INNOVATIVE ERGONOMIC SOLUTIONS

Sitting Disease – Working Postures and Alternative Workstations

December 2014

Prepared by:
David M. Antle, PhD, CCPE
Linda L. Miller, OT (D), CCPE
Ph.: 780-436-0024
www.ewiworks.com

At **EWI Works**, occupational ergonomics is our core business. Our commitment to providing effective solutions, rather than just simply identifying issues, has allowed EWI Works to stand apart from other service providers.

Corporate Office:
Unit 201, 5677-99 Street
Edmonton, Alberta, T6E 3N8
Tel: +1 (780) 436-0024
Fax: +1 (780) 436-0092
Email: info@ewiworks.com
www.ewiworks.com

Introduction

Recent biomedical research has noted prolonged hours working in a seated occupation is associated with the development of various health/wellness concerns. This topic has received a great deal of coverage in local, national and international media, and the impact of working postures has become a key component of office-based occupational health and safety. The issues associated with seated work have also led to a proliferation of furniture and devices designed to increase the amount of standing and movement in an office environment.

Particularly popular trends for office furniture changes are to move to using a height adjustable work surface that allows a user to stand and use his/her workstation. These 'sit-stand' desks vary in terms of their design and specifications, and are available from a number of suppliers. An alternative to a fully adjustable desk includes devices that attach or mount on existing furniture and allow adjustment of the workstation's monitor, mouse, keyboard, etc. to a standing work height. In both cases, these devices are often marketed as a mean of reducing musculoskeletal symptoms and improving physical activity levels and cardiovascular health at work. However, improvement of musculoskeletal symptoms is only possible for specific conditions, and there has been limited evidence to support metabolic and cardiovascular benefits of standing during office work.

Other trends involve the use of workstations that have stationary bikes and treadmills attached, allowing a user to exercise while performing work in a stationary position within an office environment. While evidence does suggest a cardiovascular and metabolic benefit to these workstations, these benefits may come at the expense of musculoskeletal comfort/health, visual comfort/health and performance efficiency and quality. Investment and use of these devices requires considerable research and evaluation before they can reasonably be applied in a workplace.

The purpose of this document is to review the issues associated with seated and standing work postures in an office context. Evidence to support the use of a sit-stand desk or device for help with specific musculoskeletal conditions is presented, along with a review of specific conditions that are unlikely to benefit from sit-standing desks/devices. In addition, biomedical literature comparing metabolic and cardiovascular outcomes of seated and standing office work is presented. We have also outlined available literature related to exercise-based workstations, and their potential office application. Work environment and organizational considerations for use of standing desks/devices and exercise-based workstations is also presented.

This document is intended to serve as a guide to stakeholders and employees when determining whether sit-stand desks/devices or exercise-based workstations are appropriate for an individual/context. In addition, this document will also outline alternative strategies to reduce seated work and improve movement/activity in the workplace.

Prolonged Seated Work and Health Effects

Seated work is noted to be the most comfortable whole-body posture in most work contexts (1), particularly for lower limb comfort (2-4). However, seated work postures are increasingly recognized for their associations with various health concerns related to sedentary behavior (5). It seems that the general decrease in daily physical activity levels may be impacted more by decreased activity in workplaces, than a general decrease in physical activity during leisure time (6). This is an important concept to consider, as there are differences between "sedentary behaviors", commonly associated with seated office work, and being "insufficiently active" (7). For example, an individual may complete 60 minutes of vigorous exercise during their leisure time to meet recommended physical activity, but if that individual spends 8-12 hours per day in a seated position the overall level of their physical activity for the day may not be sufficient.

Total sedentary time during a work day can be broken down into 1) occupational, 2) leisure time (social events, films, etc.), 3) transport-related, 4) domestic (television viewing, meals, etc.) (7). Individuals with greater domestic, transport and leisure time sedentary activities have previously been noted to have increased risk of adverse health effects (7-10), and health promotion has targeted awareness of the benefits of increasing daily physical activity. The focus has now shifted to analyzing the impact of occupational sitting on one's health, and determining what reasonable courses of action may be taken to reduce adverse health effects of office work. Media outlets have termed potential impacts of seated office work on health as *"sitting disease"*. In this section of this document we review biomedical evidence to determine whether seated office work is associated with obesity, metabolic diseases, cardiovascular disease and cancers – which are the most common issues related to *sitting disease*.

Obesity

It is interesting to note that some research has shown that individuals who perform seated work are more likely to engage in physical activity in their leisure time, but seated work is also associated with an increased risk of being overweight/obese (6, 11, 12). It has long been established that being overweight/obese is associated with increased risk of cardiovascular disorders, type 2 diabetes, musculoskeletal discomfort, and other associated health effects.

Prolonged bouts of seated work in office environments demand limited energy expenditure. Changes to technologies in offices have led to reduced need for face-to-face interaction and transit within the workplace. This increase in sedentary seated work, combined with a general maintenance of daily caloric intake, are cited as key reasons for a slow but generally steady increase in adiposity among workers. Reversing this trend is a required focus for meaningful intervention. Increasing caloric expenditure at work, along with dietary considerations, is required to reduce the risk of workers being overweight/obese.

Diabetes

An increased risk of developing type 2 diabetes from occupational sitting may be related to the increases in obesity. Limited research directly investigated associations between office-based sitting and diabetes, and in the available research there is no consensus on a link. Some research shows there to be a relationship between sitting and diabetes, while other research in different regions and contexts fail to demonstrate the relationship (13, 14).

It seems most plausible that development of diabetes mellitus is multifactorial. Occupational sitting and being overweight/obese plays a role, in addition to the level of domestic and leisure-based physical activity, diet, as well as environmental and social factors.

Cancers

Cancer development is also multifactorial, but there is some evidence of occupational sitting playing a role. A recent review article noted that seated occupations are associated with higher risk of mortality from cancers among women, but not men (7). Associations with specific types of cancer and occupational sitting have not been extensively researched, but occupational sitting was found to have a higher risk for development of endometrial cancers (15) and colon cancers (16), while a general lack of physical activity during leisure time was noted to result in a higher risk of prostate (17) and ovarian cancers (18). Overall, the rates of cancer in seated occupations are very low for the entire population, but risk for development may in impacted by sedentary behaviors at work and during leisure time.

Corporate Office:
Unit 201, 5677-99 Street
Edmonton, Alberta, T6E 3N8

Tel: +1 (780) 436-0024
Fax: +1 (780) 436-0092

Email: info@ewiworks.com
www.ewiworks.com

Cardiovascular Disease

Among popular media and furniture company marketing materials, the detrimental effects of seated office work on cardiovascular health are most commonly mentioned. The negative impacts of sedentary behavior and limited physical activity on cardiovascular health have been well documented in biomedical research. However, it is important to consider both leisure time and occupational activities, rather than focussing only on the occupational exposures. A recent set of review articles have noted that occupational sedentary behaviors, on their own, do not have a strong association with cardiovascular disease (7, 8, 13, 19), while increased sitting and a lack of physical activity during leisure time does have an association (6, 10, 13, 19). Although, individuals who are seated at work, and have limited physical during leisure time, the risk of cardiovascular disease is much higher (7, 19).

Based on this available evidence, total physical activity in a day is a more important factor in development of cardiovascular disease. If an individual has sufficient levels of physical activity outside of work, they are much more likely to gain cardiovascular benefits. However, promotion of movement at the workplace seems to provide an additional benefit when the individual is active outside of his/her employment (20), and if you are inactive for an entire workday some of the benefits of leisure time exercise may be lost (21). This evidence suggests that employers and employees should promote increased movement and walking at work, but this should be in tandem with health promotion strategies in leisure time.

