WHITE PAPER

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Adverse Health Effects of Sedentary Office Work, Its Costs to Employer, and Prevention with Breaks

PhD Olli M. Tikkanen; PhD Arto J. Pesola

1 Introduction

As people spend increasing amounts of time using a computer and mobile devices, especially in sitting position, the negative effects of sedentary behaviour, poor posture, and lack of physical activity are becoming increasingly prevalent. Digitalisation and task automatisation are increasing during work and leisure time, and we can expect a corresponding increase in the prevalence of associated health and musculoskeletal problems if appropriate countermeasures are not employed.

Sufficient physical activity has been shown to have beneficial effects on physical and cardiorespiratory fitness, weight management, blood pressure, lipid profiles, as well as chronic conditions such as diabetes, cardiovascular diseases (Kesäniemi et al. 2001) and Parkinson's disease (Thacker et al. 2007). In addition, it has been shown that sedentary behaviours per se are harmful to health even if a person is physically active (Hamilton, Hamilton & Zderic 2007). Sedentary behaviours have been found to be associated with several chronic diseases, such as type II diabetes and cardiovascular diseases (Booth, Roberts, & Laye 2012).

Musculoskeletal problems are often a result of poor posture during sedentary behaviours and a lack of sufficient breaks. These problems typically manifest in the neck and low back (e.g. Nowotny et al. 2011). Low back pain (LBP) is one of the major concerns in contemporary health care (Airaksinen et al. 2006, Dionne et al. 2008, Dagenais et al. 2010) and chronic LBP is one of the most frequent reasons for disability and inability to work. LBP causes individual suffering and immense financial costs to healthcare and social security institutions. This white paper examines the adverse health effects of sedentary office work, its costs to employers, and how effectively adverse health effects can be prevented with different types of breaks.

Section 2 provides an overview of the health effects of non-exercise activity and exercise, while Section 3 examines the adverse health effects of sedentary beahviour and attenuation of those effects with short bouts of activity throughout the day. Section 4 presents an overview of musculoskeletal problems in relation to rest and exercise breaks, and Section 5 specifically investigates low back pain, as it is the most common and costly musculoskeletal problem affecting the workforce. Section 6 is then providing overall costs estimates of chronic health conditions through both absenteeism and presenteeism, and Section 7 lays out estimates related to productivity losses due to musculoskeletal discomfort experienced by employees. And finally, Section 8 provides generic guidelines related to breaks for computer users.

2 Physical activity and Its health effects

Physical activity enables the avoidance of excessive sedentary behaviour and breaking off long sedentary periods. It is defined as bodily movement produced by the contraction of skeletal muscles that substantially increases energy expenditure over resting energy expenditure (Caspersen, Powell & Christenson 1985). Furthermore, physical activity comprising of planned, structured and repetitive bodily movement done to maintain or improve one or more components of physical fitness is referred to as exercise. Physical activity that does not fulfil the criteria of exercise is coined as a non-exercise activity.

Non-exercise activity

Non-exercise physical activity can also be called also called lifestyle physical activity. (Levine 2002.) Non- exercise physical activity typically includes light-intensity activities, like standing, self-care activities, and slow walking, which require low energy expenditure (approximately

1.6– 2.9 METs). Another way to divide non-exercise physical activity into components is based on volition, such that a spontaneous component includes actions like fidgeting, sitting, standing, and walking, and an obligatory component includes occupation, household, and daily living activities (Levine et al. 2000).

Daily energy expenditure can vary as much as 2000 kcal/day between two people of similar size. The variance in total daily energy expenditure between people of similar size can be explained by differences in activity thermogenesis due to different occupations and leisure-time activities. Energy expenditure during sedentary behaviours is very close to resting energy expenditure but supporting the body mass when stood up in combination with spontaneous fidgeting-like movements or very slow ambulation raises whole-body energy expenditure 2.5-fold more (Levine et al. 2000, Levine 2007.) The cumulative effect of non-exercise activities can be very high. When comparing the average of the lowest and highest quartiles in total energy expenditure, non-exercise physical activity-derived energy expenditure typically ranges from ~300 to ~2000 kcal/day (Hamilton et al. 2007).

Epidemiologic studies have shown a negative relationship between indexes of obesity and levels of physical activity (Weinsier et al. 1995), although the role of low energy expenditure of non-exercise activity in the pathogenesis of obesity is difficult to show with direct data (Levine 2002). Obesity has enormous health implications associated with mechanical complications, metabolic comorbidities and cancer (World Health Organization 2000). Mechanical complications include arthritis, carpal tunnel syndrome, varicose veins, oedema and sleep disorders. Metabolic comorbidities include coronary artery disease, hypertension, hyperlipidaemia and diabetes (Levine 2002), while obesity-related cancers include breast and colon cancers (Levine 2002).

Exercise

Exercise and moderate-to-vigorous physical activity have several health benefits, including improvements in respiratory and cardiovascular function, decreased morbidity and mortality, reductions in coronary artery disease risk factors and several other benefits from reductions of falls and injuries to improved psychological health (American College of Sports Medicine 2010). Many of the health effects are mediated by increasing different components of physical fitness, which are the most direct effects of physical activity (McArdle & Katch 2005).

