A study to investigate the effect on spinal angles of a self-selected and a standard position while sitting on kneeling chair

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Abstract: Back and neck pain are major problem amongst the growing number of seated workers, and enormous therapeutic and ergonomic design effort goes into reducing these problems. Educating the correct posture, choosing the right ergonomic chair, and readjusting the workstation have become very important element in any therapeutic plan. The objective of this study is to identify the difference in five spinal and pelvic angles between the self-selected and standardized position while sitting on the kneeling chair in healthy subjects. Fifteen healthy subjected (≥18 years) participated in this pilot study. The spinal angles (neck angle, head tilt, cervico-thoracic, thoracic and lumbar angle) and pelvic tilt angle were measured while sitting on the kneeling chair in self-selected and standard position. The study showed a significant difference in the ,lumbar spine and pelvic tilt angle when comparing the sitting posture with and without instructions. Che study revealed that sitting on a specially designed chair does not position the body in neutral alignment, but it can be achieved by educating subjects on the correct sitting posture.

Keywords: Back pain, neck pain, sitting posture, kneeling chair

Introduction

Working in an office typically involves spending a great deal of time sitting in an office chair in a position that adds stress to the structures of the spine. Therefore, to avoid developing or compounding back problems, it is important to have an office chair that is ergonomic and that supports the lower back and promotes good posture. There are many types of ergonomic chairs available for use in the office. No one type of office chair is necessarily the best, but there are some elements that are very important to look for in a good ergonomic office chair. In order to meet the user's needs by relaxing the muscles, reducing the physical load on the spine, avoiding fatigue, and helping users to do their work more efficiently. In the ordinary conventional office chair the adjustable seat height, seat width and depth, lumbar support, backrest, armrest, and the seat material are important to consider to ensure the user's comfort. Beside the conventional chair there are some more sophisticated ergonomic chairs that have been designed to give support, comfort and promote good posture (1). It has been thought that these newly designed chairs can be beneficial for office workers with discomfort or neck or back pain. They can be used as an alternative to the ordinary chair such as kneeling chair. The kneeling chair is an office chair that has a forward tilted seat and two cushions for knee support but without backrest, and places the user in a kneeling position (figure 1). The design is thought to encourage good posture by sliding the hips forward and aligning the back, shoulder and neck. The seat pan gives the primary support, and additional support comes from the knee support cushions. This type of ergonomic chair distributes the weight between the pelvis and the knees, which reduces spinal compression, and therefore reduces the stress and tension in the lower back and leg muscles (1).

Figure 1: kneeling chair

This chair could position the lumbar spine in a more natural alignment (lordosis) or very close to the neutral position (2). By searching the literature, three studies were found (3-5) in which the authors compare the lumbar curvature when sitting on Balance Multi chair (kneeling chair) (BMC) or Standard Conventional chair (SCC) while performing a writing task at a desk, and standing posture. In addition, Link et al. (3) investigated the relationship between lumbar curvature and a) anthropometric factors and the length of hamstring and hip flexor muscles, b) prolonged sitting whereas Bennett et al. (3) studied the electromyographic activity of the erector spinae (ES) muscles and measuring lumbar curvature during relaxed (comfortable) and erect sitting posture while sitting on three different chairs (a kneeling chair, an office chair, and a straight back chair) and during standing. In the study by Fery and Tecklin (4), forty four healthy university students (22 males and 22 females) participated in the study whereas Bennett et al. (3) used only 20 healthy young subjects, eight of which were men. In the study by Link et al. (4), sixty one 20-30 year old subjects were recruited for the study. Age and gender control were considered. This sample size in the study by Link et al. (3) was large enough to detect the differences; however, the postural alignment could vary between gender and age group (6) and the results cannot be generalized to females and the older male population. Therefore, another study is needed in which female subjects are used or which studies a sample from different age groups. The subjects in both of the above-mentioned studies had no previous experience in sitting on the BMC, which helped to eliminate the learning effect. Three measurements were taken for the lumbar spine in the three studies for each condition by a flexible ruler. In Fery and Tecklin (4) study, all measurement preparation and data collections were done by one researcher; this would have helped to standardise the procedures. Bennett et al. (3) managed to measure the lumbar curvature during standing and sitting on the kneeling chair and straight back chair; however, the authors were not able to measure the curvature during sitting on the office chair as the backrest support blocked the area. As a result, the straight back chair and kneeling chair were included in the lumbar curve measurements and analysis. Fery and Tecklin (4) palpated the spinous processes (L1 and S2) before measuring the curve in each condition, which helped to reduce the effect of skin movement. The reliability and validity of the testing procedures were not determined in these two studies. However, Hart and Rose (7) established high reliability for these procedures (r = 0.97) and good validity (r = 0.87) between the lumbar curve measurement obtained by the flexible ruler and radiograph. Bennett et al. (3) found that there was a significant difference in the lumbar curvature when in the standing position rather than the seated position. Further, the results revealed no significant difference between the two sitting (relaxed and erect) positions when standing and sitting on the kneeling chair. However, there was significant difference between the relaxed and erect posture during sitting on the straight back chair. Fery and Tecklin (4) found a significant difference in the lumbar curvature among the three positions *(*F = 120; df = 2,129; p < 0.01). Also, they found a significant difference in the curve between the mean of all pairs; the mean of the lumbar curve in standing was (31.2 ± 14.8 degrees), for the SCC it was (-9.0 ± 10.4 degrees), and for sitting on the BMC it was (-2.0 ± 13.0 degrees. Link et al (1990) found that the young men in the study spent 7.8 hours per day sitting. The lumbar spine while sitting on SCC was flexed, whereas on BMC it was nearly 9^0 more extended than on the SCC (< .05). A significant association between the lumbar curve and sitting order was found in the linear regression analysis (F = 4.35, P = 0.04, R^2 = 0.08). These studies show that the kneeler chair could position the spine in neutral position; therefore, their findings can be accepted. However, more research is needed to establish and update these results and evaluate the long term use of this chair in a work setting. The aim of this study is to investigate if there is any difference in six spinal angles (head tilt, neck, cervico-thoracic, thoracic, lumber, and pelvis angles) between the self-selected and standardized sitting position in the kneeler chair.