Key points from this section:

1. Increasing physical activity at work is important to reduce risk of being overweight/obese, and associated health issues

2. Increasing physical activity both at work and during leisure time will reduce risk of developing some types of cancer. Particularly for women, who have a higher risk of cancer-related mortality if they work in seated occupations.

3. There is no evidence that seated postures at work, on their own, are associated with diabetes mellitus.

4. There is no evidence that seated postures at work are directly associated with cardiovascular disease. However, seated postures during leisure time are associated.

5. Improving physical activity at work, in addition to leisure time physical activity, has a cardiovascular benefit.

While obesity and mild increases in cancer risk are a concern within the concept of "Sitting Disease", cardiovascular issues and diabetes mellitus ARE NOT directly associated with seated work postures. Although, increasing physical activity at work can contribute to general health improvements and reduced risk for all of these health concerns.

Sit-Stand Desks as an Intervention to Improve Health in the Office

The previous section clearly outlines that there are some issues associated with prolonged seated work, particularly as it relates to reduced daily physical activity. One common workplace intervention that was designed to reduce seated work is a sit-stand desk, or device, which allows the user to work at a computer workstation while using a standing posture. The use of these desks and devices has become increasingly popular, with the general marketing of the desk being associated with the desks allowing an increase in energy expenditure and physical activity while in the office. In this section, we will review the potential benefits of a sit-stand desk, the potential negative effects of prolonged standing work, and review the validity of claims that standing work leads to increased levels of energy expenditure.

Potential Musculoskeletal Benefits of a Standing Posture

Standing posture can allow for a more neutral position of the spine and allow increased whole-body contributions to movements (1, 22). In seated work, back, neck, shoulder and upper limb discomfort is more common than in standing (1, 23), and allowing office workers to work in a standing position has been noted to be a potentially effective intervention to reduce musculoskeletal complaints and improve overall performance. Yet, the impact of such an intervention is mixed. Some studies show rotation to benefit arousal, reduce boredom and have no negative impact on performance, but also have no effect on reports of discomfort (24, 25). Meanwhile, other studies show that implementation of sit and stand rotation results in reductions of physical discomfort (26, 27), with those suffering from previous musculoskeletal symptoms more likely to use rotation (28).

In healthy individuals, without diagnosed injuries, there is no evidence that seated postures result in higher levels of intradiscal pressure when compared to standing (29). However, from a biomechanical perspective, individuals who have spinal disc protrusion, herniation, and other structural issues in the lower back may be negatively impacted by prolonged seated posture and are most likely to benefit from use of standing workstation in an office. While seated, position of the spine is adapted and this results in alterations in compression and shear force magnitude and distribution. With a damaged or protruded spinal disc, the seated position and associated forces may aggravate symptoms. Using an upright, standing, posture allows the lower back to return to its natural "S-Shaped" position and reduces the stress on the injured tissue. While there are no peer-reviewed biomedical articles that review the impact of standing postures on disc injuries, anecdotally, ergonomists and health care professionals have noted standing postures reduce symptoms among individuals with disc protrusion and/or injury, sciatica, and injuries to surrounding tissue.

We should also consider back pain that is not related to spinal disc issues. A study showed that increased trunk flexion during prolonged sitting required only low levels of activity in lower back muscles (30). This lead the authors to hypothesize a seated injury/discomfort mechanism for the lower back whereby sustained stretch of passive lumbar structures, in combination with low levels of muscle activity, would exacerbate low back pain in workers who sit for a prolonged amount of time (30). In a standing position, increased activation of trunk musculature may reverse the passive stretching and provide relief. This may explain why standing and/or walking after a period of prolonged sitting provides relief of back pain in some individuals.

For an office work context, upper limb activities are limited in force requirements and magnitude of movement/reach. Therefore, provided the seated workstation has been properly fitted and adjusted, it is unlikely that standing work will provide any different outcomes for the shoulders, upper back and upper limb. Relief of these musculoskeletal symptoms can most likely be achieved with ergonomic adjustments to a seated position, rather than adapting to use a standing posture.

There are instances where various hip and lower limb conditions may require frequent alternations in posture to prevent aggravation of symptoms. For example “movie goers knee”, “runner’s knee”, and damage or tightness of soft tissue surrounding the hips and knee. However, these conditions and the potential benefits of using a standing desk have not been critically reviewed in biomedical literature.

Potential Risks Associated with a Prolonged Standing Work Posture

Back Problems

While the use of sit-stand desks is common when attempting to reduce back symptoms, standing work posture is also associated with back issues. In a recent review by Roffey et al. (2010) and Bakker et al. (2009) standing work did not meet their criteria for evidence of association with lower back pain (31, 32). However, these review articles did not include research conducted in occupational biomechanics and ergonomics fields. Research in Québec has noted back pain to have an association with prolonged standing work situations where workers do not have the ability to sit at will (33). Another study found that working greater than 30 minutes per each work hour in a standing position is a strong predictor of developing low back pain (34). Back pain was also noted to develop in 55% of a sample population after 45 minutes of standing, and 15 minutes of sitting was not enough to mitigate the back pain during repeated bouts of standing (35).

Some research has noted that hip musculature activation patterns during static standing can influence stiffness throughout the hip and lower back (36-39), potentially influencing postural sway patterns (40, 41). This motor control and movement strategy may play a role in the development of back pain while standing still at an office workstation. These movement and muscle activation patterns appear to differ between individuals who suffer back pain and those who do not (36-39), and the research suggests that a pre-existing motor control pattern can predispose a large percentage of the population to develop low back pain during prolonged standing work.

Although the mechanism of discomfort may be different, prolonged time spent in a standing position can result in back discomfort. While standing for a short period of period of time can relieve back discomfort associated with sitting, too much time spent standing may contribute to back discomfort as well. Therefore, standing work should be frequently alternated with seated work and walking breaks to mitigate back discomfort. Standing for more than 30 minutes has been noted to lead to back discomfort in several studies (35-37, 42, 43).

Lower Limb Discomfort and Vascular Problems

In addition to discomfort in the back, prolonged standing work has also been linked to reports of discomfort in the lower limb (3, 44). It was previously found that over 60 minutes of work, the amount of muscular fatigue in the lower limb was significantly higher during stationary standing work positions, particularly when compared to a condition where walking was allowed between tasks (45). This suggests that muscular fatigue is a factor in the development of lower limb discomfort in stationary standing work. However, there is also evidence to suggest that discomfort might be related to increases in lower limb blood pooling and oedema that places pressure on lower limb tissues (2). As upright, bipedal animals, healthy humans have built-in mechanisms to prevent excessive blood pooling in the lower limb as a result of gravity. These mechanisms include venous valves that can prevent the backflow of blood once it enters the veins of the lower limb, and the reliance on dynamic muscular contractions and movements of the lower limbs during walking/running to help pump venous blood centrally, back toward the heart (46). However, over the workday, with limited dynamic movements for long periods of time, blood begins to pool in the lower limb. This blood pooling could increase the pressure placed on tissues in the lower limb and therefore increase sensations of discomfort (47, 48). The effect of static standing during work operations on blood volume

Corporate Office:
Unit 201, 5677-99 Street
Edmonton, Alberta, T6E 3N8
Tel: +1 (780) 436-0024
Fax: +1 (780) 436-0092
Email: info@ewiworks.com
www.ewiworks.com

accumulation and blood pressure in the lower limb was confirmed during industrially-modelled tasks in recent experiments by Antle et al. (42, 43). It is likely that this is also the case with office-based standing work.

