Ergonomics SA, 2007, 19 (2)
ISSN Number : 1010-2728

Physical implications of prolonged sitting in a confined posture – A literature review

Andrew I Todd *Anthea I Bennett* *Candice J Christie*

Rhodes University, Department of Human Kinetics and Ergonomics, PO Box 94, Grahamstown, South Africa, 6140

a.todd@ru.ac.za g03b2347@campus.ru.ac.za c.christie@ru.ac.za

Abstract

The main purpose of this review article was to highlight some of the physical consequences of sitting for prolonged periods in a confined setting. More specifically, the review relates this research to call centre work and where applicable comments on the limited literature relating specifically to ergonomics research within call centre settings. In particular the article explores the biomechanical stresses placed on the musculoskeletal system during prolonged sitting at a workstation, and the physiological consequences thereof. The paper then provides possible solutions to reduce the physical strain placed on these workers by looking at workstation design and work organisation emphasizing worker education and the promotion of worker well being.

Keywords: Call centre, physical strain.

1 Introduction

A call centre can be defined as the operations (both physical and virtual) performed by a group of people who are required to spend most of their time doing business via telephone, most commonly using a computer-automated environment (Bagnara and Marti, 2001). Call centres are an increasingly important aspect of industrial development worldwide as customer relationship management has become a key role player in business. In the United States alone, it is estimated that there are over 78 000 call centres employing in excess of two million people. The global call centre services market was suggested to be in excess of $ 58 billion in 2003.

The relationship between musculoskeletal disorders and computer use (as is the case of most call centre operators) has been well documented (Pascarelli and Kella, 1993; Cook and Burgess-Limerick, 2004). Further risk factors relating specifically to call centre work are associated with the physical environmental such as the chair and monitor heights, the keyboard position and working posture which is seated and confined (Aaras et al., 1997), organizational factors such as duration of work and psychosocial factors such as stress relating both to job demands and the prolonged sitting fairly isolated and in an area with limited movement ability (Smith and Carayon, 1996). For the purposes of the present review article only the physical ergonomic factors associated with prolonged seated call centre work will be addressed, although acknowledgment of the importance of the other factors is paramount.

Traditionally call centre work has been considered to be both stressful and boring, which has often led to the industry being plagued by chronic absenteeism and high worker turnover rates. Although the design of the call centre may not be the primary cause of the problem, improvements to the working environment and work practices have been shown to significantly improve worker well being. This article therefore provides a review of the current literature relating to the biomechanical and physiological consequences of working in confined seated postures for prolonged periods. The article also addresses possible solutions to reduce the physical strain experienced by workers involved in call centre work.

2 Biomechanical consequences

The biomechanical strain placed on the human musculoskeletal system is primarily dependent on the posture adopted, as this determines the loading on the lumbar sacral region of the spine, the area shown to be the weakest link in the kinetic chain. According to Pheasant and Haslegrave (2006) the posture adopted in the working environment is dependent on the relationship between the individual’s body dimensions and the dimensions of the various items in the workspace. The extent to which posture is constrained in a call centre is reliant on the nature and number of connections between the user and the workspace. If there is a dimensional incompatibility, the short and long term consequences for the well being of the individual can be severe.

Forces that act on the spine include body weight, tension in the surrounding muscles and ligaments, intra-abdominal pressure and any external load. In an upright standing position the centre of gravity is positioned anterior to the spine, creating a flexion moment. Thus to maintain this posture, the flexion moment must be counteracted by an extensor moment generated by the back extensor muscles. Due to the fact that lumbar spinal muscles have very small moment arms, it is necessary for them to generate large forces to counteract the forward-bending moment. As such the major force acting on the spine is usually from the activity of the spinal muscles.

In a standing position the pelvis is in a vertical position, while the L_5/S_1 vertebrae make an angle of approximately 30° above and below the horizontal respectively. Due to the lack of flexibility when one sits, only part (approximately 60-70°, Corlett, 2006; Pheasant and Haslegrave, 2006) of the right angle that is made between the thighs and the trunk can be achieved though the flexion of the hip joint, as tension in the hamstring muscles restricts this movement (Corlett, 2006). As a result of the limiting hamstring tension, the tendency is to rotate the pelvis backwards for the remaining 20-30° depending on individual levels of flexibility. As the sacrum is attached to the pelvis it is also rotated, flattening the natural curve of the lumbar spine. In other words, in order to keep the trunk vertical there must be an equivalent flexion of the lumbar spine (Callaghan and McGill, 2001; Beach et al., 2005). In unsupported sitting the lumbar spine may be flexed to the edges of the range of motion, increasing the contribution of the passive tissues in the support of the upright posture.

The slumped posture associated with unsupported sitting not only increases spinal compression forces compared to standing, but also results in deformation of the intervertebral discs, which are compressed at the front and separated at the back. As a result prolonged sitting has been associated with disc herniations (Kelsey, 1975).