Material and methods

A three repeated measurements pilot study with sample size of healthy pain free subjects (5 females and 10 males with mean age 35.4 ± 11.69, SD, years) was used in the study. The subjects were excluded in case of having pain in the past six months prior to conducting the study. The ethical approval was obtained from the Cardiff University School of Healthcare Studies (SOHCS) Research Ethics Committee, and informed consent was obtained from all subjects. Eight Retro-reflective markers were placed over the right canthus, tragus, C7, T12, L4, PSIS, and ASIS (Figure 2).

Figure 2: Self-Selected Position (Comfort Position)

Testing procedures: The subjects sat comfortably (figure 2) on the chairs and carried out a typing task for 5 min during that time and about 4.5 min from the start of the typing a flash photograph was taken, a two minute break was given. This procedure was then repeated two more times. After that, the workstation was repositioned in a standard position in which the screen was placed at the edge of the desk with screen height at eye level. The subject was then asked to sit in a standard way (figure 3) on one of the chairs to continue the typing task for 5 minutes with a 2 minute break following (three trials), and then sit on the second chair and repeat the same procedures and have his or her photograph taken. The sitting instructions included sitting upright and the thigh-trunk angle was measured by the goniometer as it should be (90^0-120^0) (8). The measurements were taken before each trial. Each photograph was analyzed using MAT-lab software which has shown very high to excellent reliability in previous.

Fig. 3: Standard position

Fig. 4: measuring

Fig. 5: measuring the lumbar and thoraci

Fig. 6: measuring the thoracic

Fig. 7: measuring the head tilt and neck angles

Statistical analysis:

The mean and standard deviation (SD) of each angle were calculated using the Excel program, then imported to the statistical package SPSS version 18.0 (9). Histogram and Q-Q plot west were used to identify the normal distribution of the data. Parametric sample paired t-tests were used to serve the research question and p = 0.05 was considered as statistically significant.

According to Portney and Watkins (10), a paired t-test is used in the same or matched subject designs to compare between two conditions. As the t-test was repeated 6 times, Post Hoc Bonferroni’s correction was carried out in order to avoid type I error due to the repeated t-test. Therefore, each angle was tested at the level of significance of 0.008 (β = 0.05/6).

Results

Fifteen subjects, male (n = 10) and female (n = 5), participated in the study. As shown in table 1, the mean age of the subjects was 35.4 yrs. The mean height and the mean weight were 167.33 cms and 66.33 kgs respectively (appendix 4).

Table 1: Participant's demographic data

	minimum	maximum	mean	SD
Age/years	22.00	64.00	35.4000	11.68516
Weight/kg	46.00	91.00	66.3333	12.02181
Height/cm	152.00	185.00	167.3333	8.59956

Keys: SD = standard deviation, years = years, kg= kilogram, cm= centimetre

Table 2: Descriptive data (mean and standard deviation) of the head tilt, neck angle, and cervico-thoracic angles.