3 Sedentary behaviour and Its health effects

In health science literature, sedentary behaviour is defined as any waking activity performed in a sitting/lying position expending very little energy (about 1.0–1.5 METs) (Sedentary Behaviour Research Network 2012).

It is important to differentiate between physical inactivity and sedentary behaviour. Physical inactivity is defined as not meeting the current guidelines for health-enhancing physical activity, i.e. not exercising enough. Instead, sedentary behaviour is defined as above. Therefore, both sedentary behaviour and physical activity can coexist.

There is increasing research focus on identifying health risks associated with sedentary behaviours. The dose-response relationship between sitting time and mortality rates has been found to be comparable among those who are physically inactive and active, and across body mass index categories (Katzmarzyk, Gledhill & Shephard 2000). Indeed, epidemiological studies have shown that sedentary time predicts abnormal glucose metabolism (Dunstan et al. 2004 and 2007), metabolic syndrome (Dunstan et al. 2005, Ford 2005, Bertrais et al. 2005), type

II diabetes (Hu 2003, Hu et al. 2001), obesity (Hu 2003, Jakes et al. 2003), high blood pressure (Jakes et al. 2003), cardiovascular disease (Kronenberg et al. 2000) and all-cause mortality (Katzmarzyk et al. 2009) independently from exercise.

In addition to the negative health effect of total sedentary time, the pattern of the accumulation of this time seems to be also important. It has been shown that the total number of breaks (on average of light intensity and lasting less than 5 minutes) in sedentary time is associated with significantly lower BMI, waist circumference, triglycerides, and 2-h plasma glucose, independent of total sedentary time (Healy et al. 2008). Based on these results, it was suggested that breaking prolonged periods of sitting could be a valuable addition to the health recommendations, but biological and behavioural mechanisms and possible causalities still require further investigation (Healy et al. 2008).

The pattern of sedentary behaviour accumulation

Recent studies using isotemporal and compositional research data analysis methods have found that the activities which replace sedentary behavior modify the magnitude of sedentary behaviour-related risk. In a group of healthy participants, a statistical replacement of 10 minutes of sedentary time with moderate-to-vigorous physical activity, but not with light activity, showed beneficial associations to cardio-metabolic health markers (Hamer et al. 2014). In another study utilizing similar analysis methods, reallocating 30 minutes of sedentary time to either light activity or sleep was beneficially associated with cardio-metabolic health markers in a comparable magnitude, and moderate-to-vigorous activity provided more sizeable benefits (Buman et al. 2014). Thus, it might be that at least 30 minutes of light activity is required in exchange of sedentary time to show health benefitting associations, while for higher intensity activity considerably shorter time is already effective producing measurable changes.

A more recent study found that a statistical replacement of one-hour self-reported sitting time with both self-reported standing, walking and moderate-to-vigorous activity was associated with a decreased mortality risk, with walking and moderate-to-vigorous activity showing the strongest benefits of similar magnitude (Stamatakis et al. 2015). Thus, it remains unclear from these observational findings if a similar volume accumulated in either light or moderate-to-vigorous intensity would change the results. For example, a study by Wellburn et al. (2016) showed that 50 minutes of light activity is required to produce similar benefits to 10 minutes of moderate-to-vigorous activity, supporting previous arguments on the importance intensity of activity which replaces sedentary time (Wellburn et al. 2016).

The pattern in which sedentary time is accumulated might also modify the health risks of total sedentary time. Healy et al. (2008) showed that breaks in sedentary time were beneficially associated with waist circumference, BMI, triglycerides and 2-h plasma glucose independent of total sedentary time and moderate-to-vigorous physical activity (Healy et al. 2008). Furthermore, the authors were able to reproduce the finding on waist circumference in a larger dataset (Healy et al. 2008). As reviewed recently, cross-sectional findings support the association of breaks in sedentary time on obesity metrics (Chastin et al. 2015; Brocklebank et al. 2015) and on triglycerides independent of moderate-to-vigorous activity or total sedentary time, but the association to triglycerides is driven by adiposity (Brocklebank et al. 2015). Based on these findings, it appears as each part of the sedentary behavior pattern, namely frequency, interruptions, time and type of sedentary behavior, should be considered to have its own unique influence on health outcomes.

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Short-term efficacy of sedentary behaviour interventions

Already such a small act as standing up from a chair is a strong stimulus for the body. In addition to a mild increase in energy expenditure (13-20%), thigh muscle activity is several folds higher during standing than sitting (Tikkanen et al. 2013). Furthermore, the sympathetic nervous activity increases to adapt the cardiovascular system for the requirements of an upright posture (Supiano et al. 1990). During the past years, several acute experimental studies have explored the efficacy of different activity patterns on metabolic markers of cardio-metabolic risk using prolonged sitting as their reference condition.

