Lumbar posture and trunk muscle activation during static and dynamic seated tasks on a novel dynamic ergonomic chair

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ABSTRACT:

Low back pain (LBP) is a common musculoskeletal disorder, and prolonged sitting often aggravates LBP. A novel dynamic ergonomic chair (‘Back App’), which facilitates less hip flexion while sitting on an unstable base has been developed. This study compared lumbar posture and trunk muscle activation on this novel chair with a standard backless office chair. Twelve painfree participants completed two simulated office tasks on both chairs. Lumbar posture and trunk muscle activation were collected simultaneously, and were analysed using a two-way analysis of variance (chair x task). Sitting on the novel dynamic chair significantly ($p<0.05$) reduced both lumbar flexion and the activation of one back muscle (Iliocostalis Lumborum pars Thoracis). The discomfort experienced was mild, and did not differ significantly ($p>0.05$) between chairs. Maintaining lordosis with less muscle activation during prolonged sitting could reduce the fatigue associated with upright sitting postures. Studies with longer sitting durations, and in people with LBP, are required (to????).

Keywords: posture; back pain; ergonomics; lordosis; sitting.

Practitioner Summary

Sitting on a novel dynamic chair resulted in less lumbar flexion and less back muscle activation than sitting on a standard backless office chair during simulated office tasks among pain-free participants. Facilitating lordotic sitting with less muscle activation may reduce the fatigue and discomfort often associated with lordotic sitting postures.

1. Introduction

Low back pain (LBP) is a very common and costly disorder (Dagenais, Caro et al. 2008). While it is commonly thought that prolonged sitting may be a risk factor for the development of LBP, recent systematic reviews demonstrate that sitting duration alone is not linked to the onset of LBP (Lis, Black et al. 2007; Bakker, Verhagen et al. 2009; Roffey, Wai et al. 2010). As a result, other sitting parameters are of interest, including the chair used and the spinal curvature during sitting (and the amount of movement while seated???).

Although sitting is associated with greater lumbar flexion than standing (Scannell and McGill 2003; De Carvalho, Soave et al. 2010), there is no consensus regarding what is an optimal sitting posture (Claus, Hides et al. 2009; O'Sullivan, O'Dea et al. 2010). Both upright (Vergara and Page 2002) and slump (Womersley and May 2006) sitting postures can be provocative for patients with LBP (O'Sullivan 2000). Slump sitting results in a ‘flexion relaxation’ response of the paraspinal muscles, potentially increasing the strain on passive spinal structures (Andersson, Oddsson et al. 1996; O'Sullivan, Dankaerts et al. 2006). In contrast, more lordotic sitting postures are associated with greater trunk muscle activity with the potential cost of increased trunk muscle fatigue (O'Sullivan, Dankaerts et al. 2006; Claus, Hides et al. 2009).

Prolonged low level muscle activity has been linked to pain in other muscle groups (Westgaard and DeLuca 1999). More neutral sitting postures, involving slight lumbar lordosis and a relaxed thorax, have been recommended to facilitate activation of key trunk muscles without excessive compressive spinal load (O'Sullivan, O'Dea et al. 2010). Since posture is influenced by a wide range of factors including genetics (Seah, Briggs et al. 2011), gender (Dunk and Callaghan 2005; Smith, O'Sullivan et al.

2010), body mass index (Smith, O'Sullivan et al. 2011) and psychological factors (O'Sullivan, Smith et al. 2011), the best sitting posture may need to consider these factors as well as individual variations in specific aggravating/easing factors (Dankaerts, O'Sullivan et al. 2009).

Adjustable chairs that reduce hip flexion to promote lordotic lumbar postures have been associated with decreased lumbar muscle tension and improved muscle strength over a two-year period, but did not decrease LBP incidence (Koskelo, Vuorikari et al. 2007). Using a different saddle chair promoted less hip flexion in pain-free subjects performing typing tasks whilst sitting for two-hours (Gadge and Innes 2007). Interestingly, while the saddle seat was associated with significantly less lumbar discomfort, it was associated with significantly more hip/buttock discomfort (Gadge and Innes 2007). Another study (Gale, Feather et al. 1989) showed that the same saddle chair increased lumbar lordosis during a seated work task, but this study did not investigate the effect of this altered posture on muscle activation or levels of discomfort. Therefore, while there is some evidence that such saddle chairs may reduce hip and lumbar flexion, the effect of such seats on trunk muscle activity and sitting discomfort is unclear. This is important considering there is evidence that other ergonomic approaches such as kneeling-chairs which effectively enhance lordosis (Bennett, Gillis et al. 1989; Bettany-Saltikov, Warren et al. 2008), do not alter muscle activation (Bennett, Gillis et al. 1989), or might actually be associated with both increased back muscle activation and increased discomfort (Lander, Korbon et al. 1987).