Blood pooling in the lower limb can also have lasting effects for the employee in the form of vascular disorders (49). Medical and epidemiological literature has hypothesized that standing longer than 75% of the workday can lead to prolonged hydrostatic venous pressures (50). Epidemiological studies have shown that prolonged standing work is associated with the development of varicose veins and other peripheral vascular disorders (51-55). While there may be a mild reduction in brachial blood pressure during a long bout of standing work, the resulting increase in lower limb blood pressure and volume accumulation may lead to a higher systemic cardiovascular load (42, 43, 48).

Standing work bouts of even less than 30 minutes can lead to blood volume shifts (42, 43, 56). Therefore, this provides further evidence that static standing work would require frequent seated or walking breaks to prevent onset of vascular issues.

Energy Expenditures during Standing Work

Many sit-stand desks/device advertisements claim that standing at work during office tasks allows you be more active, improving your overall cardiovascular health and burning more calories to combat risk of being overweight/obese. However, these claims are often made without any biomedical evidence to support them.

While standing still, or with limited displacements, there is limited energy expenditure. Without walking or movement of some kind, muscle activation and metabolism remains at a relatively base level. Maintenance of the standing posture demands very little in terms of increased cardiovascular or energy demand. Recent research has compared energy expenditure during both seated and standing office work. One published article reports there is no significant difference between the positions (57). A review article evaluating a wider base of evidence and office working postures states that the evidence clearly shows that sit-stand desks alone will not provide meaningful increases in energy expenditure (58). In fact, it is estimated that standing for an entire workday would burn only 32 additional kcal when compared to seated work; therefore, it would take over 220 full 8-hour working days using only a standing posture to burn 1 kg of body fat (58).

There are also arguments that by standing more during office tasks, employees are more likely to walk throughout the workspace. While this claim has not been evaluated extensively, one intervention study using traditional and sit-stand workstations found that while the employees with sit-stand desks alternate more between seated and standing positions, they do not walk throughout the office any more than those who use a traditional seated workstation (59).

Key points from this section:

1. A standing office work position can help to reduce musculoskeletal discomfort and symptoms for various spinal disc problems and back issues. Other body regions are unlikely to be benefitted from using a sit-stand desk.
2. Too much time spent in a standing office work position can lead to back discomfort, although the pathway for the discomfort may differ from seated discomfort. Frequent rotation with sitting and walking is required for proper sit-stand desk use.
3. Too much time spent in a standing office work position can lead to lower limb discomfort and peripheral vascular issues/disorders. Frequent rotation with sitting and walking is required for proper sit-stand desk use.
4. There is no evidence that standing office work postures provide any cardiovascular or energy expenditure benefits over a seated work posture.

Sit-standing workstations can help employees with back discomfort or issues with spinal discs (herniation, protrusion, sciatica) prevent aggravation of symptoms. However, standing work can lead to back discomfort, lower limb discomfort and lower limb vascular disorder risk if used for excessive durations. Frequent alteration of standing work with seated work and walking breaks is recommended.

Additionally, standing office work DOES NOT increase physical activity or energy expenditure to any significant degree beyond levels required in seated work. Claims to the contrary lack scientific evidence.

Corporate Office:
Unit 201, 5677-99 Street
Edmonton, Alberta, T6E 3N8
Tel: +1 (780) 436-0024
Fax: +1 (780) 436-0092
Email: info@ewiworks.com
www.ewiworks.com

Exercise-Based Office Workstation Interventions

Workstations that involve treadmill walking or cycling are relatively new in design. Their application in offices has become increasingly popular over the last 5 years and they are now used by a small percentage of the population. Because these workstations are relatively new, particularly in terms of their application among the general working population, limited research is available regarding the potential benefits and negative effects that might be associated with their use. In this section we report on the potential physical activity and health benefits of using an exercise-based workstation, as well as discuss performance outcomes associated with these workstations and potential musculoskeletal and visual discomforts that may be associated with an exercise-based workstation.

Potential Physical Activity and Cardiovascular Benefits of an Exercise-Based Workstation

Based on a review of published biomedical research, it was noted that standing workstations present no appreciable benefit to improving physical activity levels at work, but active, exercise-based, workstations did provide a tangible benefit (58). Workstations that involve use of treadmills, designed to allow relatively low walking speeds of 1.6 to 3.2 km/hour while completing office tasks, have been noted to increase energy expenditure up to 2.7 times base metabolic rate, representing an individual being able to burn up to 100kcal/hour (58, 60, 61). Given that 1 kg of body fat requires approximately 7750 kcal of energy expenditure to burn, a treadmill desk would require 77.5 hours of total use to lose one kilogram; this is tremendously more efficient than using a standing-based office workstation, where it is estimated that 1292 working hours while standing would be required to burn 1 kg of body fat (58). Still, energy expenditure using a treadmill desk must be evaluated knowing the total durations employees use the desk throughout a day. Studies suggest that employees will use a treadmill workstation for 30 to 90 minutes per day (62, 63), although this number will vary between individuals and their training state. Based on use of the treadmill for 30 minutes per day, an estimated increase in energy expenditure of 50 kcal/day and with an assumed maintenance of caloric intake, this would require a total of 155 working days for an individual to lose 1kg of fat. This represents 2.35 kg of fat loss per year with these numbers. If an individual used a treadmill workstation for 90 minutes per day, this would correspond to 7 kg of fat loss per year.

Far less is known about energy expenditure outcomes with seated pedaling devices. However, a study evaluating heart rate responses while using seated pedaling did note similar increases in heart rate responses that would be common with use of a treadmill workstation (58, 64). This would suggest that pedaling workstations have the potential to produce similar benefits to energy expenditure as those seen with treadmill workstations.

One study that evaluated various health outcomes after use of a treadmill workstation for 1 year noted that there was a general reduction in body weight averaging about 1.4 kg, and average reduction in waist circumference of 4 cm (63). The authors noted that these changes were relatively minimal when considering the investment (~$3000-$15 000) to attain treadmill desks. However, when the authors looked at data from “normal” weight individuals and obese individuals, their results suggest that those who are overweight tended to benefit most from the workstation intervention. They noted that perhaps individuals in healthier weight ranges had already been taking advantage of other means of improving daily physical activity (subsidized gym memberships, increased leisure time physical activity) while the obese individuals only exposure to physical activity was the treadmill workstations.

The increases in daily physical activity, although modest if used for only 30-90 minutes, can also be accompanied by improvements in cardiovascular fitness. One study noted a small decrease in systolic blood pressure following a year of using treadmill workstations (63). These increases in physical activity can also lead to modest improvements in cholesterol levels (63).

While active, exercise-based, workstations show benefits to physical activity and overall health, these gains are relatively modest. In truth, benefits to weight loss/maintenance and cardiovascular health are much smaller than is typically reported with leisure time exercise and nutritional interventions. This level of activity may be effective in preventing increases in adiposity for an individual, provided caloric intake remains equal, but it may not account for a great deal of weight loss. However, it appears that an exercise-based workstation intervention may be more effective for individuals who do not include physical activity as part of their leisure time. Based on available data, investment in a treadmill or pedaling based workstation as a means to improve fitness, health and wellness would not represent as great a rate of return as use of gym subsidies, or office-based fitness programs during breaks or before work.