Studies have interestingly indicated that different types of breaks have a different outcome for normal weight and obese individuals. Prolonged standing (Buckley et al. 2014) or alternating between sitting and standing (Thorp et al. 2014) were effective in decreasing postprandial (i.e. occurring after a meal) glucose load in mostly overweight office workers. However, the same effect for standing breaks was not seen in normal weight young men, but walking was required to decrease postprandial glucose and triglyceride load as compared to prolonged sitting (Miyashita et al. 2013; Bailey, & Locke 2014). The benefits can at least partly be attributed to increased energy expenditure volume due to standing or walking as energy balance was not controlled for in the study. Interestingly, when the energy expenditure volume of light intensity breaks was matched to that of single exercise bouts, the frequent light intensity activity breaks affected more beneficially glycaemic fluctuation (Blankenship et al. 2014) and postprandial triglyceride, non-HDL cholesterol (Duvivier et al. 2013), insulin (Peddie et al. 2013; Duvivier et al. 2013) and glucose concentrations (Peddie et al. 2013) as compared to the single exercise bout.

Furthermore, Kim et al. (2014) showed in non-obese young men that physical exercise more effectively attenuated triglyceride response to fat tolerance test as compared to breaking up sitting with light activity breaks when the energy expenditure volume was the same, but both were beneficial to sitting (Kim et al. 2014). These findings emphasize the importance of total activity volume but suggest that accumulating this volume in short frequent bouts rather than in a single bout, is more beneficial (at least for glucose metabolism).

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In contrast to these findings, Dunstan et al. (2012) showed that breaking up sitting with both light and moderate intensity breaks were as beneficial for postprandial glucose and insulin concentrations in obese subjects, despite the different activity volume of these conditions (Dunstan et al. 2012). Similarly, Henson et al. (2015) showed that breaking up sitting with either standing or walking was equally beneficial for postprandial glucose and insulin responses in obese subjects, and the beneficial effects reached to the following day (Henson et al. 2015). A hypothesis might be put forward that the muscle activity required to maintain the upright posture is higher in obese than in normal weight people thus contributing to their greater benefits seen during light intensity activity and standing (Pesola et al. 2016).

Cardio-metabolic effects of sedentary behaviour interventions

Breaking up long sitting bouts can also have longer-term effects than those acute effects mentioned in the previous chapters. Cardiovascular diseases are common chronic conditions for middle-aged and older people and risk for these diseases can be examined through well-established risk factors that represent longer-term effects on the body. However, there are not many interventional studies that have assessed cardio-metabolic effectiveness of reducing sedentary time outside of the laboratory. One of the studies, by Danquah et al. (2016), found that, as compared to a control group, sitting time reduced by 48 minutes/workday and standing time increased by 43 minutes resulted in 0.61 percentage points lower body fat percentage during three months in 317 overweight office workers. In a three-month quasi-experimental study, Alkhajah et al. (2012) were able to demonstrate 0.26 mmol/l increase in HDL cholesterol (as compared to control group) after normal weight office workers reduced their sitting time 97 minutes per day (Alkhajah et al. 2012).

In a study by Graves et al. (2015), a worksite-delivered randomised controlled trial reduced sitting time by 80 minutes, increased standing time by 73 minutes, and resulted in 0.40 mmol/l decrease in total cholesterol after eight weeks compared to control group participants (normal weight office workers) (Graves et al. 2015). Aadahl et al. (2014) found that the 30 minutes increased standing time which replaced sitting during their half-year intervention reduced waist circumference (-1.42 cm as compared to the control group), fasting serum insulin (-5.9 pmol/l) and homeostasis model –assessed insulin resistance (-0.28) in overweight participants who were sitting more than nine hours per day at baseline (Aadahl et al. 2014).

More recently, at least two longer real-life interventions have shown long-term benefits of reducing the sedentary time during daily life (Pesola et al. 2017, Healy et al. 2017). Pesola et al. (2017) showed during a one-year intervention that intervention group was able to reduce sedentary time on average 21 minutes per day and increase one break in sedentary time an hour as compared to the control group at the beginning of the study. During the whole year, sedentary time increased in the control group. At 3 months, the intervention group enjoyed benefits in fasting glucose concentration. At 12 months, the control group's weight increased by one kg and leg lean mass decreased by 0,5 %, whereas they remained unchanged in the intervention group (Pesola et al. 2017). These results demonstrate that reducing sedentary time is important for preventing weight gain, whereas even a small increase in sedentary time may result in increased weight during a long time. Similar findings were observed in a study by Healy et al. 2017, such that the clearest changes in cardiometabolic outcomes were seen at the one-year follow-up. These results suggest that long follow-up facilitate cardio-metabolic benefits attributed to reduced sedentary time outside of the laboratory.

4 Musculoskeletal disorders

Musculoskeletal disorders (MSDs) are common and costly problems often resulting from repetitive movements or extended static postures. MSDs are problems affecting the muscles, joints, ligaments, tendons, nerves and soft tissues, and are a common cause of disability and lost productivity. Upper limb disorders (ULDs) and low back pain are common musculoskeletal disorders affecting the workforce. ULDs are a subcategory of MSDs and are conditions which affect the neck, shoulders, arms and hands. Several risk factors have been identified that increase the likelihood of developing ULDs at work. These include environmental-related factors (e.g. psychosocial factors and working environment), worker-related factors (e.g. the individual differences of workers) and task-related factors (e.g. working postures, repetition, forces and duration of exposure to these risk factors).

