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Effect of two seating positions on upper limb function in normal subjects

Amar Gandavadi, Jill Ramsay, Gill James

Many upper limb functions are performed in a sitting position. However, if seating is inadequate and poorly designed, back pain and reduced upper limb control may result. This study investigates pelvic posture and performance in an upper limb task.

In total, 15 normal healthy volunteers (aged 18–30 years) were seated in posterior and anterior pelvic tilt positions and performed a simple upper limb task. The parameters measured were electromyography of the lumbar paravertebral muscles, time taken to complete the task and the task error rate. The data were analysed by repeated measures analysis of variance (ANOVA) and post-hoc t tests. The results indicate that, when seated in an anterior pelvic tilt position, the error rate decreased (P=0.013) and the electrical activity increased (P=0.008). The time taken to complete the task was not significantly different.

Since the error rate decreased when seated in the anterior pelvic tilt position, it might be concluded that this posture facilitated task skill. It is suggested that the increase in electrical activity is related to the increased load on the lumbar muscles in maintaining the posture. This study's generalizability is limited, with small subject numbers and the use of a non-functional task. It is, however, a beginning in addressing the interrelationship between the seated posture and skilled upper limb performance.

Key words: upper limb function, seating, pelvic posture, back pain

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People are increasingly spending more time sitting – for work, for travel and for relaxation. However, it is important that the seat is comfortable, maintains a healthy posture and facilitates task performance. The purpose of this article is to describe a study investigating the effects of two different seated postures upon the muscular activation and the ability to perform a simple upper limb skill.

BIOMECHANICS

The seated posture changes the demands placed on the musculoskeletal system, since there is a tendency to gradually adopt a position in which the pelvis is rotated backward to compensate for muscular tightness in the Hamstring muscles (Pheasant, 1996). Such rotation at the pelvis is accompanied by flexion of the lumbar spine, which may be close to the end of the available range. In this position the muscles relax and the body weight is supported by passive structures such as the spinal ligaments. Therefore, slump sitting has been noted to be associated with higher intradiscal pressures (Nachemson, 1975).

The need for good sitting posture is further reinforced, since prolonged sitting has been shown to predispose individuals to the development of low back pain (Magora, 1972; Wilder and Pope, 1996). Electromyographic studies suggest that sitting in a slouched or reclined posture relaxes the trunk muscles and requires minimal muscle activity to support the body weight. However, this finding is ambiguous, since the reduction in muscular activity may not be healthier in terms of minimizing the onset of low back pain.

To sit in an anterior pelvic tilt position, the muscles must be activated to achieve and maintain the position. Further, habitual slump sitting could result in muscle fibre imbalance with slow oxidative fibres changing to fast twitch fibres (Cram and Vinitzky, 1995). Such fibre changes may result in loss of ability to maintain an upright seated posture for longer than a short period before fatigue intervenes and the person then slumps into a posteriorly tilted posture (Garlick, 1998).

Of recent years, there have been attempts to design seating that maintains the pelvis in a relatively neutral position (i.e. neither posteriorly nor anteriorly tilted). To achieve this position, the hips

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must be positioned at an angle of less than 90º. Mandel (1976, 1981) argued that a forward sloping seat surface decreases the hip flexion requirements. Various seats have been designed adopting these principles – most notably, the 'kneeling' chair.

Evaluation of such seats has been largely confined to examining user comfort (Drury and Flancher, 1985). Such investigations showed that users of the kneeling chair complained of increased discomfort in the knees, thereby limiting its usefulness.

Recently, a saddle-type seat (manufactured by Bambach; www.bambach.co.uk) has been marketed. This seat maintains the pelvis in an anteriorly tilted posture but does not bear body weight on the knees, and should therefore be investigated since theoretically, it may be more user friendly and therefore be used more widely.

SEATING AND UPPER LIMB SKILL

One aspect of seating that has been relatively neglected is the effect upon upper limb function. Reissner (1972) argues that sitting in an anterior pelvic tilt position provides pelvic stability, which is necessary to allow for dynamic spinal movements and for upper limb stability (Nwaobi, 1987). However, he fails to explain how pelvic stability affects upper limb function. Logically, sitting in an anterior pelvic tilt position promotes ease of maintenance of the natural lumbar curve and may minimize discal pressures (Keegan, 1953; Mandal, 1981; Bridger et al, 1992).