Another relevant factor may be the degree of spinal movement during sitting. During prolonged sitting, people tend to choose a varied rather than a single comfortable position (Callaghan and McGill 2001), thereby frequently changing the postural load. It has been hypothesised that dynamic sitting on an unstable base of support may facilitate spinal motion and help prevent muscle fatigue via alternating motor unit activation (van Dieen, De Looze et al. 2001). Dynamic seating has been proposed to reduce spinal shrinkage (van Deursen, Patijn et al. 1999; van Dieen, De Looze et al. 2001). However, the evidence from most studies suggest dynamic sitting results in little or no change in lumbar posture, trunk muscle activation or discomfort (van Dieen, De Looze et al. 2001; Gregory, Dunk et al. 2006; McGill, Kavcic et al. 2006; O'Sullivan, Dankaerts et al. 2006; Kingma and van Dieen 2009). To date, a comparison of a range of standardised seated office tasks in static and dynamic sitting options, with simultaneous monitoring of lumbar posture, trunk muscle activation and levels of discomfort has not been conducted.

The ‘Back App’ is a commercially available ergonomic chair that incorporates both a saddle-design to reduce hip flexion, as well as an unstable base of support. Both the chair height and the degree of instability can be adjusted. It has the potential to facilitate less flexed lumbar postures and greater spinal micro-movement, although there are currently no published data available on its effect on lumbar posture and trunk muscle activity. Therefore the aims of this study were to compare the lumbar posture and trunk muscle activation of this novel dynamic ergonomic chair with a standard office chair during both static and dynamic seated tasks. The study hypothesis was that the ‘Back App’ would be associated with less lumbar flexion in sitting, without an increase in trunk muscle activation.

2. Methods

2.1 Study design

A single session, repeated measures, crossover study was conducted. The dependent variables were lumbar posture, trunk muscle activation and discomfort. The independent variables were chair type (‘Back App’ and standard chair) and task (static and dynamic). All participants completed the same protocol apart from the order of testing, which they randomly selected from a sealed opaque envelope. Ethical approval was obtained from the local university Research Ethics Committee.

2.2 Participants

Twelve (7F, 5M) pain-free participants were recruited from the local community. All participants provided written informed consent. Participants were aged >18 years, were not pregnant, had no LBP in the last two years, no previous spinal surgery, no current pain medications, had not undertaken previous postural control training, and could speak/understand English. Participants mean+SD age was 23.3+3.6 years, height was 169.5+5.7 cm, mass was 65.9+10.2 kg and body mass index was 22.9+3.2 kg/m^2.

2.3 Instrumentation

2.3.1. Kinematics

Postural data were collected using a wireless posture monitor (‘BodyGuard’) (Figure 1). The “BodyGuard” (Sels Instruments, Belgium) incorporates a strain gauge that provides information about the relative distance between anatomical landmarks, estimating flexion/extension range of the lumbar spine by the degree of strain gauge elongation. Elongation of the strain gauge alters its internal resistance and therefore the voltage of the signal. This alteration in voltage occurs in a linear manner in response to elongation. Therefore, the voltage output is directly related to the length (flexion vs. extension) of the strain gauge. Based on the elongation of the strain gauge, lower lumbar spine sagittal plane posture is expressed as a percentage of range of motion (ROM). Therefore, the degree of spinal flexion/extension is expressed relative to a referenced ROM, for example, total lumbar flexion ROM, rather than being expressed in degrees (O’Sullivan et al. 2010). This reflects the clinical assessment of patients, where sitting posture is often considered relative to individual ROM. Calculation of posture relative to ROM has been used in previous spinal posture research (Edmondston, Chan et al. 2007). It is also similar to electromyography normalisation of muscle activity relative to maximal or sub-maximal voluntary contraction (Dankaerts et al. 2006b). This posture monitor has been shown to have very good reliability (ICC>0.84) (O'Sullivan, Galleotti et al. 2011) and validity (spearman’s correlation>0.88) (O'Sullivan, O'Sullivan et al. 2012) for the measurement of lumbar posture.