Potential Negative Effects of Exercise-Based Workstations

Musculoskeletal and Visual Discomfort

While there has been a limited amount of research on exercise-based workstations, some key comfort and performance detriments should be noted. There has not been any research that has investigated musculoskeletal disorder complaints associated with prolonged use of these workstations. However, it is highly likely that employees only use the exercise-based workstations for 30-90 minutes within a workday because it is associated with the onset of fatigue and discomfort in the lower limb, trunk and perhaps in the neck/shoulder. Furthermore, with the arms in a fixed position while walking or pedaling, and the lower body and trunk producing muscular action, there may be risks of increased loading and postural risk factors for the lower back.

It is also worth considering that visual symptoms are becoming increasingly common with office work, with 40-90% of the population reporting symptoms associated with computer vision syndrome (65-67). These visual symptoms are impacted by image quality, stability and movement (68). Head and whole-body movements associated with active, exercise-based, workstations may worsen visual symptoms. In addition, there have been associations between visual issues and development of discomfort in the neck/shoulder region (69), so movements that lead to eye strain might also lead to aggravation of symptoms in this region. Unfortunately, there have been no studies that have evaluated visual outcomes and comfort when using these types of workstations.

With no longitudinal studies on the impact of active, exercise-based workstations on back and upper limb postural outcomes, musculoskeletal disorders or visual discomfort, their application in the workplace should be cautioned. While there may be some physical activity benefits to using these workstations, further research is required to understand their effect on other physical outcomes. Until such research is available, it would not be recommended for employers to supply these workstations for general office tasks.

Productivity Impact

Performing physical activity while completing office work may have an impact on the speed and accuracy of computer based tasks, such as typing and mousing. A review article found conflicting evidence related to typing performance and a treadmill workstation, with some research showing no difference in typing performance when compared to seated work, and other research showing a reduction in speed (58). A study evaluating transcription of recorded voice to text using seated and treadmill workstations found that speed of transcription was slower when participants used the treadmill workstation (62). The efficiently and accuracy of mouse-based tasks appears to be more impacted by treadmill workstations, and researchers suggested that a walking workstation would not be appropriate for mouse intensive work (64). Few studies have evaluated the impact of pedalling workstations on typing and mousing, but of those available there appears to be a detriment to performance, although not to the same level as the treadmill workstations (64).

Based on the evidence available, consequences of using an active, exercise-based workstation may include small losses in performance. This should also be considered when considering investment in these workstations.

Key points from this section:

1. An active, exercise-based workstation will increase physical activity levels during its usage, by approximately 100kcal/hour. However, employees typically only use the exercise-based workstation for 30-90 minutes per day, equivalent to 50-150 kcal/day additional energy expenditure when compared to traditional office workstations.
2. When evaluating the benefit of the investment in an exercise-based workstation in terms of physical activity and weight maintenance/loss, realistic expectations for use of the exercise-based workstation need to be considered. If it is only used for 30-90 minutes per day, the gains are very modest.
3. Obese individuals appear to gain more benefits from exercise-based workstation than “normal” or “healthy weight” individuals.
4. The use of an exercise-based workstation may present risk factors for musculoskeletal disorder or visual discomfort/disorder. However, this had not been evaluated in biomedical research.
5. Productivity may be negatively affected while using an exercise-based workstation.

The use of active, exercise-based workstations should be cautioned until there is more evidence to support their use without detriments to musculoskeletal and/or visual health. Furthermore, gains in physical activity from using these workstations should be evaluated against other methods of improving physical activity at the workplace and during leisure time. These concepts are discussed later in this document.

Guidelines for Proper Set-up and use of Sit-Stand Workstations

Based on the available evidence found in biomedical research, it would not be recommended to use active, exercise-based workstation without further evidence regarding their outcomes. However, evidence does suggest that a sit-stand desk may be appropriate for individuals with specific musculoskeletal issues for the lower back, or medical conditions that require variations in posture to prevent aggravation of symptoms. In this section, we review typical background medical clearance that should be gained prior to investigating the feasibility of using a sit-stand workstation. We also outline some employee, space and environment considerations that should be reviewed prior to purchasing and installing a sit-stand workstation, and some notes on proper use of the workstation once installed.

Gaining Required Medical Clearance for the Sit-Stand Workstation

As noted in this document, damage or injuries to spinal discs and surrounding structures, or specific musculoskeletal disorders (particularly in the back and hips) are the only conditions likely to benefit from a sit-stand workstation. An employee should receive an examination from their physician to determine if they truly are suffering from a condition that is aggravated by prolonged seated work, or if the condition would be benefitted by other types of intervention (increased walking breaks, alternation of seated posture).

In addition, their doctor should note whether the individual has any specific cardiovascular or neurological conditions that might be aggravated by prolonged standing work. Some examples would include: peripheral vascular disorders (varicose veins, chronic venous insufficiency, etc.), orthostatic intolerance and related symptoms, any neurological condition that would affect equilibrium and balance while standing. If any of these conditions are present, standing at work may worsen the symptoms or lead to injury and/or accidents.

The physician's confirmation that the employee's condition requires a sit-stand workstation, and confirmation that no other conditions can be aggravated by standing work, should be presented to the employer in writing. Without this approval, the sit-stand workstation may not be appropriate for the employee's condition(s) and there may be underlying risk associated with using an adapted work posture.

Considerations of Employee, Space and Environment Factors for Sit-Stand Desk

Employee Considerations

If a sit-stand workstation is approved by the employee's physician, investigations to select the proper type of sit-stand desk can then begin. First, it is important to remember the research presented in the earlier sections of this document: it is not recommended to use only standing work postures, as they present risks for back and lower limb discomfort/disorders, and standing working postures should be alternated with seated work and walking breaks. Even if the individual cannot tolerate seated work for long periods, they will require some seated breaks throughout the workday. *Therefore, the sit-stand workstation should be adaptable between seated elbow height and standing elbow height.* To confirm this, with the client's chair adjusted properly, take a measure (typically in inches) of the height of their elbow from floor level. Then, with the employee standing with relaxed shoulders and their forearms bent to form a 90 degree angle between the upper and lower arms, measure the employees elbow height from the floor. A sit-stand workstation that has a range of adjustment that covers both the seated and standing elbow height will be required.

There are some products that allow height adaptability of only the keyboard and mousing surface, leaving the surrounding desk and devices in one position. These devices are not recommended. The sit-stand workstation should accommodate changes in keyboard and mouse surface, as well as height adaptability of the monitor(s). Ensuring proper visual lines are maintained in both standing and seated positions is critical to ensure proper neck postures and visual lines.

It is also important to consider the tasks the employee must perform. If they must perform a significant amount of hand writing, desk space for writing tasks should also be height adaptable. If they must reference paper documents during their work day, space for a document holding system and placement of paper sources must also be height adaptable. When the work being performed is more variable, requiring multiple input devices, paper sources, telephone work and other tasks, it becomes unlikely that devices that attach to existing furniture to allow height adaptability will be feasible. With more variable office work, a full adjustable desk or table will be required.

Space and Environment Considerations

Sit-stand desks, workstation and devices come in a variety of shapes and sizes. Therefore, it is critical to review the specifications for the item you are ordering to ensure it fits within the existing office/cubicle space. It is also important to review the mechanisms that allow height adaptation. If the device moves with mechanical adjustments (lifting, cranks, etc.) or pneumatic-assisted adjustment, they will not requires access to power sources. However, if the device is adjusted with an electric motor the desk will require access to a suitable power sources that will not cause strain on the electrical supply to adjacent devices and workstations.