Some work has been carried out investigating children with disabilities such as cerebral palsy. Myhr (1994), for example, showed greater ability to use the upper limb when seated in an anterior pelvic tilt position, thereby resulting in improved task quality and diversity. Biomechanically, more upper limb effort is required to perform movements in the posterior pelvic tilted position owing to the gravitational pull, thus rendering arm and hand function non-optimal (Ariyaratnam et al, 2000). However, there appears to have been little work investigating the effect of the seating posture upon skill performance in a population of people without such disabilities.

METHODOLOGY

Research design

A same-subject experimental design was selected, since the focus of interest is comparing the two different pelvic positions while performing the same experimental task. Surface electromyography (EMG) was used to record the electrical activity of the paraspinal muscles. EMG has been used in similar studies (Finsen et al, 1998; Callaghan and McGill, 2001) and within its constraints, is considered a suitable non-invasive method for assessing electrical activity in muscles. A wire game was used for quantifying the upper limb function. This is a simple game that needs no special skill to play, and is an easy way of measuring errors in the activity.

Ethics

The research was approved by the ethics committee of the School of Health Sciences before commencement of the research. All subjects were volunteers recruited from an advertisement placed on a noticeboard in the university. Subjects provided informed consent and could withdraw at any time without explanation.

Subject selection

Participants were included in the study if they had no low back or upper limb pain at the time of the experiment. Participants were excluded if they had any spinal deformities, acute or persistent back pain or shoulder or upper limb injury, or lacked full range upper limb movement, because the presence of these conditions could influence the outcome of the study.

Materials

Materials used were as follows:

- Adjustable-height treatment couch.
- The Bambach Saddle Seat (*Figure 1*).
- The NeuroTrac dual channel electromyograph (Verity Medical Ltd., www.veritymedical.co.uk)
- A wire game (*Figure 2*): This consists of a base with two upright arms perpendicular to the base

Figure 1. The Bambach Saddle Seat (reproduced with permission from Bambach).

Figure 2. The wire game.

and a sinuous metal wire connecting the arms. A jockey is inserted into the metal wire. The jockey consists of a hand piece with a small metal ring in front of it and with a wire attached to it. The metal ring of the jockey is inserted into the sinuous metal wire.

- Stopwatch.
- Tape measure.

Pilot study

A pilot study was carried out with one subject in order to test the methodology and to assess reliability in measuring the parameters. The experimenter and two physiotherapists measured all the parameters. No differences were observed in the results.

Task

The task involved passing a metal ring into a sinuous wire, tracing its path to the end. A light illuminated each time the metal ring contacted the wire. In order to control for possible learning effects, the subject could not see the light. All the trials were therefore carried out under the same conditions. The wire game was placed on a height-adjustable couch at distance of 1.5 forearm lengths from the trunk midline of the subject and at elbow height of the seated subject when the subject's hand was placed on the thigh.

The subjects were seated for 30 mins before the task was carried out, in order to acclimatize them to the sitting position and to standardize the condition of the subjects before the experiment. Various time periods have been used in similar studies – from very short (e.g. mins) to prolonged (Callaghan and McGill, 2001). A total of 30 mins acclimatization was used because it was long enough to allow tissues to adapt, but not so long as for fatigue to occur.

Conditions and parameters measured

Figure 3 shows the subject seated on the Bambach Saddle Seat with the pelvis anteriorly tilted. The back was unsupported and the feet were fully supported on the floor by adjusting the height of the Bambach chair. The hip was kept at an obtuse angle from the horizontal, allowing the pelvis to fall in the anterior tilted position.