Furthermore, over time the intervertebral discs deform, resulting in more of the load being transferred to the facet joints (Cheung et al., 2003), and pressure being placed on the nerves in the spinal column (Corlett, 2006). In order to 'sit up straight' and place the lumbar vertebrae in their natural standing position, the spinal muscles need to be activated to support the weight of the trunk. Under prolonged sitting conditions, such as found in call centres, this static muscle loading may become a source of postural discomfort, especially in those predisposed to suffer from back trouble.

Several studies have shown that although sitting itself is not closely related to lower back pain, sitting in association with other factors such as awkward postures show a significant increase in the risk of lower back injury (Hartvigsen et al., 2000; Lis et al., 2007). One of the key factors determining the postural load and hence the risk of musculoskeletal disorders associated with call centre work is static muscular contraction (Aaras et al., 1997). Ferreira and Saldiva (2002) argued that the prolonged static postures associated with call centre work are made more complex by the fact that operators require communication skills, cordiality, responsibility and efficiency, all while under significant time pressure and direct monitoring of performance.

Recently Beach et al. (2005) found that passive flexion stiffness was increased in males after only one hour of sitting, while it increased after two hours in females. Additionally it increased the risk of injury as well as contributing to the experience of lower back pain. According to Corlett (1981) the intensity of discomfort experienced is related to the exposure time, and that recovery time from prolonged exposure to static contraction is significantly longer than the holding time (Corlett, 2006). Compression forces on the spine during standing are significantly lower than those experienced when sitting. Spinal compression forces in upright sitting can be as much as 140-150% of those experienced during standing, while these forces increase to as much as 180-200% when sitting in a slouched position (Hall, 2007). Callaghan and McGill (2001) found compression forces in sitting to be as high as 1698 N. Although these values are significantly lower than the 3600 N compression force limit set by NIOSH, the prolonged nature of call centre work, resulting in fatigue of the spinal structures, needs to be taken into account.

An appropriate chair design with sufficient lumbar support being provided by the backrest can help to significantly reduce the spinal loading experienced by the user by relaxing the erector spinae muscles and maintain lumbar lordosis (Corlett and Eklund, 1984). As such seat design becomes an important determinant of biomechanical risks associated with call centre work. Another important seating factor to consider is the inclination of the seat. Kayis and Hoang (1999) argue that when an individual is sitting in a reclined position, the back rest supports the weight of the thorax resulting in a reduction in lumbar muscle activity and consequently reducing the lumbar load.

There is controversy in the literature as to whether seats that are most comfortable are necessarily those that place the lowest biomechanical strain on the spine. Corlett and Eklund (1984) found a direct relationship between spinal shrinkage (used as a measure of biomechanical strain) and comfort ratings. In 2001 van Dieen and colleagues found no relationship, while more recently Carcone and Keir (2007) found that seat designs that were most comfortable for the user were not necessarily those that were biomechanically optimal. Therefore caution needs to be taken when assessing seat design in industry as there is a complex interplay between ratings of comfort and least biomechanical strain.

Original studies investigating postures adopted during prolonged sitting found only small variations in lumbar angle (Bridger, 1988). However more recently Callaghan and McGill, 2001, found that only 50% of the subjects maintained a static posture during 2 hours of sitting, while the remaining subjects altered the lumbar angle on a frequent basis. In order to reduce the risk of injury, the human body requires movement. Movement provides nourishment for the bony structures, such as the nucleus pulposus and the intervertebral discs (Holm and Nachemson, 1983; Callaghan and McGill, 2001, Corlett, 2006). Furthermore movement provides periodic rest periods for the muscles, reducing the likelihood of fatigue from prolonged sitting. Furthermore Callaghan and McGill (2001) have shown that adopting multiple postures and cycling between them during the work shift helps to prevent static loading, relieving the passive tissues of the spine.

The lower back is not the only part of the body that is susceptible to injury during call centre work. Neck pain and work-related upper limb disorders (WRULDs) affecting the hand, wrist and arm are all characteristic of overuse of the muscles and other soft tissues in these areas. The overuse is likely due to prolonged static loading, repetitive motions, acute overexertion or more commonly due to any combination of these. Several authors (Hales et al., 1994; Cook and Burgess-Limerick, 2004) have argued that the relationship between neck and WRULDs and computer work is well documented, although Palmer et al. (2001) suggest that risk estimates are lower than previously reported. It is believed that one of the leading causes of neck and shoulder and arm and hand disorders is working without arm supports (Bergqvist et al., 1995; Cook and Burgess-Limerick, 2004).