Devices that attach to existing furniture (such as the Ergotron Fit-desk) will not increase the footprint or orientation of the furniture. However, it is important to consider the attachments for these devices and ask:

- Will the attachments for the device interact well with the existing surface?
- Will the existing furniture be able to support the loads of the device and the movements associated with the height adjustments? Will it remain stable?
- Are there light fixtures, shelving and other structures above the work surface that would block or interfere with the use of the device, and can they be removed if required?

Replacing a portion of a workstation with a sit-stand desk will require a section of the existing workstation to be removed. If carefully selected, the replacement portion will not require an increase in foot print, but you should ask:

- What will have to be done to stabilize the portions of the existing furniture that remain at the workstation, and will not be height adjustable? Will the remaining support structures and legs have to be altered, or will new ones have to be fabricated?
- Will the selected workstation require electricity to power adjustments?
- Are there light fixtures, shelving and other structures above the work surface that would block or interfere with the use of the device, and can they be removed if required?
- Are there structures beneath the existing desks (pedestals, cabinets, drawers, etc.) that would block the desk from being lowered? Can these items be removed or moved to another area?

Replacing the entire workstation with a height adaptable workstation will require careful measurement and selection of portions that match the required footprint. Some important questions to ask include:

- Will the selected workstation require electricity to power adjustments?
- Are there light fixtures, shelving and other structures above the work surface that would block or interfere with the use of the device, and can they be removed if required?
- Are there structures beneath the existing desks (pedestals, cabinets, drawers, etc.) that would block the desk from being lowered? Can these items be removed or moved to another area?

With adjustments of the workstations, it is important to also consider whether the adjustments will create noise or movement distractions for other employees, and if these do exist, how can these be modified or reduced. Generally, electric adjustable workstations create less movement distractions and adjust with greater speed and ease. However, they may generate some noise when compared to pneumatic-assisted adjustment. Cranking or manual lifting adjustments tend to create some movement and noise distractions, and are a general inconvenience to the employee because of the increased amount of time required to make the adjustments. Some research suggests that using cranks for height adjustment resulted in most workers not using standing work posture rotation (70), so electric or pneumatic-assisted adjustments are likely to be used more frequently.

Proper use of a Sit-Stand Workstation

This document has outlined evidence that both prolonged standing and prolonged sitting can lead to various discomforts and disorders. There is ample evidence that rotation of postures is required, rather than adopting only a standing work posture, to deal with specific disorders and prevention of secondary issues. Unfortunately, exact criteria for duration of time to use a seated and standing work posture are not available, and are likely to vary widely between individuals. What is clear, however, is that allowing an individual to alter their posture at will seems to reduce musculoskeletal discomfort (4). Other evidence has shown that musculoskeletal and vascular changes occur within 30 minutes of standing work, at least in industrially-modelled work (42, 43). *Therefore, as a loose guideline, employees who use sit-standing work postures should rotate between sitting and standing AT WILL to prevent discomfort development in any particular body region; but, by extending standing work beyond 30 consecutive minutes it may produce unwanted physiological effects and related symptoms/discomfort.*

Key points from this section:

1. An employee's physician should provide written clearance that a sit-stand workstation would provide relief for the employee's particular condition, and that standing at work will not aggravate any other underlying cardiovascular or neurological conditions.
2. Measurement of seated and standing elbow heights should be attained to ensure the sit-stand workstation will properly adjust for the client to work in both positions.
3. The sit-stand workstation should be designed in a way that allows adjustment of monitor height to accommodate standing and seated work, as well as accommodate reading, writing, phone and other input device tasks in both working postures.
4. It is important to consider attachments, space, interaction with surrounding items and structures, power supplies, noise and other environmental consideration before selecting and installing a sit-stand workstation.
5. Frequent rotation between seated and standing work postures is required.

Employees who use sit-standing work postures should rotate between sitting and standing at will to prevent discomfort development in any particular body region, but extending standing work beyond 30 consecutive minutes may produce unwanted physiological effects and related symptoms/discomfort.

Corporate Office:
Unit 201, 5677-99 Street
Edmonton, Alberta, T6E 3N8
Tel: +1 (780) 436-0024
Fax: +1 (780) 436-0092
Email: info@ewiworks.com
www.ewiworks.com

Alternative Strategies to Reduce Sedentary Seated Work for Employees

Within the previous sections of this document we have noted that standing workstations and devices do not provide tangible increases in physical activity when compared to traditional seated workstations, and exercise-based workstations may not be used for long enough duration to provide benefits to justify associated costs. At the same time, a lack of physical activity is a core concern in occupational health and wellness of office workers, and we require interventions to deal with this issue that go beyond use of alternative workstations. In this section we outline the potential benefits that can be gained through various workplace design, work organization and health promotion activities at the workplace.

However, this section should be viewed in the context that physical activity at work only provide benefits when the employees involve themselves with physical activity in the leisure time. The evidence presented in the earlier sections of this report demonstrates this core concept. Employers can promote the benefits of physical activity outside the workplace, and provide resources to access various fitness centres and activities, but the employees themselves must take an initiative to use these resources. The Canadian Society for Exercise Physiology outlines that for adults 18 to 64 years of age the recommended amount of physical activity should follow these guidelines:

- To achieve health benefits, adults aged 18-64 years should accumulate at least 150 minutes of moderate- to vigorous-intensity aerobic physical activity per week, in bouts of 10 minutes or more.
- It is also beneficial to add muscle and bone strengthening activities using major muscle groups, at least 2 days per week.
- More physical activity provides greater health benefits.

Extracted from the Canadian Society of Exercise Physiology (http://www.csep.ca/CMFiles/Guidelines/CanadianPhysicalActivityGuidelinesStatements_E.pdf)

The moderate to vigorous levels of aerobic physical activity can take the form of any activity that elicits energy expenditure at or above a brisk walking or light jogging pace of 6.4km/hour (This speed is based on an individual of average height and weight). This can include any number of activities. Later in this section, we will compare some energy expenditures for various activities to what may be gained from standing workstations and exercise-based workstations.

Design Considerations to Improve Physical Activity at Work:

Workplaces can be laid out to promote more movement in the day, and specific technologies and tools can also help allow for increased movements. For example, a strategy may be to place photo coping machine, printers and other devices of this nature in a central location, away from the office and cubicle areas. This will force employees to stand and walk throughout the day to attain printed and hardcopy materials. Similarly, for jobs where hard copy documents and resources must be attained, the document centre or library could be placed in a central location and employee would have to walk to attain the required materials. Even short bouts of walking for 1-2 minutes at a light level can provide benefits. Based on energy expenditure data (71), if an employee, weighing 60kg, can build in 7-8 walking bouts during their work day totalling 15 minutes they would achieve an estimated caloric output of 54kcal. This level of walking exceeds what would be possible with standing for an entire 8-hour workday, and would be in line with use of a treadmill desk walking at low speed for 30 minutes a day. For individuals at heavier body weights, the caloric output would be much higher; for example, an individual weighing 90kg would burn 81 kcal by building in a total of 15 minutes of walking during a their work.

Other ways to consider promotion of walking and movement throughout a workday would be to place break/lunch rooms and meeting areas in locations that require employee to walk for 1-2 minutes to reach the specific area. In addition, allowing employees to use wireless headsets or mobile phones to conduct phone calls can allow more movement. If the devices can allow the employee to stand and walk around their office or the hall way while talking on the phone, they can add several minutes of movement each day.

