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Study of a Workseat Designed to Preserve Lumbar Lordosis

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The purpose of this study was to evaluate the effect a saddle shaped seat has on the lumbar curve of workers. A saddle shaped work seat was designed and constructed. Subjects were asked to sit at a work task. Measurements were taken of their lumbar curve whilst seated on the saddle work seat and, alternatively on a conventional work seat. Photographs were used to provide a reference for measurements which were compared for the two seats. The lumbar lordosis of all subjects was found to be greater when seated on the saddle seat. The researchers concluded that the saddle seat was a viable alternative to the current range of ergonomic chairs as it has none of their inherent problems, but effectively places the user into an ergonomically correct position. Whilst further tests will be necessary to confirm these findings, it does seem that the saddle seat is a useful work seat which preserves good lumbar lordosis while allowing free upper body movement to work with accuracy, power and good vision. It therefore reduces the risk of back injury at work in accordance with the intent of the New South Wales Occupational Health and Safety Act 1983.

Key words: Ergonomic seating, back pain, work injury prevention.

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The New South Wales Occupational Health and Safety Act of 1983 legislates that employers must secure the health, safety and welfare of workers by protecting them at the workplace against risks to health and safety arising from the work activity or environment. Research by health and ergonomic professionals has concluded that:

- Intradiscal pressure is increased in the seated position due to lumbar flattening;

- The pelvic tilt angle controls the lumbar curve;
- Conventional seating may cause back pain.

Various "ergonomic chairs" have been designed to encourage lumbar lordosis, all with accompanying problems. Several researchers have suggested the possible usefulness of a saddle shaped seat in facilitating lumbar lordosis whilst alleviating the problems associated with other seats.

Background

Modern furniture in schools, factories and offices is constructed in such a way that no-one can use it properly. Each day people sit hunched over their tables in postures extremely harmful to the back. No-one should be surprised that more than half of the population today is complaining of back ache (Mandal, 1981, p. 19).

The increased involvement of individuals and public bodies in promoting healthy lifestyles has been reinforced by State and Federal legislation for health and safety at work.

The New South Wales Occupational Health and Safety Act 1983 in Division 1, Section 5, states its objectives as being:

(a) to secure the health, safety and welfare of persons at work, and

(b) to provide an occupational environment for persons at work which is adapted to their psychological and physiological needs.

Part III, Division 1, Section 15, subsection 2, states that the employer shall be in breach of the act if she or he fails:

(a) to provide such information, instruction, training and supervision as may be necessary to ensure the health and safety at work of his or her employees.

An important consequence of this has been a greater focus on the relationships between furniture, back pain and work injury.

Determining an Ergonomically Correct Sitting Position

A great deal of research has been carried out into determining the sitting position which most readily maintains spinal health and avoids back pain. An important aspect of Keegan's work (cited in Mandal, 1981, p. 21) has been his findings which show that increased intradiscal pressure in the lumbar area presses the disc back towards the spine while pulling the rear edges of the vertebrae apart. Thus, the disc is displaced to press against the nerve root causing the ligament to stretch, both of which result in pain.

Grandjean (1981, p. 153) states that preservation of the lumbar lordosis ensures the least pressure on the intervetebral disc. As he says, intradiscal pressure increases greatly when a person sits and is greatest when sitting forward with the lumbar spine flattened.

Shoberth's work also supports this claim:

> By examining 25 people, Shoberth's work (cited in Mandal, 1981, p. 21) found that an average, flattening of the lumbar curve of 30° to 40° took place in sitting down. This lumbar bending occurred in nearly all the cases in the fourth and fifth lumbar discs. It is exactly these two discs that give rise to most cases of slipped disc. Fig. 1 shows this diagrammatically.