Recent research suggests that the upper and lower lumbar spine regions demonstrate functional independence, with the lower lumbar spine being the most common area for subjects to report non-specific chronic low back pain (NSCLBP) (Dankaerts, O'Sullivan et al. 2006), and the area demonstrating the greatest postural differences among LBP subjects (Dankaerts, O'Sullivan et al. 2006; Mitchell, O'Sullivan et al. 2008). Consequently, a strain gauge was positioned directly over the spine at the spinal levels of L3 and S2, after manual palpation of these spinal levels in a slightly flexed sitting posture. Participants then performed maximal lumbar ROM to ensure the device was securely attached. To calibrate the posture monitor, manual and verbal facilitation were used to guide subjects into a fully lordotic sitting posture which was set as 0% of their lumbar ROM, and then into a fully flexed sitting posture, which was set as 100% of their lumbar ROM (O'Sullivan, O'Dea et al. 2010). This was repeated five times, to obtain a representative ROM value. Postural data were recorded continuously in real-time at 1Hz.

2.3.2 Trunk muscle activation

The activation of six trunk muscles was analysed using surface electromyography (sEMG). A Motion Lab Systems MA-300 multi-channel EMG system (Motion Lab Systems Inc., Baton Rouge, Louisiana, USA) collected sEMG data using bipolar, pre-amplified, circular electrodes 144mm^2 in size, with a fixed inter-electrode distance of 18mm. The sampling rate was 1000Hz per channel, with a bandwidth of 0-500Hz, and a gain of 2000. The common mode rejection ratio was >100dB at 60Hz. Three abdominal and three back muscles of the right hand side of the trunk were analysed, after preliminary testing had demonstrated no significant difference between right and left sides in pain-free controls during these tasks. The skin was prepared for electrode placement by abrading the skin with fine sandpaper, shaving any hair and cleansing the skin with isopropyl alcohol solution to reduce skin impedance, in line with agreed international recommendations (Hermens, Freriks et al. 2000). Pairs of surface electrodes were positioned parallel to the muscle fibre direction of each individual muscle and secured with clear adhesive tape. The muscles studied were superficial lumbar multifidus (LM) (L5 level, parallel to a line connecting the posterior superior iliac spine and L1-L2 interspinous space); iliocostalis lumborum pars thoracis (ICLT) (level of L1 spinous process, midway between the midline and lateral aspect of the participant’s body); thoracic erector spinae (TES) (5cm lateral to the T9 spinous process); external oblique (EO (just below the rib cage, along a line connecting the most inferior costal margin and the contralateral pubic tubercle); internal oblique (IO) (1cm medial to the anterior superior iliac spine); and rectus abdominis (RA) (1cm above the umbilicus and 2cm lateral to midline). These electrode placements were consistent with previous research (O'Sullivan, Dankaerts et al. 2006). A common earth electrode was placed over the ulnar styloid. Correct location of the electrodes was visually confirmed by examining the sEMG output while applying manual resistance. EMG data were normalised to a maximum voluntary isometric contraction (MVIC). To generate MVIC for the abdominal muscles, three variations of a sit-up were used, similar to previous research (O'Sullivan, Dankaerts et al. 2006). One normalization technique was used for all three back muscles, similar to previous research (O'Sullivan, Dankaerts et al. 2006) The middle three seconds of amplitude normalized EMG data, from the five-second testing period, were analysed. The highest generated contraction from any of the three abdominal tests was taken as the MVIC for each specific abdominal muscle, and the highest generated MVIC from three repetitions of the back muscle test was taken for each specific back muscle (O'Sullivan, Dankaerts et al. 2006). To avoid fatigue contraction time for all MVIC trials was five seconds duration (Soderberg and Knutson 2000) and a three minute rest was given between trials (McLean, Chislett et al. 2003).

