)	5(16.1)	4(12.9)	1.000	3(7.7)	3(7.7)	1.000	0.270	0.470
7 days (% yes)	6(19.4)	5(16.1)	1.000	5(12.8)	1(2.6)	0.125	0.456	0.044
Pain intensity ^a	0(5)	0(3)	0.752	0(1)	0(0)	0.003	0.402	0.015
Wrist/Hand								
12m (% yes)	21(67.1)	24(77.4)	0.508	26(66.7)	25(64.1)	1.000	0.924	0.227
Avoid (% yes)	7 (22.6)	8(25.8)	1.000	15(38.5)	9(23.1)	0.070	0.155	0.791
7 days (% yes)	11(35.5)	10(32.3)	1.000	12(30.8)	10(25.5)	0.774	0.677	0.543
Pain intensity ^a	3(5)	4(6)	0.646	4(7)	3(6)	0.083	0.340	0.537
Dorsal region								

12m (% yes)	6(19.4)	4(12.9)	0.625	8(20.5)	4(10.3)	0.344	0.904	0.730
Avoid (% yes)	2(6.5)	2(6.5)	1.000	3(7.7)	1(2.6)	0.625	0.841	0.425
7 days (% yes)	2(6.5)	1(3.2)	1.000	2(5.1)	3(7.7)	1.000	0.813	0.424
Pain intensity ^a	0(0)	0(0)	0.244	0(2)	0(0)	0.015	0.064	0.976
Lumbar region								
12m (% yes)	22(71.0)	23(74.2)	1.000	24(52.2)	23(59.0)	1.000	0.409	0.183
Avoid (% yes)	9(29.0)	5(16.1)	0.453	11(28.2)	9(23.7)	0.727	0.939	0.438
7 days (% yes)	8(25.8)	8(25.8)	1.000	12(30.8)	13(33.3)	1.000	0.648	0.495
Pain intensity ^a	3(5)	4(4)	0.214	6(7)	4(6)	0.083	0.109	0.440
Thigh/Hip								
12m (% yes)	6(19.4)	9(29.0)	0.375	7(17.9)	8(20.5)	1.000	0.881	0.409
Avoid (% yes)	3(9.7)	4(12.9)	1.000	3(7.7)	1(2.6)	0.625	0.768	0.095
7 days (% yes)	3(9.7)	5(16.1)	0.625	1(2.6)	1(2.6)	1.000	0.203	0.044
Pain intensity ^a	0(0)	0(4)	0.646	0(1)	0(0)	0.408	0.172	0.455
Knees								
12m (% yes)	9(29.0)	11(35.5)	0.727	11(28.2)	17(43.6)	0.146	0.939	0.492
Avoid (% yes)	6(19.4)	2(6.5)	0.125	3(7.7)	2(5.1)	1.000	0.148	0.813
7 days (% yes)	4(12.9)	4(12.9)	1.000	6(15.4)	8(20.5)	0.754	0.768	0.401
Pain intensity ^a	0(3)	0(3)	0.478	0(3)	0(3)	0.985	0.821	0.920
Ankle/Feet								
12m (% yes)	14(45.2)	16(51.6)	0.774	18(46.2)	16(41.0)	0.754	0.934	0.377
Avoid (% yes)	4(12.9)	3(9.7)	1.000	5(12.8)	4(10.3)	1.000	0.992	0.936
7 days (% yes)	5(16.1)	10(32.3)	0.180	6(15.4)	10(25.6)	0.219	0.932	0.543
Pain intensity ^a	0(3)	3(7)	0.012	1(5)	0(6)	0.351	0.314	0.299

T0 – before intervention; T1 – after the intervention; T0C – before intervention for the control group; T0I – before intervention for the intervention group; T1C – after intervention for the control group; T1I – after intervention for the intervention group. ^a data are median (interquartile range); ^b analysis by McNemar's test for categorical variables; ^c Analysis by Wilcoxon's test for continuous variables; ^d analysis by chi-square test for categorical variables; ^e analysis by Mann-Whitney's test.

12m – concerned the question of NMQ about “had some troubles or pain in the last 12 months” in body regions. **Avoid** - concerned the question of NMQ about “in the last 12 months felt some limitation caused by work in the daily activities”. **7days** - concerned the question of NMQ about “had some troubles or pain in the last 7 days”.

Discussion

This study assessed the effects of a workplace physical activity intervention program on musculoskeletal pain in different body regions in Portuguese workers.