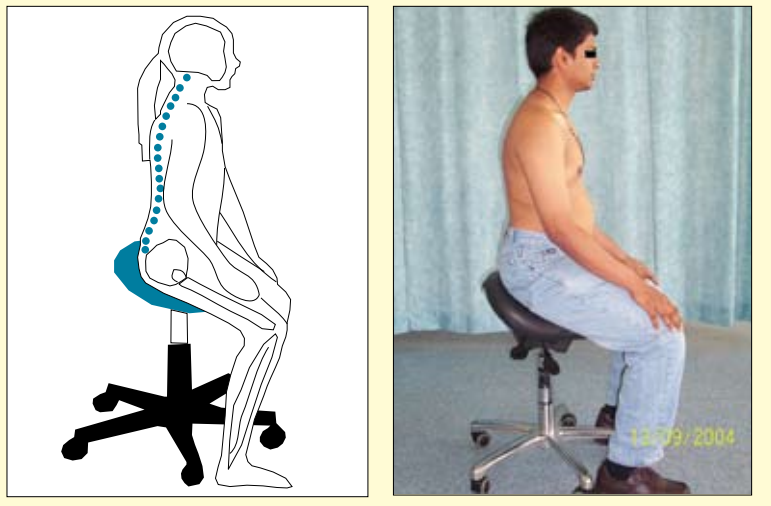

Figure 3. Subject seated on the Bambach Saddle Seat in an anterior pelvic tilt position (reproduced with permission from Bambach).

Figure 4 shows the subject seated on a couch with the back slumped and unsupported in a posterior pelvic tilt position. The feet were fully supported on the floor by adjusting the height of the couch. The order of seated positions was counterbalanced to control for any possible order effects.

The parameters measured were:

- EMG activity of the lumbar paravertebral muscles – mean of peak amplitudes of three trials. The peak amplitudes are sudden surges in amplitude, which were critical to the task being performed. The mean of these peak amplitudes was used as it uses all the data and improved the reliability of the data. Two electrodes are placed in the back at the L1/L2 spinal level and two electrodes are placed at the L4/L5 spinal level (Cram and Vinitzky, 1995).
- Time taken for task completion. The mean of the three trials was used.

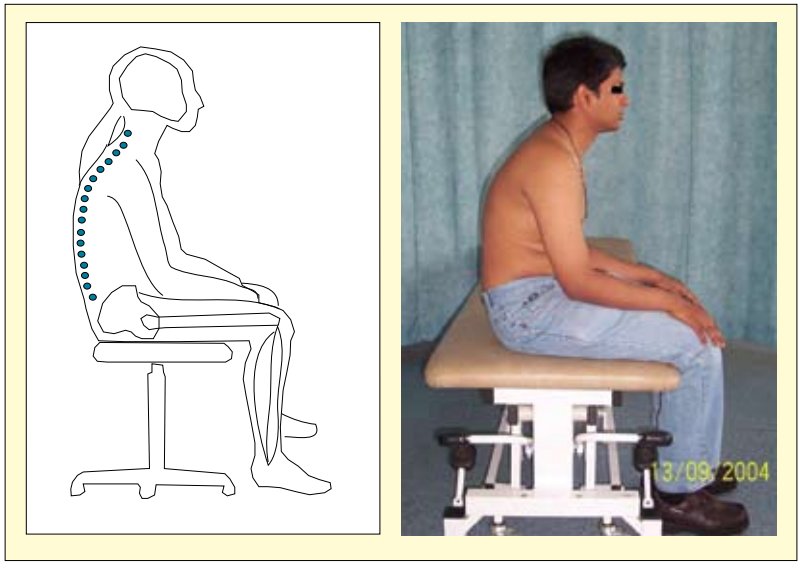

Figure 4. Subject seated on a couch in a posterior pelvic tilt position (reproduced with permission from Bambach).

- Task error rate. This was measured as the number of times the light illuminated during the task. The mean of the three trials was used.

Data analysis

All these hypotheses are two-tailed. Two-way, same-subject repeated measures analyses of variance (ANOVA) were performed to test the hypothesis that the seated posture makes a difference to the parameters stated above. Post-hoc tests (the *t* test) were calculated to examine significant differences where appropriate. Throughout, a 0.05 level of significance was used for rejection of the null hypotheses.