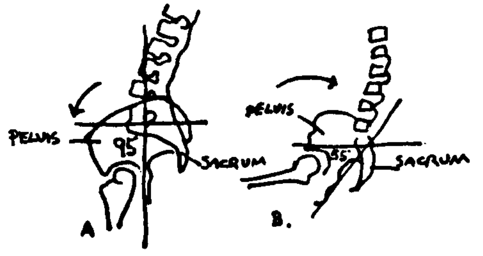

FIGURE 1

Figure 1 shows the pelvic angle in anterior tilt when standing with hip extension resulting in good lumbar curve and disc space and the pelvic angle in posterior pelvic tilt when sitting with hip flexion and subsequent flattened lumbar curve.

When a person stands, the lumbar curve is restored with anterior pelvic tilt resulting in 30 per cent lower disc pressure than when sitting (Akerblom, 1984; Burandt, 1969; Carsloo, 1972; Keegan, 1953; Shoberth, 1962; all cited in Chaffin and Anderson 1984, p. 289).

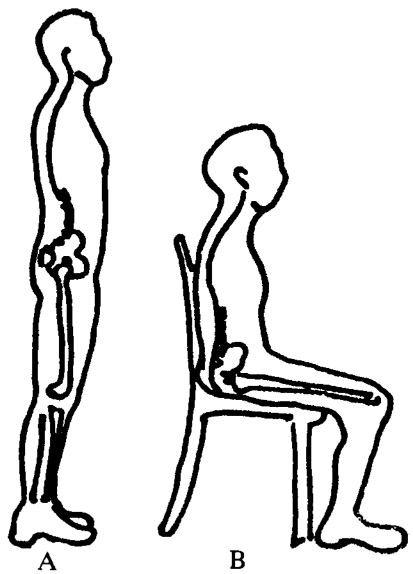

FIGURE 2

A. Shows good lumbar curve with anterior pelvic tilt and hip extension in standing.

B. Shows how the lumbar curve flattens with posterior pelvic tilt to allow the hip to flex to 90° when sitting in traditional furniture.

Keegan states that 60° of movement when sitting comes from bending the hip joint. The other 30° comes from flattening the lumbar curve. Keegan illustrates, in serial movements, the relation of the lumbar curve to position and identifies a correct or "normal" position (cited in Mandal, 1981, p. 20-21).

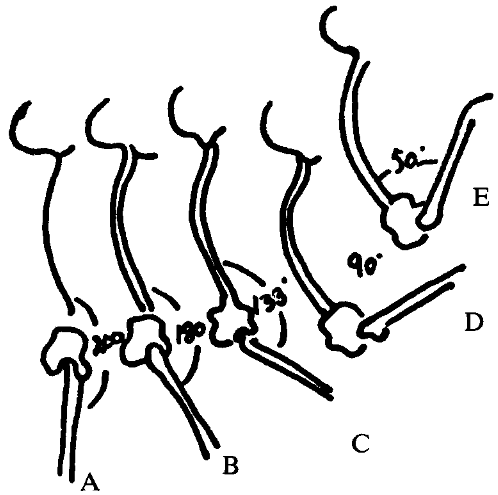

FIGURE 3

C. Shows Keegan's "normal" or optimum position with good lumbar curve, hip extension and anterior pelvic tilt.

Mandal (1984) states that this shows the importance of the position of the hip joint. Keegan's diagram (Figure 3) shows the ideal position at 45° hip flexion, with good lumbar lordosis and anterior pelvic tilt.

In order to achieve Keegan's "C" position, Mandal suggests that the height of the working furniture be increased (in relation to the person's height); that the work surface be tilted 10°-15° towards the worker; and that the seat be tilted forwards 10°-15° (1984, p. 23).