When the physical work demands exceeds the safety margin of the individual physical capacities, this environment is generally considered to enhance the risk for physical deterioration and is revealed as musculoskeletal disorders, poor work ability, and sickness absence[2]. However, effective interventions for preventing physical deterioration in job groups at high risk still need to be established.

This feature of the program enhances the probability for enabling evidence-based information for public health policy and health promotion strategies among employees in job groups with high risk for physical deterioration. Another strength of the program is that the interventions take place at the workplace, providing a high external validity of the findings.

A significant proportion of the participants of this study reported musculoskeletal pains in some parts of the body. This study also verified musculoskeletal pain with significant intensity in some body regions, particularly in the neck, elbow, dorsal region, thigh/hip, and ankle/feet, decreased after this intervention program.

The PA program was based on stretching exercises. These types of exercises are not appropriate for health gains in terms of weight, blood pressure, body fat, and waist circumference [10, 20, 21]. Has expected there were no significant differences in weight, blood pressure, body fat, and waist circumference across groups.

These results are in line with other studies that observed significant health impacts of PA worksite interventions. Indeed, several studies observed a high prevalence of musculoskeletal disorders, sickness absence, and work disability [7, 22]. Improving workers' daily physical activity may prevent weight gain and subsequently improve workers' health, increase productivity, and reduce absenteeism [23]. In this vein, a randomized, controlled trial included 16 school worksites (eight of intervention and eight of control). Intervention schools formed committees to develop and implement health promotion activities for

employees. Anthropometric measures and PA self-report data were collected at baseline and at the end of the intervention (two years later). The primary outcome measure was physical activity. This participatory intervention resulted in a modest improvement in health status and possible unmeasured secondary gains, such as improved morale and increased productivity [24].

Work which included plenty of twisting movements of the trunk, working with the trunk forward flexed or the hands above shoulder level were important work-related risk factors. Musculoskeletal pain of a working-age population has many risk factors of which age, stress, and work-related physical loading seem to play an important role. By affecting the latter factors, it may be possible to decrease the prevalence of musculoskeletal symptoms and maintain a good ability to work. Due to high morbidity rates, the importance of preventive measures must be emphasized. When studying the associations between physical exercise and musculoskeletal pain among the working-age population, researchers should pay attention to the factors which are strongly related to pain, such as stress and work-related physical loading. More research with prospective design is needed in order to achieve more reliable information of the true effects of physical exercise on musculoskeletal health. The risk factors for musculoskeletal pain form a complex mesh, many factors of which (such as the amount of exercise practiced) are difficult to measure in epidemiological research [4, 7].

The results presented here are also in agreement with those reported by Sethi, et al [25], conducted among 301 workers with different jobs and shifts in an engineering plant, in which they found a significant association between high PA and a decrease in scores of musculoskeletal discomfort and occupational stress.

In addition, the quality (i.e., different modes) and quantity of exercise should be specified. This program of physical activity was based on programs of several studies. What differentiates this program (10-15minutes three times/week) from other programs used in others studies is the blend of stretching exercises to decrease some muscular tension in some regions in order to maintain physical capacity along with exercises of general strength. were also included and Participants took home the strength and stretching training program, picturing these exercises, and were encouraged to perform them at home. In addition to

the brief training sessions, participants were encouraged orally in all training sessions to initiate aerobic leisure time exercises such as biking, walking, running, or attending different sports in the local area.

In conclusion, our intervention (our dose-response) was cost effective because the program had a low dose of physical activity but had a high response (i.e., a benefit for health).

Limitations of the study

A limitation of the program is that only simple measures of process evaluation such as the proportion of workers in uptake, the actual start of the program, and the actual completion of the intervention program are collected. Moreover, no economical cost-effectiveness evaluations are included.

Another limitation is that the intervention among factory workers is an exploratory study that is not well controlled.

Conclusion

The study population of the program (i.e., employees in job groups with high physical demands) is well documented to have a high risk for physical deterioration.

If proven effective, the specific tailored interventions to the different job groups can provide meaningful scientifically based information for public health policy and health promotion strategies for employees in these job groups at high risk for physical deterioration. This knowledge can be beneficial for occupational health professionals, supervisors, companies, and employees in these job groups. Because the interventions are carried out during ordinary circumstances at a wide range of workplaces, it is expected that the findings can be transferred and that the interventions implemented in other workplaces with high physical demands will have similar results. In conclusion, our intervention (our dose-response) was cost effective because the program had a low dose of physical activity but had a high response (i.e., a benefit for health). Despite the difficulties, an epidemiological perspective is needed since both musculoskeletal disorders and physical exercise concern vast populations.