A variety of jobs involve extended static postures or a range of repetitive movements which can result in musculoskeletal discomfort and subsequently disorders. Repetitive movements refer to work that requires the same muscle groups to be used throughout the working day or for prolonged periods. Excessive repetitions may not allow sufficient time for recovery during the day and between working days and can cause muscle fatigue due to a build-up of metabolic waste materials and depletion of energy sources. Repeated loading has been also associated with microscopic changes, inflammation and degeneration.

Static postures occur when the whole body or a part of the body is held in a particular position for extended periods of time. Static loading restricts blood flow to the muscles and other tissues, resulting in decreased recovery and metabolic waste removal. Muscles holding a static posture for an extended period of time typically fatigue surprisingly quickly (Health and Safety Executive of the U.K. book HSG60). Static and loading postures are common when maintaining the body in a certain position to do work or when holding an object steady. The overall aims of the following paragraphs are to explore the evidence of benefits in reducing the risk of musculoskeletal discomfort by performing short rest, exercise, or stretch breaks.

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The significance of rest breaks on musculoskeletal discomfort

Workers who perform repetitive or static work should have frequent breaks to ensure that muscular fatigue or loading of soft tissues does not adversely influence health or reduce performance. Several studies (e.g. Murrell 1971, Rohmert 1973, Sundeling & Hagberg 1989 and Fisher et al. 1993) have found that workers often wait until they experience musculoskeletal discomfort before taking a break for rest. Taking short rest breaks earlier could possibly prevent or at least delay the occurrence of musculoskeletal problems.

Breaks allow workers to change their posture and should be taken when performance and productivity are still high and before feeling musculoskeletal discomfort or fatigue. Having the break early enough has been stated to be better than taking a break to recover from fatigue (HSE book L26). Frequent rest breaks have been recommended to reduce static loads on the musculoskeletal system by Sundelin and Hagberg (1989), however, they also found that exercising during these breaks did not have an effect on reducing shoulder discomfort. Fisher et al. (1993) have investigated optimum rest break patterns and found that there is a reduction in repetitive strain injuries when frequent breaks are taken.

Rohmert (1973) found benefits from short rest breaks, especially due to the rapid rate of recovery occurring at the beginning of a rest period. He also suggested that short rest breaks do not compromise a worker's adaptation to work and that appropriate timing of breaks is also important. Short frequent breaks seem to be better than occasional, longer breaks. Henning et al. (1997), found that very short (30 – 60 sec) rest breaks from computer work every 15 minutes throughout the day helped to improve both musculoskeletal discomfort and worker productivity.

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Similar findings were reported also by McLean et al. (2001). They studied the benefits of micro-breaks on individuals using computers by examining myoelectric signals, perceived discomfort, behaviour, and worker productivity while performing usual typing tasks. Participants of the study were divided to three groups: 1) micro breaks at their own discretion (control group), 2) micro breaks at 20 min intervals, 3) micro breaks at 40 min intervals. Researchers found that micro breaks had a positive effect on reducing discomfort in all aspects examined, particularly when breaks were taken at 20 min intervals.

Furthermore, Galinsky et al. (2000) studied the effects of supplementary rest breaks on musculoskeletal discomfort, mood, eyestrain, and performance in data-entry workers. Discomfort significantly decreased (within different areas of the body) in the group that had supplementary rest breaks compared to the control group. According to Looze et al. (2002), rigid cued break schemes can disrupt the normal activities of work and reduce the willingness of participants to take breaks, and therefore application and timing of breaks need to be carefully considered.

There are a couple of studies that examined the effects of computer-cued exercise breaks aiming to reduces MSDs. In one of them, Trujillo and Zeng (2006) found that, with the 'stop and stretch' cueing software, 52.2% of participants reported a reduction of musculoskeletal symptoms. Looze et al. (2002) investigated how cued micro-breaks in computer operators affected self-reported severity and recovery of upper limb disorders and found that higher percentage of participants that were cued to take extra breaks, reported less deterioration (4%) than the control group (20%) and perceived more recovery (55% vs. 35%). Monsey et al. (2003) examined the effectiveness of computer-cued software in increasing compliance with a stretching program designed to decrease the risk of repetitive strain injury associated with extended use of a computer. The study findings revealed that the software had a positive impact on the frequency of stretching breaks.

The effect of rest breaks on productivity

Studies examining rest breaks and productivity have generally found that either breaks did not have a negative impact on productivity or actually had a positive impact on productivity. Galinsky et al. (2007) examined the effects of supplementary breaks and exercise in data entry operators and found that supplementary breaks reliably reduced eyestrain and discomfort without impairing productivity. However, in practice, the stretch group in the study did not actually perform the stretches during over 70% of the breaks, and therefore it was concluded that stretching had no significant effect neither on discomfort or performance. Furthermore, Trujillo and Zeng (2006) researched data entry worker's satisfaction and perceptions to the "stop and stretch" software and found that 63% of participants thought that the stretch break software had a positive effect on their productivity. So, we can conclude from the limited evidence, that well-timed supplementary breaks can be taken at work without impairing productivity.