Work Organization Considerations to Improve Physical Activity at Work

We might also consider the workflow within an office. If an employee is expected to perform multiple tasks with a particular document or set of information, the software or tools to complete various portions of the task could be located in different areas or workstation within an office. For example, productivity software, such as Microsoft Office, may be on each person's computer at their personal workstation, but speciality software for numerical analysis, graphic design and other tasks can be placed on computers in a central location. To use these devices, employees would have to move between the workstations. Short bouts of walking 1-2 minutes will not drastically decrease productivity, but may produce the desired improvements in workplace physical activity.

Other work organization strategies include mandated periodic breaks where employee will have to stand and perform various exercises or walking bouts before returning to their work. Software applications for computers and mobile phones can help with enforcement of this policy and provide reminders to take a short break to conduct physical activity at specific intervals. For example, every 60-90 minutes employees can be sent a Microsoft Outlook calendar reminder to get up and move from their workstation. There are even software packages that will lock the workstation for a 1-2minute period, preventing people from immediately returning to their work operations.

Workplace Health Promotion Programs

Many workplaces have attempted to develop programs to increase physical activity at the workplace. These include morning exercise sessions, aerobic classes, and walking groups for breaks and lunch periods. A review of the effectiveness of these programs reveals that there can be some benefits to weight loss and health measures, but they are typically only accomplished with dietary intervention and accompanying organizational adaptations (72). These organization adaptations can include: providing walking and/or exercise space and maps, providing adequate time, organizing team competitions, commitment of key management to take part and champion the project, and allowing family/friend involvement (72). These programs were noted to lead to an average loss of 1.19 kg to 1.48 kg of body weight (72), and while there are assumed to be associated health benefits to cardiovascular fitness and risk of diabetes and other disorders, there is a lack of evidence available to evaluate these potential benefits.

Furthermore, as we noted from evidence during the earlier sections of this document, engagement in leisure time physical activity is much more likely to have positive impacts on cardiovascular fitness and prevention of various diseases and disorders. This would lead us to believe that workplaces should promote their employees to take part in physical activity. This has led to fitness equipment, gyms and exercise spaces being made available at work places for afterhours use. Some workplaces offer subsidies to join various fitness centres. However, anecdotal evidence suggests that only people who already are physically active take advantage of these resources. Individuals with have issues with obesity or various disorders may not change their behaviors outside the workplace (7). Despite general knowledge of the dangers of sedentary behavior, many individuals fail to meet their recommended levels of physical activity. While a workplace can take measures to increase education related to various issues associated with a sedentary lifestyle, the individual employee must be willing to make physical activity a part of their lifestyle.

Corporate Office:
Unit 201, 5677-99 Street
Edmonton, Alberta, T6E 3N8
Tel: +1 (780) 436-0024
Fax: +1 (780) 436-0092
Email: info@ewiworks.com
www.ewiworks.com

To achieve health benefits the workers must do their part outside the office, but the employer can help to promote physical activity by providing/planning morning or lunch time walking/aerobic exercise groups, or having company outings at various points throughout the year to hike, cycle or perhaps take part in recreational sports. The company can also design the office to promote walking, and organize work and policies to provide movement breaks. Each of these actions will provide a benefit to employee if they are also engaged in activity outside the workplace. For those who are not taking part in those outside activities, little positive benefits are likely to be achieved.

In addition, based on the evidence provided, exercise programs and movement promotion at the office should be supplemented with information on diet and nutrition.

Comparing Workplace Health Promotion and Programs to Alternative Workstations

The evidence presented in this document noted that, when compared to seated work, standing workstations can burn an additional 38 kcal/day (58). Also, it was noted that most employees are only able to use an exercise-based workstations for a maximum of 60-90 minutes each day, which can burn 100-150 additional kcal/day (58). Given the cost of implementing these workstations, it would be interesting to compare these physical activity and energy expenditures to implementing an additional 15 minutes of brisk walking throughout a workday along with 15 minutes during lunch/breaks for a total of 30 minutes per day, and implementing a morning workplace fitness routine that includes 15 minutes of brisk walking and 15 minutes of calisthenics (moderate strengthening exercises). These calculations are based on an individual weighting 60kg. The outputs are higher for heavier individuals.

Daily Energy Expenditures for Alternative Workstations, 15min Workplace Walking, and a 20 min Office Fitness Program				
Standing Workstation	Treadmill Desk at Low Speed for 60-90 min	Brisk walking for 15 min at work and 15 min during breaks/lunch	30min Office Fitness Program During Lunch or After Work	30 min of Workplace Walking + 20min Office Fitness
38 kcal	100-150 kcal	108kcal*	126 kcal*	234 kcal*

*These values were produced using physiological data tables (71).

This table clearly demonstrates that standing workstations offer no benefits to energy expenditure or physical activity when compared to the workplace behavior change and fitness programs. Meanwhile, the exercise-based workstation does not provide tangibly different gains in activity or energy expenditure than changes in workplace movement behaviors and/or office fitness programs. Armed with this data, it seems unlikely that investment in alternative workstations would lead to health-related returns that are as effective as lower cost behavioral changes and fitness programs.

Conclusions

The goal of this document is to provide employers and their employees with the best evidence available regarding the health effects associated with seated office work. There has been an increased focus on the health effects associated with prolonged sitting at work, and the development of “sitting disease”. This has led to a number of workstation alternatives and devices designed to reduce sedentary work time, typically through increased static standing or through exercise-based workstations.

This document has noted that the health effects of prolonged sitting at work have been exaggerated in popular media and within advertisements for various alternative workstations. Cardiovascular disease and diabetes, for example, are impacted by total sedentary time and are more closely related to an overabundance of a sedentary lifestyle during leisure time. However, increased risk of being overweight, obese and development of some cancers among women are higher in seated occupations. This does speak to the need to reduce sedentary work time. Yet, evidence suggests that increases in physical activity at work are unlikely to provide tangible benefits without physical activity being conducted in employees' leisure time as a first step. When employees are active outside the office, additional measures to increase movement in the workplace will provide an added benefit (20).

For standing workstations and devices, there is very little benefit to physical activity levels or energy expenditure. These devices will not impact on reducing sedentary time at work, and are not likely to reduce obesity levels. They can, however, help to alleviate musculoskeletal discomfort in the back, and reduce the severity of symptoms associated with injuries and structural issues in the back, and help mitigate issues that are aggravated by static posture. The use of a standing workstation should follow guidelines outlined in this document to avoid negative health consequences or aggravation of existing neurological or cardiovascular issues.

Exercise-based workstations can increase caloric output, but evidence suggests their use by office employees is typically 30-90 minutes per day. The level of use would lead to physical activity levels and energy expenditure that can be accommodated by increases in daily walking time at work and/or short bouts of workplace fitness routines. Furthermore, the impacts of exercise-based workstations on musculoskeletal, visual and cognitive outcomes have not fully been researched. It would be difficult to approve use of this type of workstation without understanding the long term health and performance impact. Furthermore, given the limited benefits it can provide over workplace program implementation, organizational/policy changes and work behavior changes, a return on investment relative to health benefits may be hard to justify.

Armed with this document, we hope you are able to make decisions on changes to the workplace with consideration of the best available knowledge.