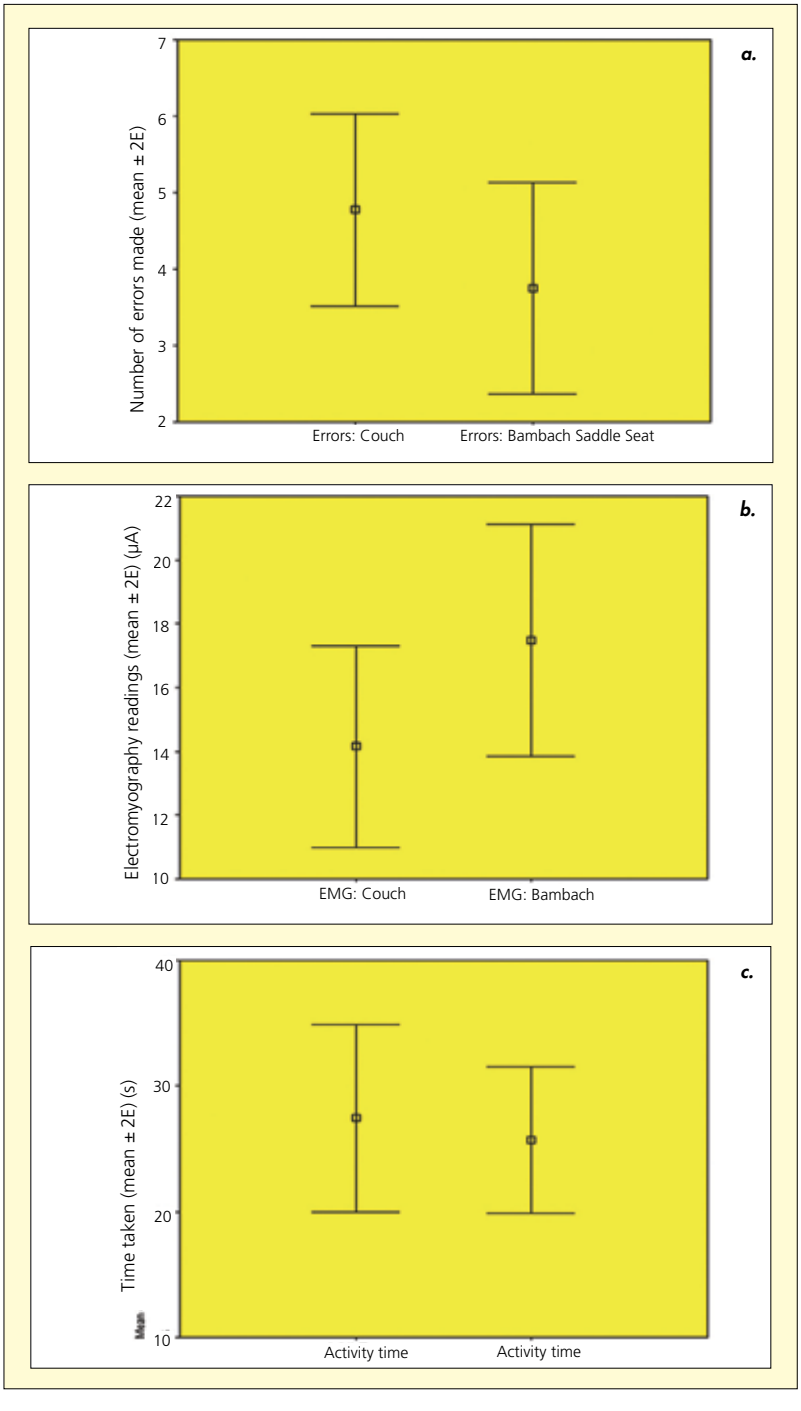

Figure 5. (a) Bar chart for errors made in the two seating positions, showing mean ±2 standard error (SE) of mean; (b) error bar chart for electromyography readings in the two seating positions, showing mean ±2 SE of mean; (c) error bar chart for time taken for activity, showing mean ±2 SE of mean.

Procedure

- The subjects were seated for 30 mins and given a magazine or newspaper to read.
- The height of the couch or seat was adjusted so the feet were flat on the floor, with the thighs fully supported.
- After 30 mins, three trials of the upper limb task were carried out.
- The seated condition was then adjusted and a further three trials of the upper limb task was carried out.
- The time for completion of the task was measured using a stop clock and the numbers of errors were noted in accordance to the number of light glows. Simultaneously, EMG measurements were taken.

RESULTS

A total of 15 subjects aged 18–30 years who fulfilled the inclusion criteria were recruited to take part in the experiment. *Figure 5* shows the mean and standard error for all three parameters. The error rate and task time had both fallen when the subjects were seated in the anterior pelvic tilt position (Bambach seat), while the mean EMG measurement increased in that condition.