3 Physiological consequences

When working in seated and confined spaces such as a call centre, where movement is limited and getting up and walking around is not possible, there is less demand on the circulatory system. As the individual is essentially in a ‘resting’ state, heart rate is low (McArdle et al., 2001) and there is virtually no dynamic muscular activity. Although this may appear to place little strain on the body, sitting for prolonged periods with limited movement can lead to swelling of the lower extremities (Stranden and Kroese, 1998; Stranden, 2000). This swelling is due to an increased net transcapillary filtration which exceeds the removal of fluids by the lymphatic system (Stranden, 2000). The dominant factor causing the oedema is the increased capillary hydrostatic pressure caused by increased venous pressure (Stranden, 2000). When in a horizontal position, the venous pressure at the feet is approximately 5 mmHg, increasing to 70-80 mmHg in an upright position while at passive sitting this pressure is between 45 mmHg and 60 mmHg (Stranden, 2000). Walking decreases the pressure to between 25 mmHg and 30 mmHg (Gardner and Fox, 1989). A consistent venous pressure of 45-60 mmHg with no respite to lower it by walking could have serious consequences. The most serious of which is ‘economy-class syndrome’ which was a term coined by Symington and Stack in 1977. This describes the venous problems caused by cramped seating conditions particularly in the economy class section of modern air crafts. Although call centre work is not in an aircraft at altitude, according to a laboratory study by Hitosugi et al. (2000), this happens in all conditions where prolonged sitting is required and is likely due to changes in blood viscosity. These authors reported that after even a fairly short period of 2 h of quiet sitting, thrombotic tendency increased locally in the leg. Stricker et al. (2003) also found a decrease in thrombin generation during sitting. These findings could therefore be applied to call centre workers and emphasizes the importance of active rest breaks to improve blood circulation.

It is well known that the human body was designed to move, and as the number of sedentary jobs has increased, so has the number of musculoskeletal disorders (MSDs). Approximately 50% of the body's muscles contract to hold the body motionless while resisting gravity (Valachi and Valachi, 2003) and the static forces resulting from these postures have been shown to be much more taxing than dynamic movements (Ratzon et al., 2000). Limited mobility also contributes to musculoskeletal disorders due to localized tension on certain regions of the body. In Figure 1 it can be seen that prolonged static postures can lead to muscle fatigue and muscle imbalances. Reduced blood flow can result in muscle ischemia resulting in pain and protective muscle contraction. The likely consequence is joint hypomobility, nerve compression or spinal disk degeneration. The neck and lower back are particularly affected and there is a steady compression on the vertebrae which can contribute to premature degeneration. When a person sits down, the hip and knee joint flex and the iliopsoas muscles shorten and the hip extensors lengthen (Link et al., 1990; Bridger, 2003). Bridger (2003) reports that the balance of antagonistic muscle forces, which keeps the pelvis at an anterior tilt, changes to a posterior tilt and continues in proportion to the flexion of the hip. To keep the head erect, the lumbar spine flexes to compensate and lumbar lordosis diminishes and eventually disappears (Bridger, 2003). Prolonged sitting at work is associated with lower back pain (Hoogendoorn et al., 2000) and ironically, many people with bad backs gravitate towards sedentary work (Bridger, 2003). Compared to many typical office workers, call handlers may be at a greater risk for developing MSDs because they use display screen equipment so intensively and have less opportunity to take breaks.

Sedentary employees may also demonstrate a gradual deterioration in health if they do not lead an active lifestyle outside of the working environment. Leading a sedentary lifestyle contributes to an increased risk for the development of coronary heart disease and many chronic diseases of lifestyle such as hypertension and hypercholesterolemia. Chronic diseases of lifestyle are increasing in South Africa in all population groups. Sparling et al. (1994) found that manual workers in South Africa were largely protected from heart disease due to the physical nature of their work. They found a dose-response effect between increased physical activity and reduced heart disease risk. Likewise, individuals who are not employed in manual work and who do no recreational exercise, have a higher prevalence of obesity and chronic diseases. According to the South African Health and Demographic Survey, over 20% of white women and over 30% of black women are obese. Although levels of obesity are lower in black males, white males also have a prevalence above 30% (Puoane et al., 2002). Obesity is a complex condition whereby excess body fat predisposes an individual to many different health problems (Lang and Froelicher, 2005). This accumulation of body fat is a reflection of energy imbalance where energy intake exceeds that of expenditure over a period of time

(Lang and Froelicher, 2005). Therefore, call centre workers who expend less energy than they take in, are likely to develop obesity and the associated risks. Total daily energy expenditure is comprised of the individual's basal metabolic rate, the thermic effect of feeding and the energy required to perform a physical activity. To counteract this expenditure, food is eaten so that energy balance is maintained over time. Low daily energy expenditure results from either a low basal metabolic rate or due to inactivity or insufficient activity (Speakman, 2004) and low energy expenditure with a high energy intake will result in weight gain (McArdle et al., 2001). However, it should be noted that genetics can explain up to 25% of an individual's body composition (McArdle et al., 2001). Clearly, individuals' working in sedentary occupations such as call centres need to be educated about the benefits of participating in regular physical activity so as to negate the negative effects of their occupation on certain diseases of lifestyle.