References

1.Lehman KR, Psihogios JP, Meulenbroek RGJ. Effects of sitting versus standing and scanner type on cashiers. Ergonomics. 2001;44(7):719-38.
2.Laperriere E, Ngomo S, Thibault MC, Messing K. Indicators for choosing an optimal mix of major working postures. Applied Ergonomics. 2006;37(3):349-57.
3.Messing K, Tissot F, Stock SR. Distal lower-extremity pain and work postures in the Quebec population. American Journal of Public Health. 2008;98(4):705-13.
4.Tissot F, Messing K, Stock S. Standing, sitting and associated working conditions in the Quebec population in 1998. Ergonomics. 2005;48(3):249-69.
5.Castillo-Retamal M, Hinckson EA. Measuring physical activity and sedentary behaviour at work: A review. Work-a Journal of Prevention Assessment & Rehabilitation. 2011;40(4):345-57.
6.Chau JY, van der Ploeg HP, Merom D, Chey T, Bauman AE. Cross-sectional associations between occupational and leisure-time sitting, physical activity and obesity in working adults. Preventive Medicine. 2012;54(3-4):195-200.

7.Stamatakis E, Chau JY, Pedisic Z, Bauman A, Macniven R, Coombs N, et al. Are Sitting Occupations Associated with Increased All-Cause, Cancer, and Cardiovascular Disease Mortality Risk? A Pooled Analysis of Seven British Population Cohorts. Plos One. 2013;8(9).

8.Grontved A, Hu FB. Television Viewing and Risk of Type 2 Diabetes, Cardiovascular Disease, and All-Cause Mortality A Meta-analysis. Jama-Journal of the American Medical Association. 2011;305(23):2448-55.

9.Chau JY, Merom D, Grunseit A, Rissel C, Bauman AE, van der Ploeg HP. Temporal trends in non-occupational sedentary behaviours from Australian Time Use Surveys 1992, 1997 and 2006. International Journal of Behavioral Nutrition and Physical Activity. 2012;9.

10.Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. Diabetologia. 2012;55(11):2895-905.

11.Du HD, Bennett D, Li LM, Whitlock G, Guo Y, Collins R, et al. Physical activity and sedentary leisure time and their associations with BMI, waist circumference, and percentage body fat in 0.5 million adults: the China Kadoorie Biobank study. Am J Clin Nutr. 2013;97(3):487-96.

12.Ryde GC, Brown HE, Peeters G, Gilson ND, Brown WJ. Desk-Based Occupational Sitting Patterns Weight-Related Health Outcomes. Am J Prev Med. 2013;45(4):448-52.

13.van Uffelen JGZ, Wong J, Chau JY, van der Ploeg HP, Riphagen I, Gilson ND, et al. Occupational Sitting and Health Risks A Systematic Review. Am J Prev Med. 2010;39(4):379-88.

14.Choi B, Schnall PL, Yang H, Dobson M, Landsbergis P, Israel L, et al. Sedentary Work, Low Physical Job Demand, and Obesity in US Workers. American Journal of Industrial Medicine. 2010;53(11):1088-101.

15.Friedenreich CM, Cook LS, Magliocco AM, Duggan MA, Courneya KS. Case-control study of lifetime total physical activity and endometrial cancer risk. Cancer Causes & Control. 2010;21(7):1105-16.

16.Simons CCJM, Hughes LAE, van Engeland M, Goldbohm RA, van den Brandt PA, Weijenberg MP. Physical Activity, Occupational Sitting Time, and Colorectal Cancer Risk in the Netherlands Cohort Study. Am J Epidemiol. 2013;177(6):514-30.

17.Parent M-E, Rousseau M-C, El-Zein M, Latreille B, Desy M, Siemiatycki J. Occupational and recreational physical activity during adult life and the risk of cancer among men. Cancer Epidemiology. 2011;35(2):151-9.

18.Zhang M, Xie X, Lee AH, Binns CW. Sedentary behaviours and epithelial ovarian cancer risk. Cancer Causes & Control. 2004;15(1):83-9.

19.Saidj M, Jorgensen T, Jacobsen RK, Linneberg A, Aadahl M. Separate and Joint Associations of Occupational and Leisure-Time Sitting with Cardio-Metabolic Risk Factors in Working Adults: A Cross-Sectional Study. Plos One. 2013;8(8).

20.Kozey Keadle S, Lyden K, Staudenmayer J, Hickey A, Viskochil R, Braun B, et al. The independent and combined effects of exercise training and reducing sedentary behavior on cardiometabolic risk factors. Applied Physiology, Nutrition, and Metabolism. 2014:1-11.

21.Levine JA. Nonexercise activity thermogenesis (NEAT): environment and biology. American Journal of Physiology - Endocrinology And Metabolism. 2004;286(5):E675-E85.

22.Lis AM, Black KM, Korn H, Nordin M. Association between sitting and occupational LBP. Eur Spine J. 2007;16(2):283-98.

23.Drury CG, Hsiao YL, Joseph C, Joshi S, Lapp J, Pennathur PR. Posture and performance: sitting vs. standing for security screening. Ergonomics. 2008;51(3):290-307.

24.Ebara T, Kubo T, Inoue T, Murasaki G, Takeyama H, Sato T, et al. Effects of adjustable sit-stand VDT workstations on workers' musculoskeletal discomfort, alertness and performance. Industrial Health. 2008;46(5):497-505.

25.Hasegawa T, Inoue K, Tsutsue O, Kumashiro M. Effects of a sit-stand schedule on a light repetitive task. International Journal of Industrial Ergonomics. 2001;28(3-4):219-24.

26.Husemann B, Von Mach CY, Borsotto D, Zepf KI, Scharnbacher J. Comparisons of Musculoskeletal Complaints and Data Entry Between a Sitting and a Sit-Stand Workstation Paradigm. Human Factors. 2009;51(3):310-20.

27.Toomingas A, Gavhed D. Workstation layout and work postures at call centres in Sweden in relation to national law, EU-directives and ISO-standards, and to operators' comfort and symptoms. International Journal of Industrial Ergonomics. 2008;38(11-12):1051-61.

28.Wilks S, Mortimer M, Nylén P. The introduction of sit-stand worktables; aspects of attitudes, compliance and satisfaction. Applied Ergonomics. 2006;37(3):359-65.

29.Claus A, Hides J, Moseley GL, Hodges P. Sitting versus standing: Does the intradiscal pressure cause disc degeneration or low back pain? Journal of Electromyography and Kinesiology. 2008;18(4):550-8.

30.Mork PJ, Westgaard RH. Back posture and low back muscle activity in female computer workers: A field study. Clinical Biomechanics. 2009;24(2):169-75.

31.Roffey DM, Wai EK, Bishop P, Kwon BK, Dagenais S. Causal assessment of occupational standing or walking and low back pain: results of a systematic review. The Spine Journal. 2010;10(3):262-72.

32.Bakker EWP, Verhagen AP, van Trijffel E, Lucas C, Koes BW. Spinal Mechanical Load as a Risk Factor for Low Back Pain - A Systematic Review of Prospective Cohort Studies. Spine. 2009;34(8):E281-E93.