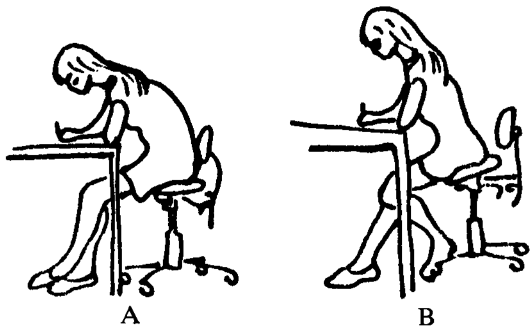

FIGURE 4

A. Shows effect of poor posture from conventional school and office furniture.

B. Shows improved posture as a result of heightened furniture with tilted workseat and table surface.

The tendency of the seated worker to slide forward has been alleviated in various ways. For example, the use of kneeling supports, especially shaped cushions to support the ischial tuberosities and so on. Chaffin and Anderson (1984, p. 309) state that the feet should rest firmly on the floor or a foot support so that the weight of the lower legs is not supported by the front part of the thigh resting on the seat.

Seats Designed to Promote Correct Positioning

A number of seats have been designed and their effect on correct positioning studied. The paper "Trunk Posture and Trapezius Muscle Load while Working in Standing, Supported Standing and Sitting Positions" by Bendix et al (1984, p. 433) describes a study made of people using a rounded or "riding" seat while working at light tasks.

This sort of seat uses the "straddle" principle based on the saddle seat to achieve Keegan's ideal or "C" position. The seat has a back rest and can be adjusted to a height so that the seated person has the thighs at 40° flexion. On evaluation, the advantages of such a seat were found to be improved precision and stability, less total body energy consumption, free movements for the legs and feet, which are influenced by a lesser hydrostatic pressure.

This study found that the lumbar spine shifted towards kyphosis using the rounded or "riding" seat, even though with this seat the hips were at 40° flexion and posterior pelvic tilt was very slight. Bendix et al (1984) therefore conceded that forty per cent hip flexion is not sufficient to maintain good lumbar lordosis.

It should be noted, however, that the rounded seat does not have "tilt" which, as Mandal (1984) points out, assists lumbar lordosis even when leaning forward to work.

One of the several problems with this experiment is that, if forward tilt had been used, the subjects would have had difficulty staying on the seat (See Fig. 5).

Another study worthy of mention, relevant to straddle seating, is that of Stewart and McQuilton ("Straddle Seating for the Cerebral Palsied Child", 1987, p. 205). Their study was based on finding a position of balanced muscle groups to encourage greater accuracy of hand function and balance. They believed that the body mass needs to be positioned over the seat base or ischial tuberosities as in horse riding not *behind* the seat base as it is in ordinary sitting. They go on to say that in this position:

> The body is extremely well balanced above its seat base, and only small adjustments have to be made to its centre of gravity to maintain this balance in posture. On horseback there is a fixed amount of abduction increasing hip flexion, and therefore an effective stabilisation of the pelvic area.

The problem encountered in this study was that the researchers found a tendency in their subjects to over flex the lumbar spine. They say the solution is to extend the hips more and tilt the seat which results in a return to a

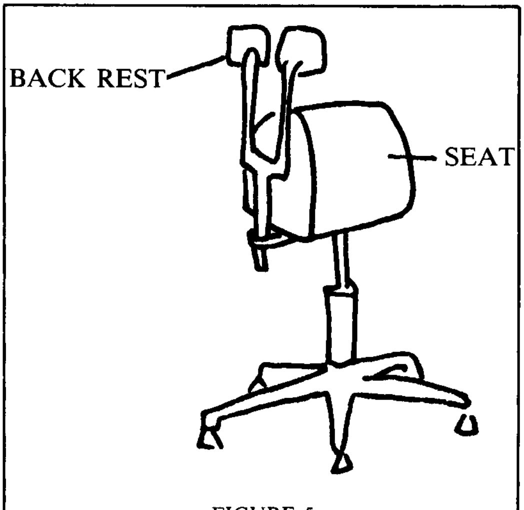

FIGURE 5
The Bendix et al seat

lumbar lordosis. Again the tilt, as recommended by Mandal, (1984) appears to be a controlling factor in gaining the lumbar lordosis and again there is the resulting problem of the tilt sliding the sitter forward.