Prolonged Static Posture

↓

Muscle Fatigue/Muscle Imbalance

↓

Muscle Ischemia/Necrosis

Trigger points and muscle substitution

↓

Pain

↓

Protective Muscle Contraction

↓

Joint Hypomobility/Nerve Compression/Spinal disc degeneration

↓

Musculoskeletal Disorder

Figure 1. Flowchart showing how prolonged static postures can progress to pain or a MSD.
(Adapted from Valachi and Valachi, 2003)

4 Possible Solutions

In recent years call centres have evolved into one of the most rapidly growing industries worldwide (Bagnara and Marti, 2001), and thus it is important to consider the conditions under which operators work in these environments. Ideally, workstation design within call centres should be driven by individual needs, however in an industry where workforce turnover can reach 20% per annum (Bagnera and Marti, 2001), this is prohibitively expensive to implement. Nevertheless effort must be made to match the workplace to worker and task characteristics to aid in productivity and reduce the problems previously detailed in the current review. Furthermore ergonomic research does suggest that there are cost effective improvements that can be made to existing call centre workstations to alleviate the musculoskeletal, physiological and psychophysical strain evidenced amongst seated workers.

4.1 Workstation design

Call centre workers typically sit for long periods of time interacting simultaneously with a personal computer and a customer, each condition presenting a specific challenge by exposing operators to various risk factors (Bagnara and Marti, 2001). Much research has focused on the ‘ideal’ seated workstation, however there is no consensus within the literature. These suggested solutions aim to provide a thorough overview of ergonomic opinion as to the ‘ideal’ office environment such that stations can be modified or designed accordingly.

4.1.1 Chair design

As sustained, awkward seated postures have been identified as important risk factors for MSDs, it is important to consider the chair where the operator spends the majority of the working shift. It has been suggested that chairs should encourage a ‘good’ posture (Rempel et al., 2006; Lis et al., 2007), however few studies detail what this posture entails. Since the late 18th century, chair designs have attempted to produce a chair that encourages this elusive ‘good’ posture based on the scientific knowledge of the time (Harrison et al., 1999), resulting in evolving chair profiles. A major design goal appears to be a chair that allows for an optimal posture while maintaining comfort and functionality; however this cannot encompass individual responses (Dunk et al., 2005). Design issues have centered around factors such as seat height, depth, seat pan tilt and backrest specifications which all play an integral and interactive role in determining seat acceptability and user comfort (Pheasant, 1991).

The majority of the literature emphasizes the importance of correct seat height to attenuate pressure on the back of the thighs, thereby preventing ischemia and perceived discomfort (Menta and Tewari, 2000). The individual’s feet should be in contact with the floor to allow transfer of 25% of body weight through the legs, effectively reducing lumbar pressure (Harrison et al., 1999; Parcells et al., 1999). Pheasant (1991) advocates that seat height should be at popliteal height, approximately 380-535mm, while Smellie (2003) extends this range to 590mm with 130mm of adjustment. More recently produced office chairs are adjustable, allowing users to correct seat height accordingly. For those situations where seat height may not be adjustable, authors have suggested use of a footrest (Kroemer, 1971; Pheasant, 1991; Fujimaki and Mitsuya, 2002), which is increasingly evidenced in industry.

To avoid unacceptable pressure on the back of the knees, and allow feet to be in contact with the floor/footrest, seat depth must not exceed buttock-popliteal length (Parcells et al., 1999; Smellie, 2003), approximately 435mm for the 5th percentile for females (Pheasant, 1991). Correct seat depth encourages use of the backrest, which is agreed as the most important aspect of the chair for attenuating stresses on the spine (Carcone and Kier, 2007). This is achieved by simultaneously allowing relaxation of passive and active structures in the spine and encouraging lumbar lordosis (Schulthess, 1905; Kayis and Hoang, 1999; Van Dieen et al., 2001; Vergara and Page, 2002; Carcone and Kier, 2007). Spring loaded backrests have been proposed as most efficient at tracking torso movements, allowing for variation in posture (van Dieen et al., 2001).

Controversy exists as to the most effective degree of backward leaning with estimates in the range of between 10^0 and 20^0 (Keegan, 1953; Knutsson et al., 1966; Parcells et al., 1999; Smellie, 2003; Corlett, 2006). Furthermore although the presence of a backrest is agreed to be important, the literature contains many conflicting standards and recommendations (Coleman et al., 1998) particularly regarding lumbar and scapular support (Goossens et al., 2003). For this reason Coleman et al. (1998) recommend height adjustable backrests, accommodating for temporal changes in operator preference and providing a prudent compromise. In the absence of adjustability, various authors advocate the use of a lumbar pad (Kroemer, 1971; Carcone and Keir, 2007). While research has not clarified preferred size, decreased neck flexion and increased lumbar lordosis have been evidenced during lumbar pad usage.

Increasing the trunk-thigh angle has been shown to reduce undesirable kyphosis of the lumbar spine (Parcells et al., 1999; Corlett, 2006), which can be achieved by tilt seating. While several authors report that tilting seat pans are practically negligible in reducing spinal load (Kayis and Hoang, 1999), most recommend either 5^0 forwards (Parcells et al., 1999) or between 5^0 forwards and backwards (Bendix and Biering-Sorensen, 1983; Smellie et al., 2003). While the excessive forward tilting seen in kneeling chairs leads to instability (Pheasant, 1991) as well as kyphosis (Bendix et al., 1996), small degrees of tilting allow for frequent posture changes (van Dieen et al., 2001), recognized as beneficial in constrained seated jobs (Legg et al., 2002).