Studies from both field (Sundelin et al 1986, Sundelin & Hagberg 1989) and laboratory settings (Sauter & Swanson 1992, Swanson & Sauter 1993) indicate that productivity and wellbeing of an individual can benefit from short breaks from continuous computer work. Rest breaks in these studies occurred every 6 to 10 minutes and lasted between 15 seconds and 3 minutes and were designed to rather supplement than replace common mid-morning and mid-afternoon rest breaks. Similarly, Galinsky et al. (2000) found that data entry performance was maintained when supplementary rest breaks were introduced in data-entry workers. And Dababneh et al. (2001) found out that additional rest breaks did not have a negative effect on productivity in meat-processing plant workers. Furthermore, McLean et al. (2001) concluded from the study that micro breaks showed no evidence of a detrimental effect on worker productivity in computer users.

Summary of rest breaks

Despite the limited amount of research studies, there is a body of evidence suggesting the effectiveness of frequent breaks throughout the day in reducing musculoskeletal discomfort and ill-health. The main findings from the research can be summarised as follows:

1. **Breaks during the working day can help reduce musculoskeletal discomfort** (e.g. Henning et al. 1997 McLean et al. 2001, Galinsky et al. 2007).

2. **Productivity was not found to decrease due to breaks during the working day** (e.g. Trujillo and Zeng 2006, Dababneh et al. 2001, Galinsky et al. 2000).

3. **Computer-cued breaks were superior to non-cued breaks as subjects perceived more recovery of upper limb discomfort when taking computer-cued breaks** (Looze et al 2002).

Effects of exercise breaks

There is considerable general interest in the effects of exercise on musculoskeletal discomfort and disorders as a possible way to decrease the prevalence of occupational MSDs. Researchers have examined the benefits of exercise but many of the studies have run into methodological problems as participants have not performed all exercises for the whole duration of the intervention. Furthermore, in at least three studies (Henning et al. 1997, Van de Heuvel et al. 2003, Galinsky et al. 2007), participants in the 'no exercise' condition walked during most of their breaks, thus reducing considerably the difference between physical activity levels of the two groups. In addition, in several studies, participants in the active break groups did not perform all prescribed exercises or stretches. Therefore, there is a clear need for solutions that provide participants sustaining motivation to perform all the exercises in every exercise break. When this condition has been met and activity levels of the control group are controlled more closely, researchers will be able to provide more accurate evidence on the matter.

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Despite the methodological difficulties, some studies have been able to examine the effects of exercise breaks on experienced musculoskeletal discomfort. For example, Fenety and Walker (2002) examined the impact of regular exercise at a workstation on musculoskeletal discomfort in computer users and found that exercise decreased reported musculoskeletal discomfort at least in short-term. This is in line with findings of Henning et al. (1997) who found that short rest breaks combined with exercise were more effective than passive rest breaks. Probably the most convincing proof comes from the set of studies of Sjögren et al. (2005, 2006a and 2006b) as they had 90 workers in a 15 weeks' cluster randomised cross-over design intervention, performing light resistance training (30% of 1 repetition maximum) and guidance, and 15 weeks with no training or guidance. They found that average training time of 5 minutes per working day decreased significantly the prevalence of headache, shoulder, neck, and low back symptoms and alleviated the intensity of neck and low back symptoms and headache among the symptomatic office workers. Furthermore, the intervention improved subjective physical well-being and after 12 months the work ability, prerequisites of functioning and general subjective well-being were at a higher level than at the baseline. These studies suggest that active recovery would be more effective at reducing musculoskeletal discomfort than passive recovery and that just 5 minutes of exercise per day can bring considerable benefits to both musculoskeletal health, work ability and well-being.

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In addition, to musculoskeletal discomfort, studies have examined eyestrain and effects on productivity. For example, Galinsky et al. (2007) found that additional breaks intended to include stretching breaks reliably minimized eyestrain and discomfort without impairing productivity. Low compliance to perform the stretching exercises prevented a valid assessment of the effects of stretching. Kietrys et al. (2007) investigated the effects of 4-week exercise intervention at work that targeted neck, shoulders and the upper back on 72 computer operators. They concluded that most subjects found the stretching and resistance exercises easy to perform and reported reduced discomfort as a result. Omer et al. (2004) examined the effectiveness of exercise programs in the management of MSDs. The participants performed supervised stretching, mobilisation, strengthening and relaxation exercises, and these were found to reduce the reported experiences of MSD pain and depression levels.

