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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

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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 fabricas 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 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 de trabalhadores portugueses.

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.

List of abbreviations

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 *Word Health Organization* (WHO) characterizes the injuries related to work has multifactorial diseases because they involve broad a 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 (BLS, 2002, 2012).

Epidemiological studies show a multifactorial model of risk for MSDs (Ramadan & JR, 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 & JR, 2006);
2. risk factors relating to the individual or individual susceptibility, also called co-risk factors (Ramadan & JR, 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, 2007).

Some studies demonstrate that excessive body weight is related with an increased risk for musculoskeletal pain (Han TS, 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 (Linde, 2012).

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 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 JO, 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 (Torill H. Tveito, 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 & Andreas Holtermann, 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 Vieira, 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 currents 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.

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, revels 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, 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 (BLS, 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 (BLS, 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 (BLS, 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, writs/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):

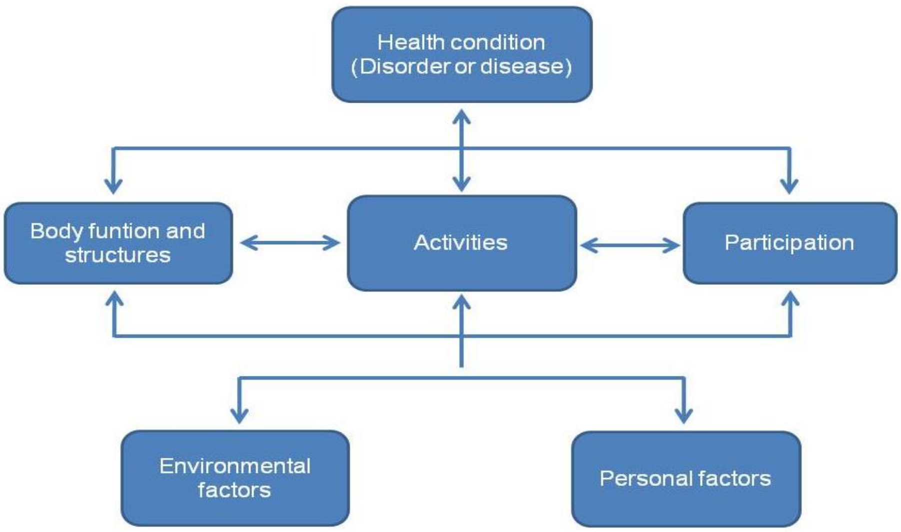


Figure 2 - International classification of Functioning Disability and Health (ICF) model (Adapted from WHO)

Epidemiological studies show a multifactorial model of risk for MSDs (Ramadan & JR, 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), overstressing 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 Vieira, 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, 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)/height^2 (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 (Snijder, 2004; van Dam, 2006). 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; Linde, 2012; van Dam, 2006). 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, 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 (Linde, 2012).Some studies demonstrate that excessive body weight was related with the increase the risk for musculoskeletal pain (Han TS, 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, 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 JO, 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 fo 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, overstressing 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 Vieira, 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 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 (Sjo¨stro¨m 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 (Edward T. Howley, 2001; Sjögrena 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)(Sjögrena et al., 2006).

International recommendations for health-promoting PA do not distinguish between occupational and leisure-time PA (Centers fo Disease Control and Prevention, 2013; Freak-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, 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 (Miranda, 2001; van Dam, 2006).

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 (Torill H. Tveito, 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 Vieira, 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 & Andreas Holtermann, 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 Vieira, 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 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.
Grbnningseter, 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	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

		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.		health. No unspecific treatment effects were observed across groups
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 complains 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: (I) 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=469 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 MMCBT 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 MMCBT group had improved their ergonomic behaviour, work potential, life quality, physical, and psychological health.
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 Feldenkrais 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 (Non-significant) 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 Feldenkrais intervention but not after the physiotherapy intervention
Linton, S. et al 2000	n=253 Aged to 35-45 years old Duration of the intervention= 1year follow-up	253 people selected from a population study were invited to participate. These people 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-minute warming up, followed by 40 minutes 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 minute 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.

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.
Weidick, 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,	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.

		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.		
Sj¨ogrena, 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.
Sj¨ogrena, 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.
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, T. et al, 2008	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.
Hartfiel, 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

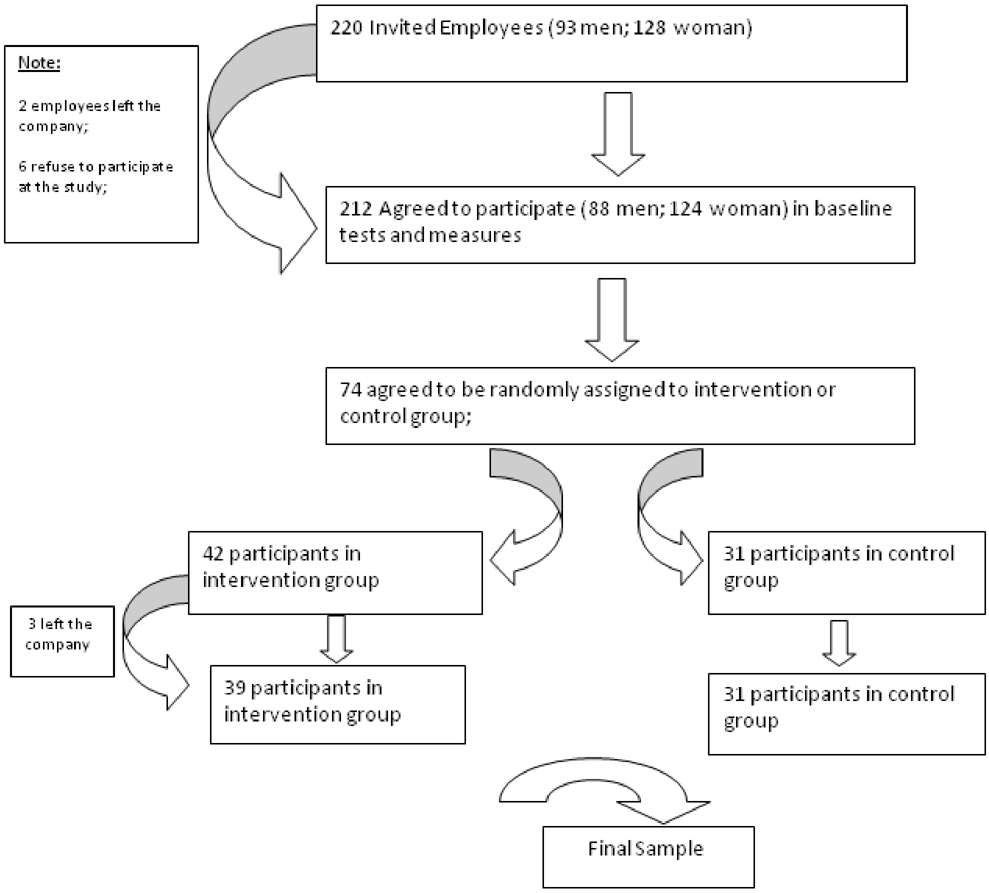
Experimental work

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, 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 (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. 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 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.

(...)

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

Associations between Body Mass Index and musculoskeletal pain and related symptoms in Different Body Regions among Workers

(…)

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

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

(…)

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 ours 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 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).

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 constrains 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, 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, 1998;; Paul A. Schulte, 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 (A Holtermann, 2011; Bonde & Viikari-Juntura, 2013; Schmier JK, 2006). Sethi et al (Jasobanta Sethi, 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, 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 Vieira, 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).

Chapter 4

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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