The ANOVA results were significant (F=216.105, P<0.000). Post hoc t tests were significant for errors (t=2.863, P=0.013) and for EMG (t=–3.106, P=0.008). The time taken to complete the task was not significant. It is clear that both the error rate and the EMG measurements (P=0.008) were significantly affected by the seating posture. While the error rate decreased when using the Bambach seat, the mean peak EMG reading increased. In both cases, therefore, the null hypothesis can be rejected and the experimental hypothesis accepted.

DISCUSSION

The study shows that there was a statistically significant difference in the subject's upper limb function relative to this task in the anterior pelvic tilted position (i.e. seated on the Bambach chair). This suggests that the principles of pelvic tilt and dynamic seating enhance natural spinal curves, good seating and upper limb function (Keegan, 1953; Mandal, 1981, Bridger et al, 1992; McClenaghan et al, 1992).

The fall in the error rate was highly significant (P=0.013), with 12 participants improving their performance in the anterior pelvic tilt position. Reissner (1972) reported that an anteriorly tilted pelvis provides pelvic stability and is necessary to allow for dynamic spinal movements. Such improved stability should enable subjects to access the wire game more easily, because movement occurs at the hip without the characteristic slouching so often seen

in other positions and facilitates the pelvic stability necessary for good upper limb movement for desktop tasks. Conversely, poor performance by the subjects sitting in the posterior tilted position was noted – a finding which apparently concurs with the study reported by Ariyaratnam et al (2000).

An increase in EMG activity was noted when subjects were seated in the Bambach seat. Biomechanically, in the anterior pelvic tilted position, the line of gravity falls anterior to the axis of rotation at the ischial tuberosities, gravity acts to flex the head and trunk so as to pull it down. In order to maintain a stable posture, the back and neck muscles generate an equal torque in the opposite direction (Norkin and Levangie, 1983). There is a reflex activation of the postural muscles as well as the order in which these muscles are recruited for postural alignment and stability. This supports the reason for increased EMG activity of the back muscles reported in this study.

When asked to comment on the two postures, participants indicated that they believed that their upper limb performance was enhanced by their improved posture. However, three of the participants reported that they were more comfortable sitting in the posterior pelvic tilt position and perceived difficulties in performing the task in the anterior pelvic tilt position. The reason for this might be a muscle fibre imbalance associated with the habitual slumped position – instead of slow oxidative fibres of postural or antigravity muscles, the fast twitch muscle fibres can be activated (Cram and Vinitzky, 1995).

This study should be regarded as a pilot study, owing to its small subject numbers and the narrow age band from which subjects were recruited. It would be useful to replicate the study with a larger sample drawn from a wider age range. Additionally, it would be useful to study subjects with either low back pain or neck or upper limb dysfunctions. The task is unfunctional and therefore adopting a similar methodology but using a functional work-related task should be attempted. However, such a study would require a method of evaluating skilled performance.

KEY POINTS

- When subjects were seated in an anterior pelvic tilt position, upper limb task performance was significantly better than when they were seated in a posterior pelvic tilt position.
- There was increased electrical activity in the lumbar paravertebral muscles in the anterior pelvic tilt position.
- The decreased error rate in the anterior pelvic tilt position (using the Bambach Saddle Seat) appears indicative of enhanced upper limb function.
- Sitting in an anterior pelvic tilt position should promote healthier working postures and may minimize discal pressure.

CONCLUSIONS

Within these limitations, however, it is possible to draw several positive conclusions. It appears that the ability to carry out upper limb tasks may be influenced by the seated posture – specifically, the angle of pelvic tilt. Interestingly, it may be that the altered posture facilitates skilled performance, although this aspect needs further investigation.

The increase in EMG activity, however, indicates caution since subjects may need time to adapt to sitting with the pelvis tilted anteriorly. Even allowing for such training time, this position may not suit everyone and in those cases, it is possible to speculate that performance will be adversely affected. However, for those people whom this sitting posture suits, it could logically create healthier working postures and may thereby decrease morbidity in those individuals with work-related dysfunctions. IJTR

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