Some studies have also examined and evaluated the prescribed exercises for breaks. Lee et al. (1992) evaluated 127 individual exercises recommended for the prevention of musculoskeletal discomfort and disorders among office workers. They reported that in most cases the prepared instructions for the exercise were satisfactory and that the exercises could be performed at the workstation. However, they reported that half of the exercises would significantly disrupt the work routine. Furthermore, they also noted that over a third of the exercises were conspicuous and potentially embarrassing to perform. These finding highlights that also social aspects of exercises need to be considered when designing interventions for the workplace as often exercises are performed in a public space and it is important that employees don't feel embarrassed performing those exercises.

Summary of exercise breaks

Following main limitations need to be considered when interpreting some of the inconclusive findings for the effectiveness of exercise breaks on musculoskeletal discomfort:

- **The exercises were not performed at every break during part of the studies** (Galinsky et al. 2007, Henning et al. 1997, Van den Heuvel 2003).
- **It is difficult to isolate the effect of breaks per se from exercise,** and in some studies, exercise and non-exercise groups did not have a significant difference in the activity levels of breaks.
- **In some studies, participants in the non-exercise groups were walking** during their breaks decreasing the difference between exercise and control groups.

Following main conclusions can be drawn from the research findings:

1. **Short rest breaks with exercise were more ef-**

fective in reducing musculoskeletal discomfort than passive breaks (Fenety and Walker 2002, Henning et al. 1997).

2. **As little as 5 minutes of exercise per working day have been shown to decrease headache, neck, shoulder and low back symptoms and subjective physical well-being** (Sjögren et al. 2005, 2006a, and 2006b).

3. **Some studies reviewed were found to be inconclusive in their findings** (Galinsky et al. 2007, Kietrys et al. 2007, Lock and Colford 2005).

5 Low back pain and static postures

Low Back Pain (LBP) is defined as a pain that arises from a lower part of the spine, which can be local but can, in addition, radiate to lower extremities (Waddell 2004). It has been suggested that at minimum LBP is defined to be "bad enough to limit your usual activities or change your daily routine for more than one day" (Dionne et al. 2008). Prevalence of LBP is high in all western industrial countries (Waddell 2004) as well as in Africa (Louw 2007). LBP causes a massive burden on the person suffering from LBP, their families, and to social security institutions. Chronic LBP is one of the most frequent reasons for disability and inability to work.

Effects of static postures

In an extended period of static posture, the passive and active systems are under stress. If a constant (or a repetitive) longstanding stress is applied to collagenous tissue, the tissue slowly starts to lengthen through this force. After several hours of loading, the recovery of the collagenous fibres is not immediate and the structures remain elongated (hysteresis) (Bogduk 2008, King et al. 2009, LaBry et al. 2004, Solomonow 2009). With animal models, it has been shown that 7 hours of creep causes a hysteresis that lasts for about same 7 hours in relaxation (King et al. 2009, D`Ambrosia et al. 2010). Loading of the ligaments (cyclic or static) causes an increase in markers of inflammation (D`Ambrosia et al. 2010, King et al. 2009, Solomonow 2006). This phenomenon is thought to explain cumulative trauma disorder (CTD) (Solomonow 2006, King et al. 2009). With passing time, the structures get adapted to these new positions and the collagenous fibres remain elongated and do not return to their original lengths.

The strain of the tissues can cause nociceptive pain. In a normal situation, the individual would change position automatically due to the pain. However, it has been hypothesised that some people habituate to this and stop noticing the slight pain and actually become accommodated to incorrect postures. It would be an interesting topic of research to examine whether exercise breaks decrease the tendency of individuals to accommodate incorrect postures and subsequently sit in better postures, and that way decreasing the risk of musculoskeletal disorders.

> "…some people stop noticing the slight pain and actually become accommodated to incorrect postures."

One common incorrect posture is to sit with flexed lumbar spine. Prolonged flexion of the lumbar spine causes tension-relaxation phenomenon and subsequent laxity of its viscoelastic structures (Williams et al. 2000). During prolonged flexion muscle called multifidus is first to react with spasms (verified by muscle activity measurements), but after 2 to 3 hours of loading, muscle activity decreases considerably. This exposes the spine to a considerable risk of instability (Youssef et al. 2008, Le et al. 2009). It has been found that a static flexion loading for 20 minutes caused a considerable decrease in muscle activity of multifidus muscle, which did not recover in the following 7 hours (Jackson et al. 2001). It has also been shown that longstanding static and cyclic (6 times 10 minutes for 40 Newtons) loading in flexion causes the loss of viscoelastic tissue compliance (Arabadzhiev et al. 2008, Olson et al. 2009). The risk of cumulative musculoskeletal disorder (CMD) increases with increasing number of repetitions, (Sbriccoli et al. 2007) and is a typical reason in over-use syndromes, where the pain originates from the myofascial system.

Incorrect posture and musculoskeletal problems

Many of the aches, pains and musculoskeletal problems of adults are the result of the long-term effects of incorrect postures or body misalignment. For example, postural kyphosis (excessive rounding of the upper spine) in adolescence may be a result of poor sitting and standing habits. Scientific studies have linked poor posture to several health problems and concerns, including back pain, neck pain, spinal stress, reduced lung capacity, joint and muscle injury, headaches, fatigue, high blood pressure, stroke, higher susceptibility to injury, and even dental problems and diabetes.