Competing interests

The authors declare that they have no competing interests.

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Overall Discussion

The main findings of the studies presented in this dissertation support the hypothesis that physical activity programs can decrease musculoskeletal pain and related symptoms in workers.

In our meta-analyses of twelve studies that showed there is moderate quality of evidence that workplace PA interventions significantly reduce general musculoskeletal pain and neck and shoulders pain. Additionally, there is low quality of evidence that workplace physical activity interventions significantly reduce low back and arms, elbows, wrists and hands/fingers pain. These results can be related with the lack of studies.

Moreover, this review presents results for general pain, neck and shoulders pain, low back, arms, elbows, wrists, hands/fingers pain.

PA and multidisciplinary interventions (e.g. diet and ergonomics) seem to have a positive effect on the prevention of some MSDs, and comprehensive treatment interventions seem to have an effect on sick leave, costs and prevention of new episodes of pain and physical discomfort and consequently MSDs (David M. Kietrysa et al., 2005; Gerr et al., 2005; Tveito et al., 2004). It appears that there are advantages in adopting active lifestyles, both at individual and professional/employment (Conn et al., 2009).

It can be said that PA interventions are a helpful feature to consider when dealing with some issues currently experienced by companies. However, some evidence suggests that PA interventions in the workplace may not have a significant positive impact in bio psychosocial factors particularly, in reducing musculoskeletal disorders and associated symptoms (i.e. pain). Such results may be influenced by small sample studies and other constraints associated with the implementation of controlled trials to assess health interventions in workplaces. In this context, this review may contribute to evidence based practice of the prevention of MSDs.

Other main finding of the studies presented in this dissertation suggested that in our sample exist a significant proportion of the participants whose reported musculoskeletal pain in some regions of the body. This study verified that being overweight or obese was associated with musculoskeletal pain in shoulder and wrist/hand compared to their lean counterpart. The results

suggested that overweight/obese participants were more likely to have musculoskeletal pain and related symptoms in the last 12 months in the shoulders. In this study, a high proportion (60.6%) of overweight/obesity was seen among workers. Likewise, a cross-sectional study has found overweight/obesity prevalence among 627 of 864 employees at 34 worksites whose agreed to participate in PACE (Promoting Activity and Changes in Eating) (Wendy E. Barrington et al., 2012). There is some evidence shows that overweight and obesity are more prevalent among blue-collar and shift workers than among white collar and office workers (Karlsson et al., 2001; Nakamura et al., 1997; Nakamura et al., 2000). In our study we also found a higher proportion of overweight/obesity in blue-collar workers. Additionally, obesity may represent an supplementary risk factor for diseases that result from workplace exposures (Paul A. Schulte et al., 2007; Wendy E. Barrington et al., 2012). These findings emphasise that efficient weight loss programs may are highly relevant as health promotion for this sector. Indeed, some studies highlight the importance of the reduction of body weight in sedentary works, in order to decrease the risk to related musculoskeletal disorders, occupational-psychosocial stress and improve life quality (Christensen et al., 2011; E. M. H. Haldorsen et al., 1998;; Paul A. Schulte et al., 2007).

Obesity is related to occupational health because it is a risk factor for injuries and preterm exit from the labour market (Bonde & Viikari-Juntura, 2013). There is a positive association between overweight/obesity and as sleep apnea leading to fatigue, osteoarthritis leading to physical limitations, or altered biomechanics leading to postural instability and increased risk of musculoskeletal disorders, sickness absence, work disability, cardiovascular disease and mortality (Bonde & Viikari-Juntura, 2013; Holtermann A. et al., 2011; Schmied JK, 2006). Sethi et al (Sethi et al., 2011), in 301 workers with different jobs and shifts in an engineering plant, found a significant association ($p < 0.001$) between high BMI and increased scores of musculoskeletal discomfort and occupational stress. In a cross sectional study the authors concluded that the risk of musculoskeletal pain among overweight/obese individuals was 1.7-times more as compared with non-overweight subjects. (Bihari et al., 2011).