Position	Type of chair	head tilt °		neck angle °		cervico-thoracic angle °	
		mean	SD	mean	SD	mean	SD
Self-selected	**kneeling**	149.3333	6.53462	60.3222	8.02008	175.0622	6.76697
Standard	**kneeling**	146.8467	7.74905	55.0400	8.59239	172.3844	7.66161

Keys: SD= standard deviation

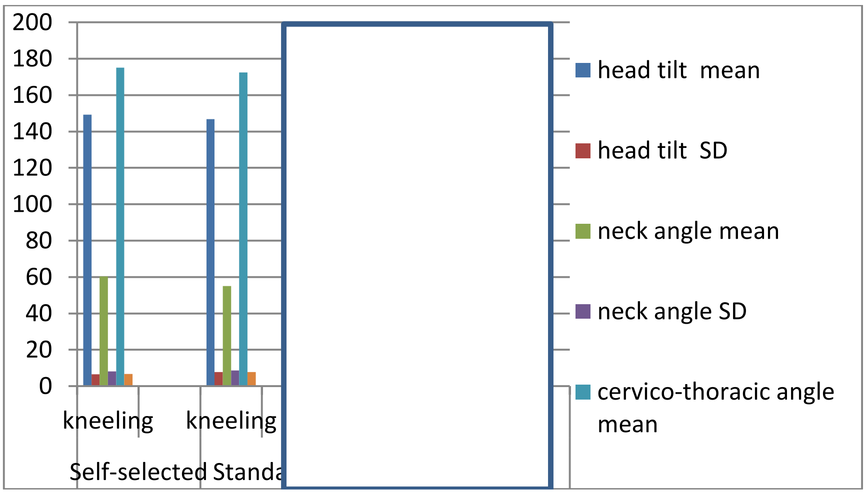

Figure 8: mean and standard deviation of head tilt, neck angle, and cervico-thoracic angles.

Key: SD= Standard deviation.

It can be observed from table 2 that there was no large variation in the three spinal (head tilt, neck, and cervico-thoracic) angles in different positions as the mean value were large with relatively small standard deviation (Figure 8).

Table 3: Descriptive data (mean and standard deviation) of the thoracic spine, lumbar spine, and pelvic tilt angles

Position	Type of chair	Thoracic spine angle °		Lumbar spine angle °		Pelvic tilt angle °	
		Mean	SD	mean	SD	mean	SD
Self-selected	**kneeling**	46.7044	7.01384	0.1511	15.87447	1.9195	7.41048
Standard	**kneeling**	44.3022	7.47207	7.4356	13.25817	6.8849	7.01388

Keys: SD= standard deviation

In table 3 however, a large variation was observed in the lumbar and pelvic tilt angles, which can be understood from the small mean value of these two angles with relatively large standard deviation in each position. The values can be visually observed and understood in figures (9), it can be seen also in the table 3 that the hyper-lordosis and the posterior tilt of the pelvis are reported as negative values.

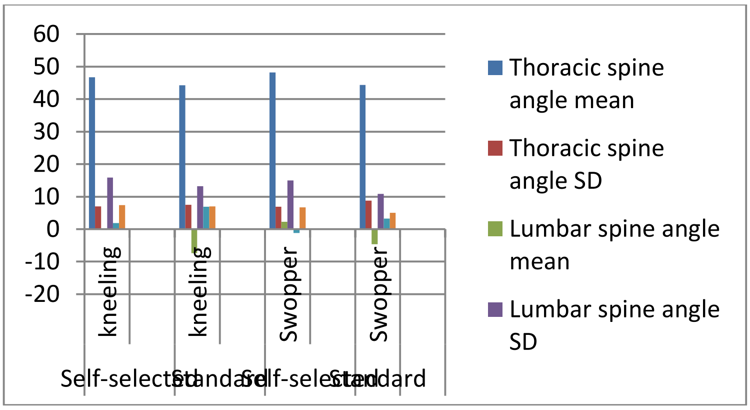

Figure 6: mean and standard deviation of the thoracic spine, lumbar spine, and pelvic tilt while sitting on the kneeling chair in the two sitting positions.