Gregory (Cited in Richardson, 1987, p. 5) designed a "Phyz Chair" which includes "tilt" with a special cushion of variable density rubber to prevent sliding forward. This seat does not appear to place the centre of gravity above the ischial tuberosities. Another possible disadvantage is that the person's legs may experience hydrostatic pressure in order to maintain the seat position (See Fig. 6).

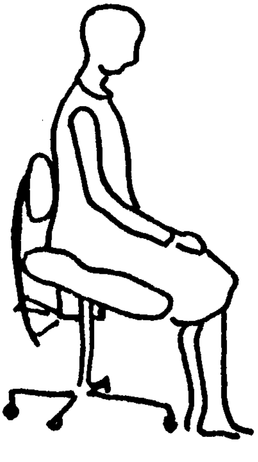

FIGURE 6
The Phyz chair

Miriam Brunswick (1984, p. 43) also challenges conventional seating, adding her opinion to others that it may in fact be detrimental to health.

> Stability of the body is of paramount importance when performing tasks requiring force or accuracy. In order to perform a task, people overcome the difficulties presented by conventional seats. The price is an unstable position, impeded circulation and a potential strain on the lumbar spine.

Brunswick recommends the "Balans Aktiv Junior Seat" which uses a tilting seat to gain 60° hip flexion and encourages lumbar lordosis. The problem of sliding forward is solved by a knee pad which supports the knees at 120° flexion (See Fig. 7).

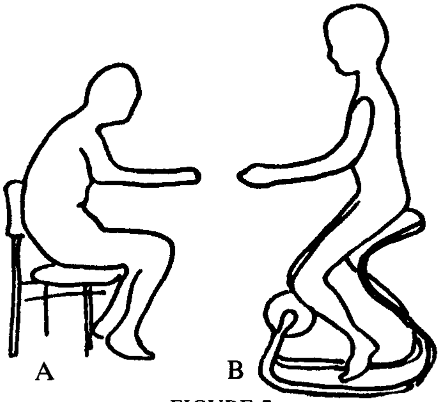

FIGURE 7
A. Shows a person sitting on a conventional seat.
B. Shows the ability of the Balans Aktiv seat to improve posture.

There are, however, problems with this seat such as knee pressure, knee flexion, the need for constant pushing back on to the seat, as well as some awkwardness in standing up. Other problems include the loss of desirable plantar contact of the feet and a possible eventual shortening of hamstrings as well as knee problems from pressure. Nevertheless, this seat has been found to be successful for some people in relieving back pain while working.

Mandal (1981) says that without doubt the best sitting posture is obtained on horseback. The hip joints are in the resting position with a bend of 45°, the lumbar curve is maintained and a perfect, balanced position is obtained.

Mandal (1984, p. 50) also says that when sitting in a riding saddle, "one has no problem with sliding forward because of the shape of the saddle . . . This sitting posture is theoretically ideal and I have experimented with it."

Noting that the seated position on a horse most closely approximates Keegan's riding saddle as a design model, the authors of this paper photographed people on horseback to observe the position and noted that the rider does assume Keegan's "C" position in order to stay balanced on the horse.

Considering the problems associated with all the other seats, it was decided to design a work seat with the following characteristics:

1. Position for good lumbar lordosis using tilted seat with a curve to prevent sliding forward.
2. Allows hip flexion to 45° to maintain anterior pelvic tilt while leaning forward to work.
3. Variable height to suit the individual.
4. Swivel action to assist trunk rotation.
5. Enables plantar contact of the feet to support the legs.

This approximates as closely as possible the seated position on a horse (See Fig. 8).