This postural movement is specifically encouraged in ‘dynamic chairs’, which allow the seat and backrest to move either together or independently (van Dieen et al., 2001). This is important as it appears that the relationship between backrest and seat tilting are imperative in decreasing lumbar pressure (Lengsfeld et al., 2000). Moreover these chairs impart passive forced motions (Callaghan and McGill, 2001) which reduce lumbar compression and promote leg movements (Stranden, 2000). Individuals tend to use dynamic chairs if given a choice (Miedema et al., 1999), however often worker education is necessary to ensure correct use (van Dieen et al., 2001). Furthermore, the user should be able to ‘lock’ the seat elements in position as in practice, constant movement may not always be psychophysically acceptable (Pheasant, 1991; Smellie, 2003). Debate remains as to the effectiveness of dynamic chairs (Dunk et al., 2005) and the variety of methodology evidenced hinders comparison between existing studies.

Armrests have been shown to reduce muscular exertion in the trapezius muscles (Harrison et al., 1999), however if used there must be a gap between the armrest and the backrest so that the ulnar nerve is not impeded (Pheasant, 1991) and furthermore, it must not compromise movement or accessibility to the desk (Smellie, 2003). Ideally Smellie (2003) advocates that the armrests should be detachable although this is unlikely in all but custom made chairs.

Despite a high degree of adjustability in the current office chair, it has been established that these features are ineffective if workers are not educated as to their correct use (Rudnick, 2000; van Dieen et al., 2001). This illustrates the importance of continued worker education with reference to workplace set up and correct adjustment of chairs. Proper ergonomic set up of workstations tends to be hindered by the 'hot-desking' that often occurs in call centres, whereby operators constantly use different workstations; hence this practice should be minimized as far as possible within organizations (Taylor et al., 2003) to allow workers to efficiently adjust the workspace to their needs.

4.1.2 Workstation organisation

Margaritis and Marmarus (2007) emphasise the importance of workstation layout in the reduction of MSDs amongst seated workers. Incorrect keyboard and visual display unit (VDU) placement, insufficient table space, lack of forearm support and glare of screens have all been identified as workstation problems associated with MSDs and visual problems (Hunting et al., 1981; Harrison et al., 1999; Rudnick, 2000; Seghers et al., 2003; Smellie, 2003; Rempel et al., 2006; Margaritis and Marmarus, 2007). Pheasant (1991) thoroughly details workstation layout based on anthropometric measures, however this level of detail is only useful in the design process for office furniture.

In established workstations, frequently used objects such as the keyboard, mouse and telephone, should be placed within easy reach (Pheasant, 1991; Rudnick, 2000). Screens should be placed at right angles to windows and parallel to overhead lights to reduce glare (Pheasant, 1991), while diffuse lighting is preferable to direct overhead light (Aaras et al., 2001). Authors agree that VDUs should be placed below eye height to reduce neck muscle activity and take advantage of the natural downward gaze (Fujimaki and Mitsuya, 2002; Seghers et al., 2003), however the actual degree varies, with some authors advocating 15^0 (Pheasant, 1991; Seghers et al., 2003) or 30^0 below (Smellie, 2003) while others argue that anything between 15^0 and 30^0 is acceptable depending on user preference (Aaras et al., 1997). Hunting et al. (1981) recommend VDU placement 400-800 mm away from the operator while Pheasant (1991) argues that 500 mm should be the minimum viewing distance and both this author and Smellie (2003) advocate 750 mm where possible.

Keyboards should be kept at elbow height (Hunting et al., 1981; Smellie, 2003) and close to the desk surface so as to reduce wrist extension (Rempel et al., 2006). Ergonomic keyboards have been shown to be generally preferable to the traditional QWERTY layout, however familiarity and associated learning requirements with implementation has hindered the use of such keyboards (Amell and Kumar, 1999). More commonly evidenced are forearm and wrist supports; forearm support has been found to be advantageous by a variety of authors (Kroemer, 1971; Hunting et al., 1981; Aaras et al., 2001; Cook and Burgess-Limerick, 2004) and their relatively cost effective implementation has seen them frequently used in reactive ergonomic interventions (Amell and Kumar, 1999). However Rempel et al. (2006) caution that the whole forearm must be supported, not just the wrists, thereby allowing for less localized contact stress. Nevertheless it has been suggested that, if provided, the majority of people will use forearm support as opposed to just the desk being offered as a supporting surface (Smellie, 2003).

