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Application of Zen sitting principles to microscopic surgery seating

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ABSTRACT

This paper describes the application of an alternative seating concept for surgeons that reflects the research of Zen sitting postures, which require Zazen meditators to maintain fixed postures for long durations. The aim of this alternative approach is to provide sitters with a seat pan with sacral support[1] that provides a more even distribution of seat pressures, induces forward pelvic rotation and improves lumbar, buttock and thigh support.

This approach was applied to the development of a chair for microscopic surgery. The experimental chair is a seat pan that closely matches the three-dimensional contours of the user's buttocks. Seat comfort was evaluated by comparing both changes in pelvic tilt and seat pressure distributions using *Regionally-Differentiated Pressure Maps* (RDPM) with subjective ratings of surgeons while operating in prototype and conventional chairs.

Findings include that the sacral support of the prototype chair prevents backward pelvic rotation, as seen in *zazen* (Zen sitting postures). Preliminary data suggests that the prototype provided greater sitting comfort and support for constrained operating postures than did the conventional chair. These findings support the selective application of concave-shaped seat pans that conform to users' buttocks and reflect Zen sitting principles.

1. Introduction

1.1. Western view of seat comfort

Pynt et al. (2002) and Pynt and Higgs (2010) trace early attention to sitting postures to Ancient Egypt, pointing to the design of a forward tilting seat from 1500 BC. Even so, much innovation in Western seating has evolved from the findings of Keegan (1953, 1964), who reported that open thigh-torso angles more evenly distribute loads on the spine. Keegan[2] focused on pathological problems caused by flexion of the lumbar spine associated with seated postures and proposed design criteria to promote lumbar lordosis. Mandal (1982a,b) expanded on Keegan's findings and proposed forward tilting seat pans to induce lumbar lordosis. Congleton et al. (1985) espoused the adoption of more neutral forward and back sitting postures. A broad range of new and innovative designs expanded on these Western concepts of seating.

Yet, despite the vast body of literature on the topic, we continue to struggle to define seat comfort. Corlett and Bishop (1976) shifted our focus from measuring comfort to discomfort because comfort is more difficult to measure and interpret and also because the two represent not one dimension but rather different constructs. Habsburg and Mittendorf (1980) concluded that subjects' comfort ratings were based on something other than their own personal experience.[3] Analyses by Zhang et al. (1996)

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[1] The term 'sacral support' seems to be commonly used in the U.S., while Japanese people customarily use 'pelvic support'. The first known use of the term 'pelvic support' appeared in Yu and Keyserling (1989). Wu et al. (1998) performed an in-depth analysis of the effectiveness of pelvic support for inducing pelvic tilt. In recent years, advances in technology have enabled the direct measurement of pressures on the sacral area that are distinct from those on the pelvic area. In this article, the term 'sacral' is used only when the sacral area is identified by palpation. The distinction between pelvic and sacral supports is defined in Section 6.2.1 of this article in relation to Fig. 10.

[2] It might be *pointed* out that Keegan's research, though brilliant and historically pivotal, would have been considered quite limited today as it represented repeated X-rays of a single young male lying on a horizontal surface.

[3] These authors found that raters judged seats more stringently in the personal suitability judgment (for me/not for me) than in their ratings on overall seat comfort, suggesting that their comfort judgment hinged upon the projected comfort of an independent and objective user.

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and Helander and Zhang (1997) on the properties of comfort and discomfort led them to conclude that the two constructs measured different dimensions. Kuijt-Evers et al. (2005) proposed a unified field theory for comfort and discomfort.

The process becomes even more complex when attempting to evaluate design solutions. Reviews by Lueder (1983) and Corlett (1989) emphasized the lack of objective measures for evaluating sitting comfort; on this basis, the latter suggested instead focusing on the specific context and functional requirements of a seat. In their review, De Looze et al. (2003) noted the dearth of commonly recognized measures and objective findings for sitting comfort.

The research on sitting comfort demonstrates a particularly pronounced relationship between seat pressure and comfort. De Looze et al. (2003) concluded that the most consistent predictor of seat comfort related to seat pressure distribution[4] and that this relationship was considerably more straightforward than with research measuring muscle activity or spinal profiles. Using a specially designed seat fixture, Goossens (1998) varied pressures and found a strong correlation between the amount of pressure applied to the buttocks and discomfort. Goossens et al. (2005) found subjects were quite sensitive to JND/Just Noticeable Differences in seat pressures at the ischial tuberosities.

Compressive loads and displacement of force are affected by our age and the degeneration of the spine (e.g., Pollintine et al., 2004). Even so, Dolan and Adams (2001) noted, "tissue stress probably plays a major role in determining if a given tissue is painful, it is tissue stress rather than overall loading which influences the metabolism of connective tissue cells".