2.3.3 Chairs

The ‘Back App’ chair (Figure 2) facilitates dynamic sitting through an unstable ball positioned at its base, whose prominence can be altered to vary the degree of motion allowed, and thereby the postural challenge. For testing, the degree of motion allowed on the ‘Back App’ chair was standardised at the ‘green zone’, which involves a mild degree of movement. The standard office chair (Figure 3) was adjustable, backless and had wheels. Participants were instructed to “sit as you normally would” while on the chair, and simply to maintain their balance while sitting on the ‘Back App’.

2.3.4 Discomfort

Participant discomfort was rated numerically using the Body Part Discomfort Scale (BPDS) (Fenety and Walker 2002). This involved participants rating discomfort across each of 12 body areas from 0 (no discomfort) to 5 (intolerable discomfort) (Fenety and Walker 2002). Low back discomfort, as well as overall body discomfort using the mean discomfort of the 12 body parts, was recorded (Fenety and Walker 2002).

2.4 Procedure

2.4.1. Workstation set-up

A simulated workstation was created. An adjustable height desk was elevated until it reached the underneath of the elbow, to allow a 90° elbow angle in line with the trunk (Kingma and van Dieen 2009). Following this, the desk was positioned in line with the radial styloid process. Participants distance from the desk was standardised as their greater trochanter being 30cm from the desk. Goniometry was used to measure both hip and knee angles. The standard chair was adjusted to allow an angle of 90º for both the hips and knees with the feet placed firmly on the floor (Figure 1), while the ‘Back App’ was adjusted to allow a 125º hip angle with the feet placed on the footplate (Figure 2). Participants were blinded as to when all posture and sEMG measurements were recorded. After the orders were assigned, participants completed both static and dynamic tasks in the same order of sitting conditions. A one-minute break was given while changing between chairs.

2.4.2. Static Task (Typing)

A laptop was placed 10cm from the edge of the desk. Participants typed the same piece of literature, placed on a stand to the side of the laptop, for 10 minutes on each chair. EMG data were recorded on three occasions (after three, six and nine minutes) for five seconds duration, similar to previous research (McGill, Kavcic et al. 2006). In between the two sitting conditions each participant was allowed to walk around the laboratory area for five minutes (Callaghan and McGill 2001). At time intervals 0, 5 and 10 minutes (you write the numbers for minutes here but write them as words in line 7 above) of the static typing task, participants rated discomfort using the BPDS. To control for variations in baseline discomfort level and order of testing, the progression of discomfort over time (discomfort after ten minutes – discomfort at baseline) was used to determine the discomfort associated with each sitting condition. (do we have a reference for this calculation?)

2.4.3 Dynamic office task

Following each ten-minute typing task, participants performed a thirty-second dynamic office task while remaining seated. Based on previous data (Callaghan and McGill 2001) demonstrating large postural variability during uncontrolled deskwork in sitting, this task was closely controlled. This dynamic task involved leaning forward to pick up a ringing phone, answering it, placing it back down to its original position, arranging a number of pages in the correct sequence and then stapling them together.

2.5 Data analysis

Posture did not change significantly over time during the static typing tasks on both chairs. Consequently, a single value for average (mean) posture and variation in posture (SD) was calculated for each participant for each chair.

All raw EMG files were visually inspected. The middle three seconds of raw EMG data from all testing periods was processed using a root-mean-square (RMS) algorithm, and expressed as %MVIC. For the typing task, the mean of the three values was used, as there was minimal variance between them, in line with previous studies who found no significant effect of time on trunk muscle activity in short duration sitting tasks (McGill, Kavcic et al. 2006).

Data were analysed using SPSS 18.0. For all statistical tests, significance was set at $p<0.05$. Normality of distribution and homogeneity of variance were established using Shapiro-Wilk's and Levene's tests. A two-way Analysis of Variance (ANOVA) was used to analyse lumbar posture and trunk muscle activation. The independent variables were Chair and Task and the dependent variables were XXXXXXXA paired t-test was used to compare mean discomfort on both chairs during the static typing task only.

3. Results

The overall results for lumbar posture and trunk muscle activation on both chairs during both tasks are illustrated in Table 1.

3.1 Posture

3.1.1 Mean Posture

There was no significant interaction ($F_{1,36}$=0.463, p=0.501) between Chair type and Task. There was a significant main effect for Chair type ($F_{1,36}$= 6.17, p=0.018), with significantly less lumbar flexion when sitting on the ‘Back App’. In contrast, there was no significant main effect for Task ($F_{1,36}$=0.077, p=0.783).