Galinsky et al. (2000) suggest that the discomfort evidenced in the neck and shoulders in seated workers has proven difficult to counteract during ergonomic interventions. Furthermore these authors report that the static postures evidenced may not be fully eradicated through workstation redesign, therefore organisational changes become increasingly important

4.2 Work organisation

Regarding seated postures, research indicates that rest breaks are fundamentally important in reducing discomfort and injury allied to static muscular contractions (Rudnick, 2000; Palmer et al., 2001; Corlett, 2006; Cagnie et al., 2007). The proportional relationship between exposure and recovery time means cumulative discomfort is unlikely to occur over a traditional lunch break, indicating that rest breaks should be short and frequent (Galinsky et al., 2000; Corlett, 2006). Furthermore compulsory planned rest breaks encourage peer interaction that is traditionally scarce in call centre work (Berquvist et al., 1995), leading to increased worker well being. These may further help to relieve the cognitive strain evidenced in operators involved in complex problem solving activities for the majority of the working shift (Bagnera and Marti, 2001). Furthermore standing/walking should be encouraged during breaks as spinal loading patterns are significantly different and provide relief for the structures of the back (Callaghan and McGill, 2001).

Bagnera and Marti (2001) suggest that insufficient training accounts for the high cognitive strain reported amongst contemporary call centre workers. By investing in appropriate training strategies companies could look to increasing worker productivity and competency. Furthermore these authors express a necessity for user-friendly software and clearly defined organizational structures as means of reducing cognitive load on operators.

Regular worker education concerning ergonomics, correct workstation set up and the dangers associated with long term constrained seated postures is a key element in reducing the effects of these environments (Smellie, 2003). Harrington and Walker (2004) call attention to the importance of education of seated workers specifically and show that simple software and computer based training packages can be used to aid this learning process. Simple leg exercises such as knee raising, stepping and heel raising have shown positive effects on sedentary workers (Winkel and Jorgensen, 1986; van Deursen et al., 2000). Leaflet-style instructions, as detailed by Coleman et al. (1998), provide continual reference points to adjust seating according to preference. It must be noted that constant education is vitally important; Rudnik (2000) advocates that to encourage successful outcomes companies must consider ergonomics as an on going programme and encourage workers to do the same.

Moreover encouraging workers to participate in this process leads to increased feelings of well being and involvement (Rudnick, 2000). This personal involvement may be impractical in large companies, however ergonomic education would be particularly important here where supervisors are not on hand to continually provide basic ergonomic principles.

5 Conclusions

The prolonged confined seated posture call centre operators are required to assume has been shown to have negative impacts from both a biomechanical and physiological perspective. However appropriate workstation design, specific to the needs of the individual, and effective work organisation can effectively reduce the physical demands being placed on the human operator. Optimizing the call centre environment to suit the physical capabilities of the workers will not only significantly reduce the risk of injury, but also improve productivity.

References

Aaras A, Fostervold K, RO O, Thoresen M and Larsen S (1997). 'Postural load during VDU work: a comparison between various work postures', Ergonomics, vol. 40, pp. 1255-1268.

Aaras A, Horgen G, Bjorset HH, Ro O and Walsoe, H (2001). 'Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomics interventions'. A 6 year prospective study: Part II ', *Applied Ergonomic*s, vol. 32, pp. 559-571.

Amell TK and Kumar S (1999). 'Effect Cumulative trauma disorders and keyboarding work', *International Journal of Industrial Ergonomics*, vol. 25, pp. 69-78.

Bagnara S and Marti P (2001). 'Human work in call centres: a challenge for cognitive ergonomics', *Theoretical issues in Ergonomics and Science*, vol. 2, pp 223-237.

Beach TAC, Parkinson RJ, Stothart JP and Callaghan JP (2005). 'Effects of prolonged sitting on the passive flexion stiffness of the in vivo lumbar spine', The Spine Journal, vol. 5, pp 145-154.

Bendix T and Beiring-Sorensen F (1983). 'Posture of the trunk when sitting forward inclining seats', *Scandinavian Journal of Rehabilitation Medicine*, vol. 15, pp. 197-203.

Bendix, T, Poulsen, V, Klausen, K and Jensen, CV (1996). 'What does a backrest actually do to the lumbar spine?', *Ergonomics*, vol. 39, no. 4, pp. 533-542.

Bergqvist U, Wolgast E, Nilsson B and Voss M (1995). 'Musculoskeletal disorders among visual display terminal workers: individual, ergonomic and work organizational factors', *Ergonomics*, vol. 38, no. 4, pp. 763-776.

Bridger RS (1988). 'Postural adaptations to a sloping chair and work surface', *Human Factors*, vol. 30, pp. 237-247.

Bridger RS (2003). *Introduction to Ergonomics*. 2nd edn, Taylor and Francis.

Callaghan JP and McGill SM (2001). 'Low back joint loading and kinematics during standing and unsupported sitting', *Ergonomics*, vol. 44, pp 280-294.

Carcone SM and Keir PJ (2007). 'Effect of backrest design on biomechanics and comfort during seated work', *Applied Ergonomics*, vol. 38, pp. 755-764.

Cheung JT-M, Zhang M and Chow DH-K (2003), 'Biomechanical responses of the intervertebral joints to static and vibrational loading: a finite element study', *Clinical Biomechanics*, vol. 18, pp. 790.