Table 4: results of t-test to compare the spinal angles between the self-selected and standard position while sitting on the kneeling chair

	Spinal angle	t-value	Significance
Pair 1	Head tilt angle/SS- Head tilt angle/S	1.952	.071
Pair 2	Neck angle/SS- Neck angle/S	3.049	.009
Pair 3	Cervico-thoracic angle/SS- Cervico-thoracic angle/S	2.140	.050
Pair 4	Thoracic angle/SS- Thoracic angle/S	2.107	.054
Pair 5	Lumbar angle/SS- Lumbar angle/ S	5.039	.000
Pair 6	Pelvic tilt angle/SS- Pelvic tilt angle/S	-3.698	.002

Keys: SS= self-selected position, S= standard position

A comparison of the spinal angles between the self-selected and standard position while sitting on the kneeling chair (table 6). In the 6th table the t-value and level of significant are reported, and show some significant values. For instance, there is a significant difference between the self-selected and standard position while sitting on the kneeling chair in the lumbar spine as the P > 0.008 (P = 0.000) which was more lordotic in the standard position in comparison with the self-selected position. Also, a significant difference is observed in the pelvic tilt (P = 0.002) due to the posterior direction of the pelvic tilt in the self-selected position, whereas, no significant differences are observed in the other angles.

Discussion

In order to understand and eliminate the problem of neck and back pain (NP, BP), sitting posture (postural analysis PA) has been regularly investigated in the field of physiotherapy and the healthcare profession. Ergonomic chair designs may influence the sitting posture and muscle activity; therefore, the type of chair has become an area of interest for many researchers. Despite this interest, there has been only limited research regarding posture while sitting on the kneeling chair (11, 12). Therefore, there is a need for up to date research investigating the effect of using the kneeling chair in reducing NP and BP.

This study showed no large variation in the head tilt, neck angle, the cervico-thoracic angle, and thoracic angle while sitting on the kneeling chair and doing a typing task (tables 2 and 3). However, there were large variations in the lumbar angle and pelvic tilt (table 3). These findings could mean that any major changes happened in the lower spine (lumbar spine and pelvic tilt angles) due to sitting on an ergonomic chair not making any changes in the upper spine. On the other hand, it was found that significant changes happen in the lumbar and pelvic tilt angles only. Which could have been affected by two main factors: firstly, educating subjects about the correct sitting posture and secondly, the structural design of the kneeling chair and the presence of the forward tilt (10). Fery and Tecklin (4) and Link et al (5) studied the difference in the lumbar curvature while sitting on the standard conventional chair and the kneeling chair in a comfortable sitting position. The authors revealed that there was a significant difference in the lumbar curvature between the two chairs, as it had 9 degrees more extension and was very much closer to the lumbar curvature in the standing position in the k neeling chair than to the lumbar curvature in the standard conventional chair. This result is not supported by the present study, which could be due to the difference in the methodology as well as the chair design and the performed task. Regarding the neck angle, the results (table 6) showed that the level of significance of the neck angle was just over 0.008 (P = 0.009); this result could be significant with a larger sample size which should be applied in future. From the above mentioned results, it seems that sitting on the kneeling chair on its own does not position the body in the optimal position. However, educating workers and raising their awareness regarding the ideal sitting posture has a major impact on their posture. These results challenge the proposed aim and widespread idea of using the kneeling chair for good postural alignment without giving any instruction about sitting posture. On the other hand, Bennett et al. (3) reported a significant difference in the lumbar curvature, as it was greater when sitting comfortably on the kneeling chair than on the straight back chair. Bennett et al. (3) studied the lumbar curvature as well as muscle activation while sitting on the kneeling and straight back chair in the relaxed (self-selected) and erect (upright) position using a flexible ruler. They revealed no significant difference in the lumbar curvature between the relaxed and erect position while subjects were seated on the kneeling chair. However in the current study there was a significant difference in the lumbar spine. This contradiction could be explained by the fact that Bennett et al. (3) studied young subjects whose ages ranged between 22 and 37 years old, whereas in the current study the age group was wider. Further, the measuring techniques of the spinal posture were different. In addition, two tasks were used in the study by Bennett et al (3) (a typing and a writing task), whereas in this study the typing task was the only one performed. Bennett et al. (3) explained their findings by the fundamental function of the kneeling chair design and in this they were the same as Fery and Tecklin (4).

In conclusion: The ergonomically designed kneeling chairs is designed to maintain neutral postural alignment especially in the lumbar curvature, and sometimes are recommended to be used as part of a therapeutic plan for back pain patients. The current study revealed that sitting on a specially designed kneeling chair does not inherently position the spine in the correct posture. Also, the results significant difference between the two positions in the lumbar spine and pelvic tilt angles when sitting on the kneeling chair. These results raise an issue around the proposed aim of using kneeling chair to intentionally correct sitting posture. Therefore, the results do not support the clinical claim that using the ergonomically designed chair as an alternative to the ordinary office chair will adjust the spine to a good postural alignment. Instead, more focus should be placed on educating sitters on how to sit correctly, which could help to reduce the prevalence of neck and back pain.

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