Evidence shows that exercisers are healthier than non-exercisers. The most of the adults do not perform enough PA to achieve health and well-being benefits. Workplaces may implement physical programs in hopes of keeping workers healthy and avoiding musculoskeletal pain and related disorders and consequently reducing healthcare costs (Vicki, 2009). Employed adults spend about half of their workday waking hours at workplaces, PA programs at workplace is a possible efficient strategy to increase PA and consequently decrease musculoskeletal pain poor work ability, and sickness absence.(Andreas Holtermann, 2010). However, effective interventions for preventing physical deterioration in workers groups at high risk still need to be established.

The fact that existing standards of formal and informal communication among employees in a worksite and possible corporate behaviour norms are potential advantages of worksite programs over other approaches (Pratt CA., 2008).

Our research verified significant musculoskeletal pain intensity in some body regions, particularly in the neck, elbow, dorsal region, thigh/hip, and ankle/feet that decreased after PA intervention program, among factory workers. The results showed that the subjects after the PA intervention felt less limitation caused by work in daily activities in the last 12 months in the neck and the pain intensity decreased after the PA intervention.

These results are in line with other studies that observed significant health impacts of PA worksite interventions. Indeed, several studies observed a high prevalence of musculoskeletal disorders, sickness absence, and work disability (Miranda, 2001; Schmier JK, 2006). Improving workers' daily physical activity may prevent weight gain and subsequently improve workers' health, increase productivity, and reduce absenteeism (Lisanne M Verweij, 2009).

Musculoskeletal pain of a working-age population has many risk factors of which age, stress, and work-related physical loading seem to play an important role. By affecting the latter factors, it may be possible to decrease the prevalence of musculoskeletal symptoms and maintain a good ability to work. Due to high morbidity rates, the importance of preventive measures must be emphasized. When studying the associations between PA and musculoskeletal

pain among the working-age population, researchers should pay attention to the factors which are strongly related to pain, such as stress and work-related physical loading. More research with prospective design is needed in order to achieve more reliable information of the true effects of physical exercise on musculoskeletal health. The risk factors for musculoskeletal pain form a complex mesh, many factors of which (such as the amount of exercise practiced) are difficult to measure in epidemiological research(Miranda, 2001; Osilla K., 2012).

In addition, the quality (i.e., different modes) and quantity of exercise should be specified. This program of physical activity was based on programs of several studies. What differentiates this program (10-15minutes three times/week) from other programs used in others studies is the blend of stretching exercises to decrease some muscular tension in some regions in order to maintain physical capacity along with exercises of general strength. Were also included strength and stretching training program, picturing these exercises, and were encouraged to perform them at home. In addition to the brief training sessions, participants were encouraged orally in all training sessions to initiate aerobic leisure time exercises such as biking, walking, running, or attending different sports in the local area.

In spite of Physical Activity Guideline for all adults do not focus stretching exercises several studies shows some evidence for the effectiveness of stretching exercises in reducing and preventing musculoskeletal pain and related disorders(Costa & Ramos V., 2008).

The limitations of this dissertation were described in detail in all three papers.

The prevalence of musculoskeletal disorders, sickness absence, and work disability becomes an important public health problem in the industrial world. Thus, improving workers' daily physical activity may prevent weight gain and subsequently improve workers' health, increase productivity, decrease musculoskeletal pain and reduce absenteeism.

In this line, our intervention (our dose-response) was cost effective because the program had a low dose of physical activity but had a high response (i.e., a benefit for health).

Conclusions

Based on the purpose and findings of the present dissertation, we emphasize the following conclusions:

- 1) The meta-analytic review showed interventions focusing on improving workplace PA are moderately effective in reducing musculoskeletal pain of employees.
- 2) Overweight and/or obesity are positively associated with musculoskeletal pain and related symptoms in shoulders among workers. This study provides the insight to the health professionals about the relationship between BMI and musculoskeletal pain and related symptoms, in order to formulate well designed training program to prevent MSD'S and possibly overweight and/or obesity.
- 3) The intervention study, showed that fifteen minutes per day of stretching and general strength exercises three times a week, decreased the prevalence and related symptoms of MSD's, particularly in some body regions, such as elbow and dorsal region.

Perspectives for future research

The results of this dissertation emphasize the need for more research on the relationship between a workplace physical activity intervention program and musculoskeletal pain and related symptoms in workers. However, we were not able to assess differences among subgroups of employees.

Despite the difficulties, an epidemiological perspective is needed since both musculoskeletal disorders and physical exercise concern vast populations.

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