Furthermore, multiple studies have found an association between poor work posture and back pain (e.g. Nowotny et al. 2011, Wong et al. 2009, and Tissot et al. 2009). Studies have shown that prolonged static trunk flexion can subject the spine to reduced muscle activity of multifidus (Williams et al. 2000), provoke flexion relaxation phenomenon of the thoracic erector spinae (resulting in the creep response of the tissues of lumbar spine) (e.g. McGill & Brown 1992), reduce the oxygenation of lumbar extensors due to the constant isometric contraction (McGill et al. 2000), and increase the intradiscal pressure (Wilke et al 1999). The effects of incorrect posture also include disturbances of the symmetric distribution of tensile and compressive forces acting on both sides of the body and the emergence of harmful shear forces. Additionally, the torques of antigravity muscles also change unfavourably. This may lead to the development of a repetitive strain syndrome, compression of nerve roots, stenosis of intervertebral foramina, and back pain (Nowotny et al. 2011) therefore highlighting the importance to avoid poor work postures and have enough variation in postures and tasks throughout the day.

Task variation

Task variation in repetitive work has been an area of interest as it can possibly alleviate fatigue and the risks of MSDs. Task variation includes changes in task characteristics, postural changes, and breaks. Especially important are breaks that include an exercise regime, or a change in posture from that used when working. Even though there is rather little high-quality scientific evidence about positive effects of variation in postures, there is general agreement among clinicians and researchers that variation is better than static postures that are held in extended periods of time. Increased variability between job tasks of an individual can be achieved by introducing new tasks that vary in the movements and postures required (Moller et al., 2001, HSE, 2002, Canadian centre for occupational health and safety, Brown & Mitchell, 1988, Ergo in demand, Occupational safety and health, 1991 and the Swedish work environment authority, 2005). Similarly, performing exercises can be considered as a way of providing a variation of movement and posture. Exercise breaks or conventional rest breaks provide a way of increasing 'variation' in the job without requiring work tasks to be reallocated among workers. Therefore, different kind of breaks provide a practical way to decrease the risk of musculoskeletal disorders and is one of the most frequently recommended interventions against musculoskeletal disorders (Konz 1998).

> "There is general agreement among clinicians and researchers that variation is better than static postures that are held in extended periods of time."

6 Costs of chronic health conditions

Collins et al. 2005 have done one of the most comprehensive survey to provide the overall picture of the costs of chronic health conditions in a diverse workforce. They found that among employees reporting at least one primary condition, the highest total cost per worker was for those reporting depression, anxiety, or emotional disorder as their "primary health condition" (absenteeism-related costs close to $15,000 annually per person with the condition).

Researchers also reported that absenteeism-related costs for back and neck pain were approximately $1,000, for heart or circulatory-related conditions $800, and for diabetes $500 (annually per person influenced with the condition). In addition, and more importantly cardiovascular disease, diabetes, and back and neck disorders each causing over $5000 costs per person influenced due to work impairment (i.e. presenteeism).

When weighing these values by the survey prevalence of each condition studied in their survey across all U.S. workers within the company, the average costs per employee were $2,278 for medical care, $661 from absenteeism, and $6,721 from work impairment. Projecting these values to the entire U.S. workforce of the company studied, the total cost estimate was 10.1% of total labour costs: 1.0% resulting from absenteeism, 2.3% from the use of medical care, and 6.8% from presenteeism.

Chronic health conditions are common, cause considerable costs, and have the potential to significantly impact the financial performance of companies in different fields. Traditionally, most management attention has focused on direct medical costs and absenteeism, although there is a far greater loss of productivity resulting from decrements in presenteeism, representing a substantial management opportunity as well as a compelling opportunity for different health-related solutions.

As breaking of sedentary behaviour and increase in physical activity have been scientifically proven to decrease the occurrence and alleviating the symptoms of chronic health conditions (e.g. Healy et al. 2008; Booth et al. 2012), it is clear, that correct actions in the workplace can considerably decrease the occurrence of these conditions. This would subsequently reduce the costs related to lost productivity.

Summary of costs

Following conclusions can be drawn from the cost of chronic health conditions:

1. **Mental health problems had the highest costs** per person influenced.
2. **Costs related to presenteeism were almost 7 times higher** than the costs of absenteeism.
3. **The total costs of chronic health conditions can be 10% of total labour costs.**

7 Productivity losses due to musculoskeletal disorders

While the earlier chapter gave a general idea of costs related to back and neck problems, this chapter examines more closely productivity losses related to musculoskeletal disorders. Whilst the risk factors and aetiology for musculoskeletal disorders in computer users have been well studied (Hagberg & Sundelin 1986, Ong 1992, Hales et al. 1994, Jensen et al. 2002, Gerr et al. 2004, Lassen et al. 2005) the impact of disorders on productivity has not been examined thoroughly. The main reason for the dearth of information is that data regarding productivity is difficult to measure.

