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ERGONOMICS

Rethinking design parameters in the search for optimal dynamic seating

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Summary Dynamic *seating* design purports to lessen damage incurred during sedentary occupations by increasing sitter movement while modifying muscle activity. Dynamic *sitting* is currently defined by O'Sullivan et al. (2013a) as relating to 'the increased motion in sitting which is facilitated by the use of specific chairs or equipment' (p. 628). Yet the evidence is conflicting that dynamic seating creates variation in the sitter's lumbar posture or muscle activity with the overall consensus being that current dynamic seating design fails to fulfill its goals.

Research is needed to determine if a new generation of chairs requiring active sitter involvement fulfills the goals of dynamic seating and aids cardio/metabolic health. This paper summarises the pursuit of knowledge regarding optimal seated spinal posture and seating design. Four new forms of dynamic seating encouraging active sitting are discussed. These are 1) The Coreflex with a split seatpan to facilitate a walking action while seated 2) the Duo balans requiring body action to create rocking 3) the Back App and 4) Locus pedestal stools both using the sitter's legs to drive movement. Unsubstantiated claims made by the designers of these new forms of dynamic seating are outlined. Avenues of research are suggested to validate designer claims and investigate whether these designs fulfill the goals of dynamic seating and assist cardio/metabolic health. Should these claims be efficacious then a new definition of dynamic sitting is suggested; 'Sitting in which the action is provided by the sitter, while the dynamic mechanism of the chair accommodates that action'.

Introduction

Studies worldwide demonstrate that sitting accounts for 51—68% of an adult's waking day (Healy et al., 2008, 2011). Days spent at work are associated with two hours more sitting and therefore less standing and walking time than leisure days (McCrady and Levine, 2009). The greatest part of daily energy expenditure is more often related to light intensity activities such as standing, slow walking, lifting light objects, rather than moderate or vigorous activity e.g. brisk walking or running. However, light activities have become significantly reduced because of improvements or

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changes in technology, including dynamic chairs that encourage prolonged sitting in the workplace as well as the home (Dunstan et al., 2012).

Dynamic chairs were introduced to address ramifications from prolonged sitting by facilitating movement while decreasing static muscle activity. However, in their systematic review of dynamic sitting, O'Sullivan et al. (2013a) concluded that there was no evidence to 'support the use of dynamic sitting approaches as an effective, or beneficial, means of modifying trunk muscle activation during sitting' (p 633). The conclusions of the systematic review studies were: joint and muscle activity is affected more by task than dynamic design (Ellegast et al., 2012; Van Dieën et al., 2001), unstable surfaces (e.g. sitballs) do not improve lumbar posture (McGill et al., 2006; O'Sullivan et al., 2006), cause increased discomfort (Gregory et al., 2006; McGill et al., 2006), spinal shrinkage and increased (Kingma and van Dieën, 2009) or unchanged superficial trunk muscle activity (McGill et al., 2006; O'Sullivan et al., 2006). The few advantages; sitballs increase trunk movement (O'Sullivan et al., 2006), pneumatic lumbar support improves upright and reclined lumbar posture (McGill and Fenwick, 2009), dynamic seats with backrests decrease spinal shrinkage (Van Dieën et al., 2001), are overridden by the disadvantages.

To date therefore, dynamic seating design has failed to attain its objectives. This finding suggests the need to rethink design parameters in the search for optimal chair design. The current ergonomic paradigm is design that minimises load and muscle activity. Instead, Straker and Mathiassen (2009) propose increasing joint movement and muscle activity, citing the use of sit/stand tables as one method of achieving more activity. However Gallagher et al. (2014) calculate it would require standing or walking for 5.5 h of a 7.5 h working day to gain metabolic benefits from light activity proposed by Owen et al. (2011) and that standing stationary at a desk for 45 min causes low back pain (lbp) unrelieved by 15 min of sitting.