Coleman N, Hull BP, and Ellit G (1998), 'An empirical study of preferred settings for lumbar support on adjustable office chairs', *Ergonomics*, vol. 41, pp. 401-419.

Cook A and Burgess-Limerick R (2004). 'The effect of forearm support on musculoskeletal discomfort during call centre work', *Applied Ergonomics*, vol. 35, pp. 337-342.

Corlett EN and Eklund JA (1984). 'How does a backrest work?' *Applied Ergonomics*, vol. 15, pp. 111-114.

Corlett EN (2006). 'Background to sitting at work: research requirements for the design of work seats', *Ergonomics*, vol. 49, pp. 1538-1546.

Dunk NM and Callahagan JP (2005). 'Gender based differences in postural responses to seated exposures', *Clinical Biomechanics*, vol. 20, pp. 1101-1110.

Ferreira Jr, M and Saldiva PHN (2002). 'Computer-telephone interactive tasks: predictors of musculoskeletal disorders according to work analysis and workers' perception', *Applied Ergonomics*, vol. 33, pp. 147-153.

Fujimaki G and Mitsuya R (2002). 'Study of the seated posture for VDT work', *Displays*, vol. 23, pp. 17-24.

Galinsky TL, Swanson NG, Sauter SL, Hurrell JJ and Schleifer LM (2000). 'A field study of supplementary rest breaks for data entry operators', Ergonomics, vol. 43, no. 5, pp. 622-638.

Gardner AMN and Fox RH (1989). *The Return of Blood to the Heart: Venous Pumps in Health and Disease* (London: John Libbey).

Goossens M, Snijders C, Roelofs G and van Buchem F (2003). 'Free shoulder space requirements in the design of high backrests', *Ergonomics*, vol. 46, pp. 518-530.

Hales TR, Sauter SL, Peterson MR, Fine LJ, Anderson V, Shleifer LR, Ochs TT and Bernardi BP (1994). 'Musculoskeletal disorders among visual display terminal users in a telecommunications company', *Ergonomics*, vol. 37, No. 10, pp. 1603-1621.

Hall SJ (2007). '*Basic Biomechanics.'* New York – McGraw-Hill publishing.

Harrison DD, Harrison SO, Croft AC, Harrison DE, and Troyanovich DC (1999). 'Sitting Biomechanics Part 1: Review of the literature', *Journal of Manipulative and Physiological Therapeutics,* vol. 22, no. 9, pp. 594-609.

Hartvigsen J, Leboeuf-Yde C, Lings S and Corder EH (2000). 'Is sitting-while-at-work associated with low back pain? A systematic, critical literature review', *Scandinavian Journal of Public Health*, vol. 28, no. 3, pp. 230-239.

Hitosugi M, Niwa M and Takatsu A (2000). 'Rheologic changes in venous blood during prolonged sitting'. *Thrombosis Research,* vol, 100, pp. 409–412.

Holm S and Nachemson A (1983). 'Variations in the nutrition of the canine intervertebral disc induced by motion', *Spine*, vol. 8, pp 886-874.

Hoogendoorn W, Bongers PM, de Vet HCW, Douwes M, Koes BW, Miedema MC, Ariens GAM and Bouter LM (2000). 'Flexion and rotation of the trunk and lifting at work are risk factors for low back pain'. Spine, vol. 25, pp. 3087-3092.

Hunting W, Laubli T and Grandjean E (1981). 'Postural and visual loads at VDT workplaces I. Constrained postures', *Ergonomics* , vol. 24, no. 12, pp. 913-931.

Kayis B and Hoang K (1999). 'Static three dimensional modeling of prolonged seated posture', Applied Ergonomics, vol. 30, pp. 255-262.

Keegan J (1953). 'Alterations of the lumbar curve related to posture and seating', *Journal of bone and Joint Surgery*, vol. 35A, pp.589-603.

Kelsey JL (1975). 'An epideimiological study of the relationship between occupation and acute herniation lumbar intervertebral discs', *International Journal of Epidemiology,* vol. 4, pp. 197-205.

Kroemer KHE (1971). 'Seating in plant and office', *American Industrial Hygiene Journal*, vol. 32, pp. 636-651.

Lange A and Froelicher ES (2005). ‚Management of overweight and obesity in adults: behavioural intervention for long-term weight loss and maintenance'. *European Journal of Cardiovascular nursing,* vol. 34, pp. 1-13.

Legg SJ, Mackie HW and Milichich W (2002). 'Evaluation of a prototype multi-purpose office chair', *Ergonomics,* vol. 45, no. 2, pp. 153-163.

Lengsfeld M, Frank A, van Deursen DL and Griss P (2000). 'Lumbar spine curvature during office chair sitting', *Medical Engineering and Physics*, vol. 22, pp. 665-669.

Link Cs, Nicholson GG, Shaddeau SA, Birch RB and Gossman MR (1990). 'Lumbar curvature in standing and sitting in two types of chairs: relationship of hamstring and hip flexor muscle length'. *Physical Therapy,* vol. 70, pp. 611-618.