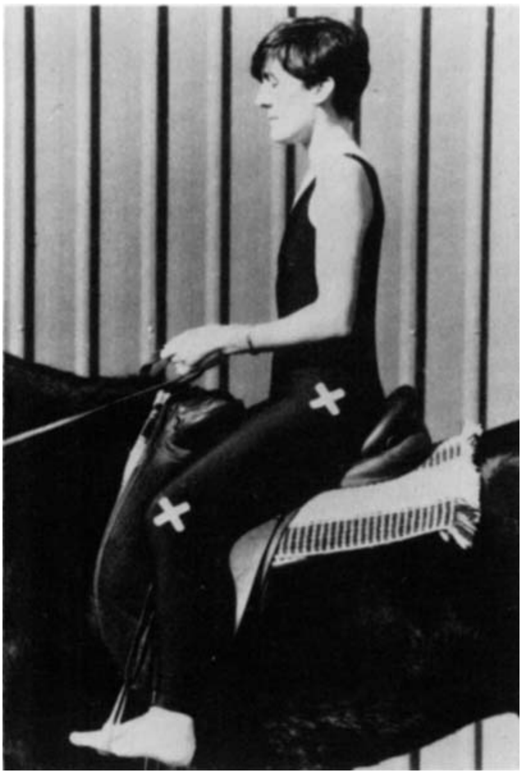

FIGURE 8

METHOD

Subjects

The subjects used in this study were employees of A.F. Bambach Proprietary Limited, a company involved in the manufacture of electrical wires and cables. The six subjects were male. Their ages varied and their work involved the winding of wire whilst sitting at a winding bench. Subjects involved in this type of work were chosen as the work demands use of the upper limbs whilst maintaining the body as a whole in a static position.

Testing Equipment

A seat was designed and made which simulated, as closely as possible, the shape of a saddle. It was upholstered and then mounted on a gas cylinder stem with a five star castor base. A conventional four legged bench stool was used as the alternative to the saddle seat for comparison.

Procedure

Subjects were seated at their work place and asked to sit comfortably and take up an attitude of work. Their side view was then photographed. A large grid was situated behind them, to be used as a reference in the subsequent calculation of angles. Each subject was photographed on both the bench seat and the saddle seat. Different orders of procedure of one seat before the other were used as the six subjects were photographed. The photographs were later used to calculate the angle of the lumbar curve. A line was drawn between the most prominent point of the thoracic kyphosis (C) to the most prominent point of the gluteals (D) above the seat. The length of this line was measured. A line, perpendicular to this line, was drawn to meet the lowest part of the lumbar curve (E-F) and the length of this line was also calculated.

These two measurements were used to calculate the angle between the two lines C-E and C-F.

$$\text{ARC TAN}\,\alpha = \frac{\text{C F LENGTH}}{\text{C E LENGTH}}$$

This angle was seen to represent the angle of the lumbar curve (See Figs. 9 and 10).

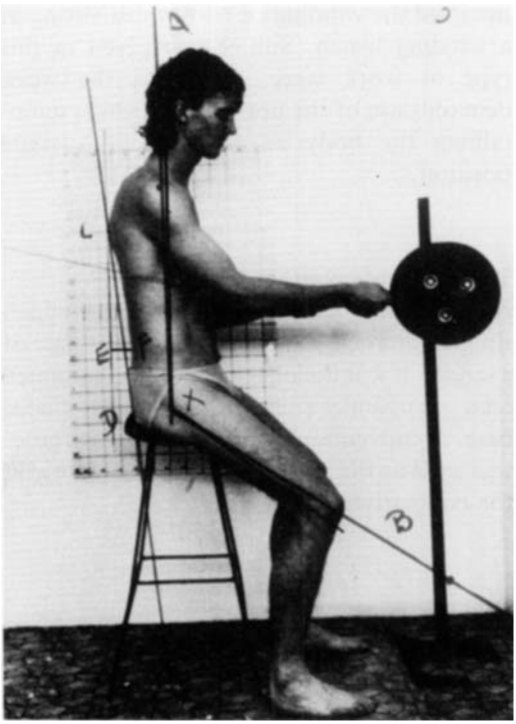

FIGURE 9

RESULTS

The results for the lumbar curve of the six subjects on both the stool and the new work seat were as follows:

	On Stool	On "Saddle" work seat
1.	1.0	3.17
2.	0	2.14
3.	3.17	4.76
4.	3.36	5.04
5.	0	6.7
6.	0	4.08

The average difference between the two is 3.06°. The new work stool therefore would seem to facilitate a greater lumbar curve.