3.1.2 Variation in Posture

There was a significant interaction ($F_{1,36}$=6.676, p=0.014) between Chair type and Task, with greater variation in posture occurring mainly during the dynamic task on the ‘Back App’. There was a significant main effect for Task ($F_{1,36}$= 11.535, p=0.002), with significantly greater variation in posture for the dynamic task. In contrast, there was no significant main effect for Chair type ($F_{1,36}$=1.397, p=0.245).

3.2. Trunk Muscle Activation

Trunk muscle activation during both office tasks are illustrated separately in Figures 4 and 5. There were no significant interactions between Chair type and Task for any of the six trunk muscles studied (all p >0.05). There was a significant main effect for Chair type ($F_{1,34}$= 5.114, p=0.030) for ICLT only, with less ICLT activation when sitting on the ‘Back App’. There was a significant main effect for Task ($F_{1,34}$=8.351, p=0.007) for LM only, with less LM activation during the static task.

3.3 Discomfort

The level of both low back discomfort and overall body discomfort experienced during the static typing task was mild, and did not differ significantly (p>0.05) between the standard chair and the ‘Back App’ chair.

4. Discussion

The results indicate that during brief simulated office tasks, painfree participants sat in less lumbar flexion, and displayed less lumbar muscle activation, when sitting on a novel dynamic ergonomic chair compared to a standard backless office chair. This change in lumbar posture and lower paraspinal muscle activation was achieved without altering mean overall body discomfort. There were few differences in posture or muscle activation between the static and dynamic tasks. Increased variation in lumbar posture occurred during the dynamic task, primarily when sitting on the ‘Back App’, and the activation of LM was much greater during the dynamic task.

No previous study had examined the effect of a dynamic saddle chair similar to the ‘Back App’ on lumbar posture or trunk muscle activity. The current results are consistent with data demonstrating that static saddle seats (Gale, Feather et al. 1989; Koskelo, Vuorikari et al. 2007) are associated with increased lumbar lordosis. However, the existing data on the effects of saddle chairs on trunk muscle activation are less clear. Consistent with our results, one study (Koskelo, Vuorikari et al. 2007) demonstrated reduced muscle activation at two year follow-up among students who used adjustable saddle chairs in the intervening two years. However, another study (Bennett, Gillis et al. 1989) observed no difference in muscle activation when sitting on these adjustable chairs, possibly due to using chairs with a backrest for comparison, since lumbar supports and increased seat back inclination angle also reduce paraspinal muscle activation (Magnusson 1998). In contrast to the current results, it appears that other ergonomic methods of increasing lumbar lordosis such as kneeler chairs increase lumbar lordosis but at the cost of increasing paraspinal muscle activation and discomfort (Lander, Korbon et al. 1987; Bennett, Gillis et al. 1989).

The existing research on the influence of dynamic sitting is contradictory. It appears to increase the overall amount of spinal motion in sitting (O'Sullivan, Dankaerts et al. 2006; Kingma and van Dieen 2009), but the effects on height of the spinal column (spinal shrinkage) are unclear (van Dieen, De Looze et al. 2001;

Kingma and van Dieen 2009). Most of the evidence suggests that dynamic sitting is associated with no change in mean spinal posture (van Dieen, De Looze et al. 2001; McGill, Kavcic et al. 2006; O'Sullivan, Dankaerts et al. 2006) although it may increase anterior pelvic tilt (Gregory, Dunk et al. 2006). Similarly, most research suggests dynamic sitting does not change (van Dieen, De Looze et al. 2001; McGill, Kavcic et al. 2006; O'Sullivan, Dankaerts et al. 2006) or in fact increases (Gregory, Dunk et al. 2006; Kingma and van Dieen 2009) trunk muscle activation, in contrast to the trend towards reduced lower paraspinal muscle activation seen in the current study. Finally, dynamic sitting may be associated with increased discomfort (Gregory, Dunk et al. 2006), unlike the current study. Overall, since most previous research on dynamic sitting suggests no major differences in posture or muscle activation (van Dieen, De Looze et al. 2001; Gregory, Dunk et al. 2006; McGill, Kavcic et al. 2006; O'Sullivan, Dankaerts et al. 2006; Kingma and van Dieen 2009), it is likely that the changes seen in posture and muscle activity while sitting on the ‘Back App’ are primarily related to the reduction in hip flexion. As a result, if dynamic sitting has a benefit, it may be in preventing static loading of spinal tissues which may be relevant in LBP (Vergara and Page 2002) rather than as a means of altering trunk posture or trunk muscle activation (van Deursen, Patijn et al. 1999; van Dieen, De Looze et al. 2001; O'Sullivan, Dankaerts et al. 2006). The lack of any significant difference in abdominal muscle activation on the chairs suggests that the novel dynamic ergonomic chair has minimal effect on abdominal muscle activation.