Lis AM, Black KM, Korn H and Nordin N (2007). 'Association between sitting and occupational LBP', *European Spine Journal*, vol. 16, pp.283-298

McArdle WD, Katch FI and Katch VL (2001). *Exercise Physiology*. 5th edn, Philadelphia: Lippincott Williams and Wilkins, Publ.

Mehta CR and Tewari VK (2000). 'Seating discomfort for tractor operators- a critical review', *International Journal of Industrial Ergonomics*, vol. 25, pp. 661-674.

Palmer KT, Cooper C, Walker-Bone K, Syddall H and Coggan D (2001). 'Use of keyboards and symptoms in the neck and arm - evidence from a national survey', *Occupational Medicine*, vol. 51, no. 6, pp. 392-395.

Parcells C, Stommel M and Hubbard RP (1999). 'Mismatch of classroom furniture and student body dimensions', *Journal of Adolescent Health*, vol. 24, pp. 265-273.

Pascarelli E and Kella J (1993). 'Soft-tissue injuries related to use of the computer keyboard', *Journal of Occupational Medicine*, vol. 35, pp. 522-532.

Pheasant S (1991). *Bodyspace: Anthropometry, Ergonomics and the Design of Work*, 2nd edn, Taylor and Francis, London.

Pheasant S and Haslegrave CM (2006). *Bodysapce: Anthropometry, Ergonomics and the Design of Work*, 3rd edn, Taylor and Francis, London.

Puoane T, Steyn K, Bradshaw D, Laubscher R, Fourie J, Lambert EV and Mbamamga N (2002). 'Obesity in South Africa: The South African Demographic and Health Survey'. *Obesity Research*, vol. 10, pp. 1038-1048.

Ratzon NH, Yaros T, Mizlik A and Kanner T.(2000). ‚Musculoskeletal symptoms among dentists in relation to work posture'. *Work*, vol. 15, pp.153-158.

Rempel DM, Krause M, Goldberg R, Benner D, Hudes M and Goldner GU (2006). 'A randomized controlled trial evaluating the effects of two workstation interventions on upper body pain and incident musculoskeletal disorders among computer operators', *Occupational and Environmental Medicine*, vol. 63, pp. 300-306.

Rudnik SD (2000). 'Improve your call centre with an ergonomics makeover', Call centre CRM Solutions in Focus, Available http://www.tmcnet.com/ articles/ccsmag/0600/0600if_magnitude.htm. Accessed 12 September 2007

Seghers J, Jochem A and Spaepen A (2003). 'Posture, muscle activity and muscle fatigue in prolonged VDT work at different screen height settings', *Ergonomics*, vol. 46, no. 7, pp. 714-730.

Smellie S (2003). 'The limitations of a standard workstation for its user population', *Clinical Chiropractic*, vol. 6, pp. 101-106.

Smith M and Carayon P (1993). Work organization, stress and cumulative trauma disorders. In Moon SD and Sauter SL (eds), *Beyond biomechanics. Psychological aspects of musculoskeletal disorders in office work*, Taylor & Francis, London, pp. 23-43.

Speakman JR (2004). 'Obesity: The integrated roles of environment and genetics'. *American Society for Nutritional Sciences*, pp. 2090s-2105s.

Stranden E (2000). 'Dynamic leg volume changes when sitting in a locked and free floating tilt office chair'. *Ergonomics,* vol. 43, pp. 421-433.

Stranden E and Kroese A (1998). 'Venodynamics in healthy subjects and in patients with venous dysfunction'. *Scope on Phleboloby and Lymphology*, vol. 5, pp. 4-12.

Stricker H, Colucci G, Alberio L, Mombelli G. (2006). 'Variation in coagulation inhibitors during prolonged sitting: possible pathogenetic mechanisms for travel-associated thrombosis'. *Journal of Thrombosis and Haemostasis*; vol 4: 900–2.

Symington IS and Stack BHR (1977). 'Pulmonary thromboembolism after travel'. *British Journal of Chest*, vol. 71, pp. 138-140.

Van Deursen DL, Deursen LLJM, Snijders CJ and Goossens RHM (2000). 'A field study of supplementary rest breaks for data entry operators', *International Journal of Industrial Ergonomics*, vol. 26, pp.521-526.

Van Dieen JH, de Looze MP and Herman V (2001). 'Effects of dynamic office chairs on trunk kinematics, trunk extensor EMG and spinal shrinkage', *Ergonomics*, vol. 44, pp.739-750.

Valachi B and Valachi K (2003). 'Mechanisms leading to musculoskeletal disorders in dentistry'. *Clinical Practice*, vol. 134, pp. 1344-1350.

Vergara M and Page A (2002). 'Relationship between comfort and back posture and mobility in sitting posture ', *Applied Ergonomics*, vol. 33, pp.1-8.

Winkel J and Jorgensen K (1986). 'Evaluation of foot swelling and lower limb temperatures in relation to leg activity during long term seated office work', *Ergonomics*, vol. 29, no. 2, pp. 313-328.