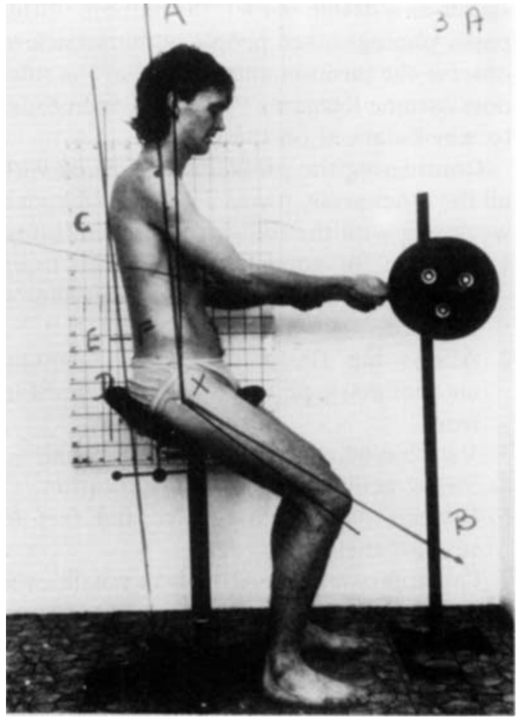

FIGURE 10

DISCUSSION

The researchers have been urged on by the requirements of the New South Wales Occupational Health and Safety Act 1983 to design an appropriate work seat which facilitates lumbar lordosis without introducing other difficulties. Whilst a variety of seats have been developed, all seem to have various restrictions — increased pressure on knees and feet, tendency to slip forward, difficulty in maintaining lumbar lordosis when leaning forward to work, and so on.

The use of a work seat based on the shape of a saddle would seem to alleviate these problems. There is no danger of slipping forward and weight is distributed evenly throughout the legs and body. The results of this study support the conclusion that a seat of this design facilitates the development of lumbar lordosis, even while the user is in a working position.

These results confirm the opinion of various researchers who have suggested the usefulness of a saddle shaped work seat. Such results have far reaching implications for the future design of work seating. Health professionals need to be aware of the various factors involved in providing a work seat which facilitates, as the saddle shaped work seat does, the correct positioning of the lumbar spine. Further thought should be given to its many potential applications. It can be used as a tool for preventing back pain, as well as a means of alleviating discomfort for those with a history of back pain.

More research in this area is needed to confirm these initial results, particularly as this study was limited in many ways: for example, limited numbers of subjects and imprecise location of parameters for measurement. The effects of age, sex, type of work and subjects expectations of the seat were not considered. It is also recognised that the long term use of the seat may yield different results.

Future studies could therefore involve comparison of larger groups of subjects, questionnaires to determine the subjects experience and expectations of the seat, and the taking of data whilst the subjects use the seat over longer periods of time.

There may also be a need to work on various aspects of the seat's design. Changes made to the degree of abduction, the type of base, the stackability or foldability of the seat, for example, could all be advantageous. The present study provides a basis for continued interest in the use of a seat designed to simulate the position of a person sitting on a horse. Positive evidence has been provided to support the use of such a seat. Researchers such as Mandal (1981, 1982, 1984, 1987) would appear to have been moving in the right direction in terms of the design of good seating. The challenge now is to encourage continued research so that the usefulness of such a seat is confirmed.

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