Sitting is associated with increased spinal flexion compared to standing (Dunk, Kedgley et al. 2009; De Carvalho, Soave et al. 2010). It has been observed that while sitting on traditional chairs, paraspinal muscle activation is closely related to seated lumbar curvature (O'Sullivan, Dankaerts et al. 2006). For example, actively increasing anterior pelvic tilt and lumbar lordosis are associated with increased paraspinal muscle activation (O'Sullivan, Dankaerts et al. 2006; Claus, Hides et al. 2009). However in this study, back muscle activation, especially ICLT, was reduced even with an increase of lumbar lordosis while sitting on the ‘Back App’. This suggests the ‘Back App’ chair passively assists lumbar lordosis, without requiring an increased level of paraspinal muscle activation. Considering suggestions that sustaining lordotic sitting postures may place an unsustainable stress on the back muscles and contribute to pain and fatigue (Claus, Hides et al. 2009), this is potentially advantageous in moderating spinal loads. The values for trunk muscle activation in the current study appear representative of previous research (O'Sullivan, Dankaerts et al. 2006; Claus, Hides et al. 2009) and are minimal, with mean trunk muscle activation ranges from 4 to 14% MVIC.

Considering that the ‘Back App’ is likely to alter lumbar lordosis by reducing posterior pelvic rotation, it is not surprising that the lower paraspinal muscles (ICLT and LM) are most influenced by its use. While sitting posture also influences the activation of the abdominal muscles and TES, these muscles are not as closely affected by changes in pelvic rotation (O'Sullivan, Dankaerts et al. 2006; Claus, Hides et al. 2009). While there is considerable evidence that the activation of muscles such as LM and transversus abdominis may be delayed in people with LBP (Hodges 2001; MacDonald, Moseley et al. 2009), there is also evidence that overall amplitude of trunk muscle activation may be increased in some subjects with LBP (Dankaerts, O' Sullivan et al. 2006).

Sustained sitting can induce significant discomfort (Vergara and Page 2002), which can be alleviated by the use of backrests (Gale, Feather et al. 1989; Leivseth and Drerup 1997). Both chairs in the current study induced very low discomfort levels, which did not differ significantly. The short duration of testing, the use of a rest-break between the static exposures, and the painfree nature of the participants may explain the low levels of discomfort reported. A previous study (Gadge and Innes 2007) reported that overall body and lumbar discomfort were slightly reduced during a typing task on a static saddle chair compared to a standard office chair, but that lower limb discomfort was increased on the saddle chair. A similar study (Koskelo, Vuorikari et al. 2007) reported that students using adjustable height chairs were more comfortable than those using traditional chairs. In contrast, in another study (Gregory, Dunk et al. 2006) overall body discomfort was significantly higher after a one-hour period of dynamic sitting compared to a standard office-chair. However, this increased discomfort may be explained by the fact that in their study the exercise ball appears to have facilitated anterior pelvic tilt through increased paraspinal muscle activation, which differs significantly from the current study.