This paper explores the proposition that by making sitting more active, incidental activity may be increased without musculoskeletal penalty, thus addressing cardio/metabolic and postural health. Research pertaining to seated posture and seating design optimal to lumbar postural health is summarised. Future research options are proposed using a new generation of dynamic seating, the claims of which are largely unsubstantiated.

The quest for the least damaging seated posture/s

Table 1 outlines the circuitous route of the pursuit for optimal seated posture and design that was impacted variously by experiential, anecdotal, sociocultural and scientifically validated advice. Table 2 and Fig. 1 compare the damage caused by sitting in a) sustained kyphosis, b) lordosis same as standing c) individual neutral. In summary, in the absence of spinal anomaly (e.g. symptomatic lytic/degenerative listhesis or canal stenosis) seated postures that maintain some degree of lordosis are the least damaging to spinal health. The question in the last decade has been: how much lumbar lordosis is optimal?

There is a strong body of evidence in the current literature that a neutral position of the lumbar spine is least damaging for those historically free of non specific chronic lbp (NSCLBP) (Claus et al., 2008; O'Sullivan et al., 2010; Scannell and McGill, 2003), particularly when stationary (McGill, 2004). A neutral posture is balanced midway between individual full kyphosis and lordosis (McGill, 2004; Scannell and McGill, 2003) neither flexed nor extended (McGill and Fenwick, 2009), achieved by tilting the pelvis slightly anteriorly while maintaining a relaxed thoracic spine (O'Sullivan et al., 2010) or, in the absence of a backrest, a position with flat thoracic and lumbar spines that retains minimal lordosis (Claus et al., 2008, 2009). O'Sullivan et al. (2010, 2012) quantify their definition of neutral position as 30% off individual maximal sitting lumbar lordosis where maximum lordosis is 100% of lumbar range and maximum kyphosis is 0% of sitting lumbar range.

However, O'Sullivan et al. (2012b) concur with Callaghan and McGill (2001) that providing a posture is not maintained at end of range and does not require damaging muscle activity, then chair designs affording ease of movement between multiple postures are preferable to those that constrain to one 'optimal' position.

Advising on individual optimal postures

Individuals with NSCLBP history unnecessarily increase spinal load by choosing painful end-range kyphosed or hyperlordosed sitting postures (Dankaerts et al., 2006b) and moving in dysfunctional, pain producing patterns (McGill et al., 2003a; McGill, 2004) in the direction they know causes them pain, thus increasing their pain and preventing recovery.

Finding the optimal sitting posture/s for an individual requires examining for motor control aberrations, muscle impairments and dysfunctional movement patterns contributing to pain production (Astfalck et al., 2010; Dankaerts et al., 2006a,b; Dankaerts and O'Sullivan, 2011; McGill et al., 2003a; McGill, 2004; O'Sullivan et al., 2013d) given that such aberrations increase muscle activity and loads, predisposing the back to further injury (McGill et al., 2003b). Other variables to consider include, but are not limited to, direction of movement that improves or worsens symptoms, physical individual ranges of motion in the thoracic and lumbar spines in sitting, the natural degree of hypo/hyperlordosis in standing and the impact that sitting, which increases lumbar kyphosis compared to standing, has on posterior tissue strain, the frequency/ease of movement permitted by the seat and tasks pursued while seated (Claus et al., 2009; Keegan, 1953; McGill, 2004; O'Sullivan et al., 2012b). Psychosocial issues such as coping mechanisms and depression contributing to chronicity are also important (McGill et al., 2003a).

It is essential to correct poor postural habits and retrain motor function in order to avoid daily chronic cumulative trauma that hinders/prevents recovery (McGill, 2004). Lay term advice is required that in the short term pain from sustained kyphosed sitting may be caused by creep irritating pain receptors in ligaments and lumbodorsal fascia (Callaghan and Dunk, 2002) and in the long term may be the result of accumulation of microtrauma in the ligaments