That is because commonly computer users perform a wide variety of tasks making the productivity of an individual difficult to measure. Hagberg et al. (2002) further stated that job relevant productivity cannot be accurately expressed by simple metrics such as keystrokes per minute, duration of telephone calls, or duration of computer use since the output is based on innovation, synthesis, and reflection. Another, and often more relevant, way to assess productivity is to have the employee rate their productivity by themselves.

Costs of presenteeism related to musculoskeletal discomfort

Hagberg et al. (2002) assessed self-reported levels of reduced productivity in computer users and whether those were due to musculoskeletal symptoms. The results showed that 76% of men and 87% of women reported musculoskeletal symptoms and of these 11.2% and 9.2% reported reduced productivity due to the symptoms. For 8.3% of men and 6.1% of women, this reduced productivity did not involve sickness absence. The average self-reported reduction in productivity was 13% for men and 15% for women. It was found that the persistence of symptoms was a strong predictor for reduced productivity.

The authors of the study calculated that for an employee (in the study group) the mean loss of productivity was 16.8 hours per month. As lowered productivity without sick-leave was reported by 8.3% of the men, this equals 1.4 hours lost work per month per employee on average (the corresponding figure for women being 1.0 hour). If salary and associated costs for employees are $4,800 per month then losses due to decreased productivity (without sick leave) can be estimated to be $42 (1.4 h/160 h) x $4800) per month per employee for computer user men. In a company with 50 employees, this would mean an additional "hidden" cost of $25,200 per year.

Findings of the study were supported by the study of Van den Heuvel et al. (2007), who investigated self-reported productivity losses in computer users with neck/shoulder symptoms and hand/arm symptoms (n=654) in the preceding three months. Productivity loss was reported by a total of 8.6% of employees but only 2.6% of them reported that being due to sickness absence. This means that approximately only one-third of workers reporting productivity losses due to musculoskeletal symptoms actually do take sick leave. Pain intensity, low job satisfaction and high effort were identified as being associated with productivity loss. The results indicate that the consequences of musculoskeletal symptoms are more extensive than the visible sickness absence due to these symptoms.

> "...only about one-third of workers who report productivity loss due to musculoskeletal symptoms actually take sick leave."

Summary of productivity losses

Although there are only a few studies which have examined the effects of musculoskeletal disorders and discomfort on productivity, following conclusion can be drawn from those studies:

1. **Absenteeism is not the only source of lost productivity** resulting from musculoskeletal disorders and discomfort.

2. **Experiencing discomfort while still present at work (presenteeism) results also in a loss of**

productivity for rather a considerable part of workers (reported as 6% to 9% of workers).

3. **Both psychosocial and physical factors have their influence** on productivity losses due to musculoskeletal symptoms.

4. **Productivity loss estimates are a possible way to calculate the 'hidden' costs** of musculoskeletal discomfort and disorders.

5. **By targeting corporate wellness interventions to the factors associated with the loss of productivity** due to musculoskeletal symptoms an organisation can improve productivity and get a better return on investment for wellness interventions.

8 Guidelines related to breaks for computer users

Breaking up long periods of computer work can help prevent fatigue, eye strain, upper limb problems and discomfort in the lower back. Where the computer work involves intensive use of the keyboard or mouse, any activity that would demand broadly similar use of the hands or arms should be avoided during breaks. Furthermore, if the computer work is visually intensive any activities during breaks should be of a different visual nature. Breaks should also allow users to vary their posture and it is recommended to have the break in a different posture than that used when working. Exercise routines (for example stretches, upper or lower body exercises, blinking of the eyes) can be helpful and beneficial during breaks. Stretches and exercises can help to combat adverse health effects (such as reduced blood flow and changes in metabolism) arising from the sedentary nature of most computer work. Brief stretching exercises can be performed whenever necessary and not only during formal breaks.

Demands and nature of the job determine the requirements of the breaks, their timing and duration and therefore it is difficult to give detailed guidelines for breaks. These general guidelines apply for most jobs and should be followed when designing breaks:

1. **Breaks should be included in the working time.** They should reduce the total workload, i.e. the introduction of breaks should not result in a higher intensity or pace of work.

2. **Breaks should be taken when performance and productivity are still close to maximum** and before the user starts to get tired. This is better than taking a break to recover from considerable fatigue. Appropriate timing of the break is probably more important than the length of the break.

3. **Short and frequent breaks are more effective** than occasional, longer breaks: for example, a 2-5 minute break after 30 min of work is more beneficial than a 15-20 minute break every 2 hours.

4. **Employees should be allowed some discretion when to take breaks** and how to carry out tasks wherever practical. Individual control over the nature and pace of work allows for distribution of effort over the working day that considers differences between individuals. However, if employees do not take proper breaks (despite being trained), it may be necessary for employers to lay down minimum requirements for breaks.

5. **Changes of activity and posture appear to be more effective** than formal rest breaks in relieving visual fatigue.

6. **Breaks should be taken away from the workstation, and give employees the possibility to stand up, move about, and change posture.** Furthermore, employees should be discouraged from using the computer during breaks for any purpose.

7. **Employers should ensure that employees are given adequate training and information** on the advantages and need for breaks.

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