It has to be acknowledged that there are some limitations to the current study. This study involved only a small sample of painfree participants, without estimation of a necessary sample size to XXXXX. In addition, the duration of exposure was relatively short. Both the short duration and small sample size reduce the likelihood of finding significant differences between the two sitting conditions. Nevertheless, significant differences in posture and muscle activity were still evident. Differences in posture, muscle activation and particularly discomfort may be even more pronounced during longer sitting exposures in a larger sample of participants with LBP. Although the dynamic office task was standardised, the exact duration participants spent on each specific part of the task may have varied between the chairs. Most standard office chairs have backrests which may also decrease the muscular effort and discomfort of sitting (Vergara and Page 2000), and comparison of the ‘Back App’ to a standard chair with a backrest should be completed. However, we chose to compare to a chair without a backrest to initially examine the influence of an altered hip angle and a degree of instability without the possible influence of a backrest. Furthermore, backrest use is reduced in many office tasks such as typing (Vergara and Page 2000), diminishing the importance of chair backrests during functional tasks such as those examined in this study. The ‘Back App’ has the potential to vary the level of instability, and the effect of greater levels of instability is unclear. Future studies may consider the effect of ‘Back App’ sitting in occupational settings for a longer duration. Notwithstanding these limitations, the study had many strengths such as the use of closely standardised functional tasks that replicate an office situation.

5. Conclusion

The use of a novel dynamic ergonomic chair facilitates a less flexed lumbar spine posture, while requiring less intense activation of the lower paraspinal muscles, especially ICLT, during brief, simulated seated office tasks. The degree of discomfort was low, and similar on both chairs. It is likely that this effect is achieved by the reduced hip flexion passively facilitating anterior pelvic tilt and lumbar lordosis. The relative contribution of the dynamic sitting element is unclear. Maintaining lumbar lordosis with less intense muscle activation is potentially advantageous during prolonged sitting, as it could reduce the potential for fatigue and discomfort often associated with lordotic sitting postures. Future studies in subjects with LBP are warranted.

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Table 1. Mean+SD trunk muscle activation and lumbar posture during static and dynamic office tasks on both a standard office chair and the 'Back App' chair.

	Static Task		Dynamic Task	
	Standard chair	Back App	Standard chair	Back App
EO	5.6+3.8	4.0+1.4	6.2+2.8	6.1+3.1
IO	7.6+6.0	7.3+7.5	7.1+4.8	8.5+6.5
RA	6.4+6.8	3.9+2.6	5.5+3.8	5.3+3.3
TES	12.0+5.8	10.2+5.5	10.3+6.1	9.7+4.8
ICLT*	11.9+4.8	8.3+3.9	12.0+5.5	9.8+4.1
LM#	7.3+5.5	5.3+3.2	13.9+7.5	9.4+4.7
% Flexion (Mean)†	70.13	46.34	67.10	53.54
% Flexion (Variation)‡	6.72	4.98	7.73	12.41

EO - external oblique; IO - transverse fibers of internal oblique; RA - rectus abdominis; TES - thoracic erector spinae; ICLT - iliocostalis lumborum pars thoracis; LM - superficial fibers of lumbar multifidus; All muscle activation expressed as %MVIC (Maximum Voluntary Isometric Contraction); All posture expressed as %flexion range of motion (ROM); * - significantly less activation on 'Back App'; # - significantly less activation during static task; † - significantly less flexion on 'Back App'; ‡ - significant interaction, with greater variation in posture during the dynamic task, particularly on the 'Back App'.

Figure Legends

Figure 1: The BodyGuard posture monitor

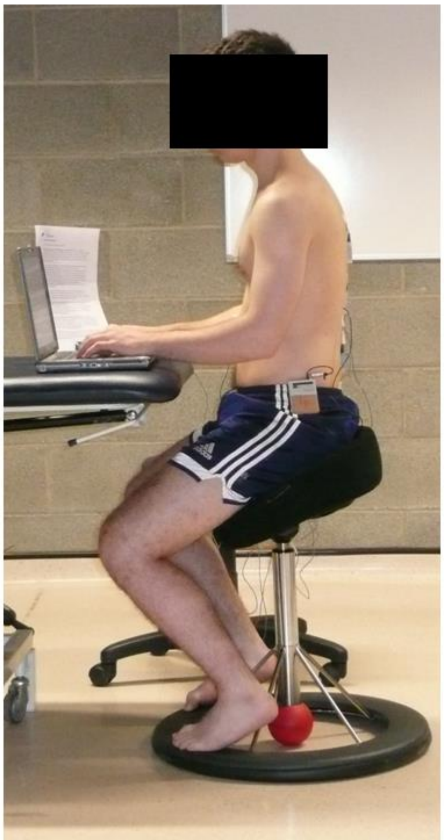
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Figure 2: Sitting on the ‘Back App’ chair