33.Tissot F, Messing K, Stock S. Studying the relationship between low back pain and working postures among those who stand and those who sit most of the working day. Ergonomics. 2009;52(11):1402-18.
34.Andersen JH, Haahr JP, Frost P. Risk factors for more severe regional musculoskeletal symptoms - A two-year prospective study of a general working population. Arthritis and Rheumatism. 2007;56(4):1355-64.
35.Gallagher KM, Campbell T, Callaghan JP. The influence of a seated break on prolonged standing induced low back pain development. Ergonomics. 2014;57(4):555-62.
36.Nelson-Wong E, Callaghan JP. Is muscle co-activation a predisposing factor for low back pain development during standing? A multifactorial approach for early identification of at-risk individuals. J Electromyogr Kinesiol. 2010;20(2):256-63.
37.Nelson-Wong E, Gregory DE, Winter DA, Callaghan JP. Gluteus medius muscle activation patterns as a predictor of low back pain during standing. Clinical Biomechanics. 2008;23(5):545-53.
38.Nelson-Wong E, Callaghan JP. Changes in muscle activation patterns and subjective low back pain ratings during prolonged standing in response to an exercise intervention. Journal of Electromyography and Kinesiology. 2010;20(6):1125-33.
39.Nelson-Wong E, Howarth S, Winter DA, Callaghan JP. Application of Autocorrelation and Cross-correlation Analyses in Human Movement and Rehabilitation Research. Journal of Orthopaedic & Sports Physical Therapy. 2009;39(4):287-95.
40.Freitas S, Wieczorek SA, Marchetti PH, Duarte M. Age-related changes in human postural control of prolonged standing. Gait & Posture. 2005;22(4):322-30.
41.Lafond D, Champagne A, Descarreaux M, Dubois J-D, Prado JM, Duarte M. Postural control during prolonged standing in persons with chronic low back pain. Gait & Posture. 2009;29(3):421-7.
42.Antle DM, Côté JN. Relationships between lower limb and trunk discomfort and vascular, muscular and kinetic outcomes during stationary standing work. Gait & Posture. 2013;37(4):615-9.
43.Antle DM, Vézina N, Messing K, Côté JN. Development of discomfort and vascular and muscular changes during a prolonged standing work task. Occupational Ergonomics. 2013;11(1):21-33.
44.Messing K, Tissot F, Stock SR. Should studies of risk factors for musculoskeletal disorders be stratified by gender? Lessons from the 1998 Quebec Health and Social Survey. Scandinavian Journal of Work Environment & Health. 2009;35(2):96-112.
45.Balasubramanian V, Adalarasu K, Regulapati R. Comparing dynamic and stationary standing postures in an assembly task. International Journal of Industrial Ergonomics. 2009;39(5):649-54.
46.Raffetto JD, Khalil RA. Mechanisms of varicose vein formation: valve dysfunction and wall dilation. Phlebology. 2008;23(2):85-98.
47.Laurikka JO, Sisto T, Tarkka MR, Auvinen O, Hakama M. Risk indicators for varicose veins in forty- to sixty-year-olds in the Tampere varicose vein study. World Journal of Surgery. 2002;26(6):648-51.
48.Ngomo S, Messing K, Perrault H, Comtois A. Orthostatic symptoms, blood pressure and working postures of factory and service workers over an observed workday. Applied Ergonomics. 2008;39(6):729-36.
49.Sudol-Szopinska I, Bogdan A, Szopinski T, Panorska AK, Kolodziejczak M. Prevalence of Chronic Venous Disorders Among Employees Working in Prolonged Sitting and Standing Postures. International Journal of Occupational Safety and Ergonomics. 2011;17(2):165-73.
50.Kroeger K, Ose C, Rudofsky G, Roesener J, Hirche H. Risk factors for varicose veins. International Angiology. 2004;23(1):29-34.
51.Bahk JW, Kim H, Jung-Choi K, Jung M-C, Lee I. Relationship between prolonged standing and symptoms of varicose veins and nocturnal leg cramps among women and men. Ergonomics. 2012;55(2):133-9.
52.Bergan JJ, Schmid-Schonbein GW, Smith PDC, Nicolaides AN, Boisseau MR, Eklof B. Mechanisms of disease: Chronic venous disease. New England Journal of Medicine. 2006;355(5):488-98.
53.Tuchsen F, Hannerz H, Burr H, Krause N. Prolonged standing at work and hospitalisation due to varicose veins: a 12 year prospective study of the Danish population. Occupational and Environmental Medicine. 2005;62(12):847-50.
54.Tuchsen F, Krause N, Hannerz H, Burr H, Kristensen TS. Standing at work and varicose veins. Scandinavian Journal of Work Environment & Health. 2000;26(5):414-20.
55.Bradbury A, Evans C, Allan P, Lee A, Ruckley CV, Fowkes FGR. What are the symptoms of varicose veins? Edinburgh vein study cross sectional population survey. British Medical Journal. 1999;318(7180):353-6.
56.Van Dieen JH, Vrielink H. Evaluation of work-rest schedules with respect to the effects of postural workload in standing work. Ergonomics. 1998;41(12):1832-44.
57.Speck RM, Schmitz KH. Energy expenditure comparison: A pilot study of standing instead of sitting at work for obesity prevention. Preventive Medicine. 2011;52(3-4):283-4.
58.Tudor-Locke C, Schuna JM, Frensham LJ, Proenca M. Changing the way we work: elevating energy expenditure with workstation alternatives. Int J Obes. 2013.
59.Healy GN, Eakin EG, LaMontagne AD, Owen N, Winkler EAH, Wiesner G, et al. Reducing sitting time in office workers: Short-term efficacy of a multicomponent intervention. Preventive Medicine. 2013;57(1):43-8.

60.Levine JA, Miller JM. The energy expenditure of using a “walk-and-work” desk for office workers with obesity. British Journal of Sports Medicine. 2007;41(9):558-61.
61.Hamilton MT, Hamilton DG, Zderic TW. Role of Low Energy Expenditure and Sitting in Obesity, Metabolic Syndrome, Type 2 Diabetes, and Cardiovascular Disease. Diabetes. 2007;56(11):2655-67.
62.Thompson WG, Levine JA. Productivity of transcriptionists using a treadmill desk. Work-a Journal of Prevention Assessment & Rehabilitation. 2011;40(4):473-7.
63.Koepp GA, Manohar CU, McCrady-Spitzer SK, Ben-Ner A, Hamann DJ, Runge CF, et al. Treadmill desks: A 1-year prospective trial. Obesity. 2013;21(4):705-11.
64.Straker L, Levine J, Campbell A. The Effects of Walking and Cycling Computer Workstations on Keyboard and Mouse Performance. Human Factors: The Journal of the Human Factors and Ergonomics Society. 2009;51(6):831-44.
65.Portello JK, Rosenfield M, Chu CA. Blink Rate, Incomplete Blinks and Computer Vision Syndrome. Optometry and Vision Science. 2013;90(5):482-7.
66.Segui MD, Ronda E, Wimpenny P. Inconsistencies in Guidelines for Visual Health Surveillance of VDT Workers. J Occup Health. 2012;54(1):16-24.
67.Woods V. Musculoskeletal disorders and visual strain in intensive data processing workers. Occupational Medicine-Oxford. 2005;55(2):121-7.
68.Blehm C, Vishnu S, Khattak A, Mitra S, Yee RW. Computer Vision Syndrome: A Review. Survey of Ophthalmology. 2005;50(3):253-62.
69.Menendez CC, Amick BC, Robertson M, Bazzani L, DeRango K, Rooney T, et al. A replicated field intervention study evaluating the impact of a highly adjustable chair and office ergonomics training on visual symptoms. Applied Ergonomics. 2012;43(4):639-44.
70.Lewis P. A different look at Sit/Stand workstations: Why everyone should not be standing? . Applied Ergonomics Conference March 18-21st, 2013; Hilton Anatole, Dallas, TX, USA2013.
71.McArdle W, Katch F, Katch V. Exercise Physiology: Energy, Nutrition, and Human Performance. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2001.
72.Verweij LM, Coffeng J, van Mechelen W, Proper KI. Meta-analyses of workplace physical activity and dietary behaviour interventions on weight outcomes. Obesity Reviews. 2011;12(6):406-29.