Although backrests may provide important benefits (*s.f.* Pynt and Higgs, 2010; Rohlmann et al., 2001, Wilke et al., 1999), some emphasized the particular importance of pelvic and sacral support. Grandjean (1973) pointed to the relative superiority of pelvic and sacral support to lumbar supports "since the prolonged maintenance of an upright seated posture with a lordosis of the lumbar spine results in strain on the extensor muscles of the back". Zacharkow (1988) recommended the provision of pelvic supports just below the posterior pelvic rim in order to support the upper sacrum, pelvis and lumbar spine. Corlett (1999, 2006) emphasized the functional requirements of pelvic support of the buttocks and thighs.

Others focused on promoting natural postures through the design of the seat pan. Research by Yu and Keyserling (1989) led to the development of a work chair for sewing with a contoured seat pan that tilted at the front to promote thigh, pelvic, lumbar and thoracic-support. Rempel et al. (2006) found that garment workers provided with an adjustable height seat pan that tilted at the front experienced a greater improvement in neck/shoulder pain over a four-month period than the control group using an adjustable height flat seat pan. New and innovative designs such as Corlett's and Gregg (1994) and Corlett's (2006) Nottingham chair, Opsvik's Balans chair (Lueder, 2010) and the Bambach Saddle Seat (Gale et al., 1989; see also Gadge and Innes, 2007) emphasized promoting neutral postures through the design of the seat pan.

Wu et al. (1998) found that seat pans with pelvic support promoted forward pelvic tilt and induced a more neutral posture than did backrest lumbar supports. Rohlmann and Bergmann (2000) found a padded wedge improved back shape, though not implant loads. Even so, Rohlmann et al. (2001) concluded from their study of a group of patients that opportunities to move are more important than features of the chair.

[4] De Looze et al. (2003) reviewed studies that compared seat comfort findings that matched physiological parameters with subjective measures of seat comfort.

1.2. Alternative Eastern perspectives of seating

It is not surprising that Western assumptions about sitting and seating contrast markedly with traditional Eastern perspectives on sitting. Howes (1957) reviewed the cultural differences in postures and styles of sitting that are specific to gender and nations, particularly between the East and West. Mauss (1979) and Gurr et al. (1998) point to the limitations of Western concepts of posture and seating, which translate poorly to other cultures and may increase associated risk of musculoskeletal disorders.

1.2.1. What is Zen sitting?

Noro (2009a,b) reviewed the concept of seat comfort as it applies to Zen sitting, an Eastern way of sitting.[5] Noro (2007) surveyed Zen priests' *zazen* postures, which reflect the principles of *Zazen* Buddhism and was developed by the great Master Dogen in the 13th century, who introduced the *Zafu* posture to promote postural stability. For this reason, Zen monks in Japan now commonly assume *Zafu* while meditating (Fig. 1)

The *Zafu* sitting style is in marked contrast with those in the West. While *Zafu* sitting promotes postural stability, Western chair designs aim to facilitate changes of posture. Placing a *Zafu* underneath one's buttocks facilitates deep breathing and lengthens the spine by inducing a forward pelvic tilt underneath the gluteus maximus around the sacrum (Fig. 1). In contrast, Western seats commonly attempt to induce pelvic tilt through lumbar supports.

1.2.2. Zen sitting and chairs

Noro et al. (2006) contrasted this Eastern view with Western assumptions in seating, based on both medical findings and observations of users interacting with chairs.

The implications of medical findings are addressed first. Adams and Hutton (1985) pointed to a lack of reliable evidence that upright sitting benefits the lumbar spine. These authors cited findings of Fahrni and Trueman (1965) from their radiographic experiments on lumbar spines and posited the superiority of kyphotic lumbar spines over postures with lumbar lordosis. They based their opinion on evidence that lumbar disc degeneration is rare among people who habitually sit or squat in postures that flex (flatten) the lumbar spine. In his review, Deyo (1998) reported that numerous studies demonstrate the high prevalence of disk bulges or herniation among asymptomatic people.[6]

Some findings point to alternate perspectives in chair design. Shimode (1992) noted that the forward inclination of lumbar vertebra is necessary for standing but not sitting. Mandal (1982a,b,1994) suggested that lumbar supports function only when backrests recline. Corlett and Eklund (1984) suggested backrests only promote desirable lumbar curvatures when users lean back; once the flattening occurs during work, "the curve will

[5] Zen sitting is only one of many Eastern sitting postures cited by Howes (1957). The *lotus position* is a particularly important Zazen posture, which Buddha first introduced circa 500 BC. The lotus sitting style differs from traditional Yoga sitting postures and is characterized by symmetrical positioning of the left foot over the right thigh and the right foot over the left thigh. As Buddhism spread from India across the East, the influence of the lotus sitting style expanded across Asia.

[6] As one example, Deyo described a "1990 study by Scott D. Boden of the George Washington University Medical Center and his colleagues looked at 67 individuals who said they had never had any back pain or sciatica …MRI found them in one-fifth of pain-free study subjects under age 60. Half of that group had a bulging disk, a less severe condition also often blamed for pain. Of adults older than 60, more than third have a herniated disk visible with MRI, nearly 80 percent have a bulging disk, and nearly everyone shows some age-related disk degeneration".