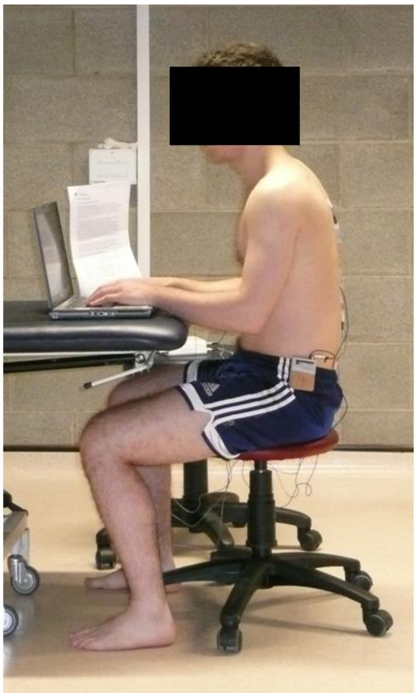
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Figure 3: Sitting on the standard office chair

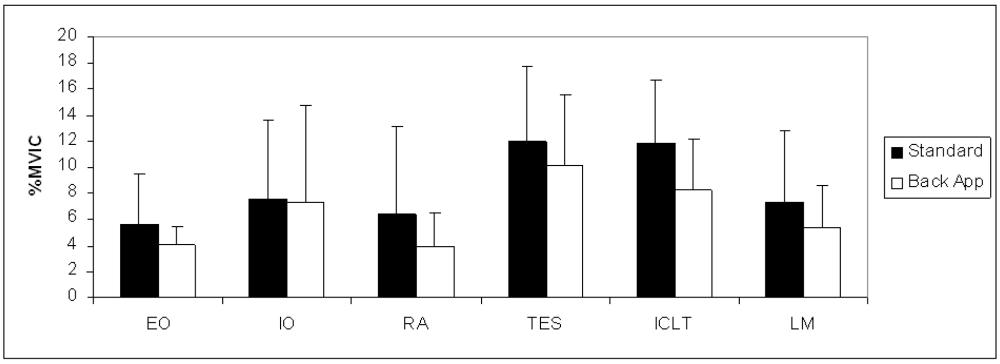

Figure 4: Mean+SD trunk muscle activation during a simulated static typing task on both a standard office chair and the 'Back App' chair.

%MVIC = percentage of Maximum Voluntary Isometric Contraction; EO - external oblique; IO - transverse fibers of internal oblique; RA - rectus abdominis; TES - thoracic erector spinae; ICLT - iliocostalis lumborum pars thoracis; LM - superficial fibers of lumbar multifidus.

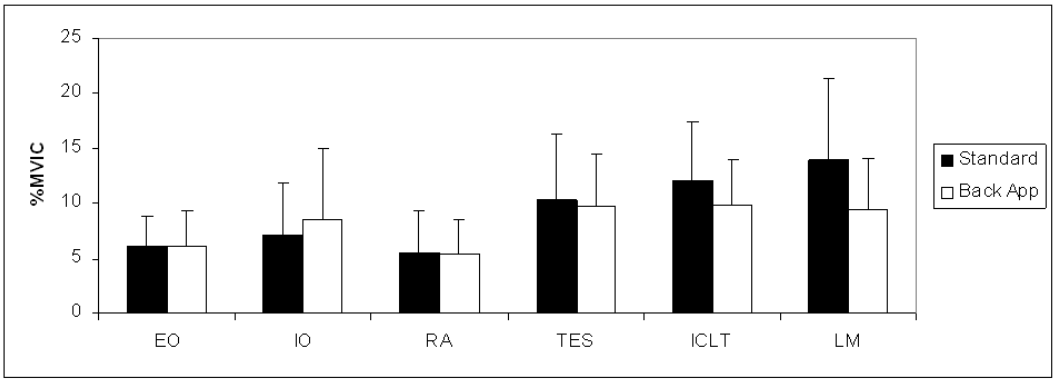

Figure 5: Mean+SD trunk muscle activation during a simulated dynamic office task on both a standard office chair and the ‘Back App’ chair.

%MVIC = percentage of Maximum Voluntary Isometric Contraction; EO - external oblique; IO - transverse fibers of internal oblique; RA - rectus abdominis; TES - thoracic erector spinae; ICLT - iliocostalis lumborum pars thoracis; LM - superficial fibers of lumbar multifidus.