Comparisons of Seated Postures between Office Tasks

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Seating is an active area of ergonomics research; however, little research has been performed that evaluates seated body postures for a variety of tasks and chairs. The goal of this study was to evaluate the effects of common office tasks on head, upper extremity, torso, hip, and leg postures. Prolonged awkward postures may contribute to musculoskeletal pain and disorders. Twenty-five participants performed four office tasks using four office chairs while postures were recorded using a 3D optical marker system. The tasks were typing on a desk fixed at 73.7cm (29"), typing with the desk adjusted to be slightly above elbow height, reclined movie watching, and a forward leaning writing task. Head angle, pelvis-to-head angle, thoracic cage angle, and pelvis angle were all significantly different between tasks (p=<0.0001). This method for full body posture measurement will allow further research into the effects of tasks and chairs on seated posture.

INTRODUCTION

Everyone sits. For many, a majority of waking hours are spent sitting. The task that we are performing while seated can have a significant effect on posture. Understanding the effects of task on posture enables us to better design chairs to improve comfort and productivity.

In the past, chair evaluations have largely focused on spinal curvature, upper extremity posture, and cushion types (e.g., O'Sullivan 2006; Dowell 2001; Legg 2002). Few studies have investigated the effects of different office tasks on pelvic or lower limb posture (e.g., Shackel 1969).

While full body postural tracking has been used for standing tasks (Nadeau 2003), it is relatively new in seated studies, largely due to the technical challenges involved. One challenge with seated postures is access to key landmarks that may be obscured by a seat, desk or other objects.

The goal of this study was to determine how common office tasks affect body posture as well as to develop a method for full body seated posture testing. Specifically, this study investigated the effects of forward leaning active, reclined relaxed, and upright active tasks on lower and upper body postures. A variety of common chairs were used while participants performed the tasks.

METHOD

The null hypothesis was that posture would not be affected by common office tasks. The independent variable was task; mean postures were calculated across chairs. The dependent variables were head angle, thoracic cage angle, head rotation relative to pelvic angle, pelvic angle, knee angle, and ankle angle.

This is a repeated measures laboratory study in which participants performed four simulated office tasks (writing, typing at two desk heights, and reclined viewing), in four chairs, while body posture was measured using optical marker tracking. Chair order and task order within each chair was randomized. Required participation criteria included being able to type greater than 25 words per minute and having a BMI below 28kg/m^2 (to ensure that surface markers would accurately represent bony landmarks). The study was approved by the University of California, San Francisco Committee on Human Research and written informed consent was given by each participant prior to starting the study.

Anthropometry Measurements

Participants' height and weight without shoes were measured. Using the methods outlined in NASA (1978), the following were measured: eye height, resting elbow height, forearm length, hand length, biacromial breadth, mid-shoulder height, popliteal height, thumb-tip reach, and buttock popliteal length. While not presented here, demographic data was collected on age, sex, race, and handedness.

Workstation Setup

A 17-inch height adjustable computer monitor (model 1703FPs, Dell Inc.), standard QWERTY keyboard (model RTD720, Dell Inc.), and standard mouse (model M-Saw34, Logitech Co.) were mounted on a height adjustable table (Deskline DL6, LINAK). The monitor was adjusted so that the center of the monitor was approximately 15° below the horizon from the eyes, centered on the chair, and approximately 60 cm from the eyes when the participant was typing with the desk at 73.7 cm (29"). The keyboard was positioned so that the home row (i.e., row with A, S, etc.) was 19 cm from the edge of the table.

Chairs

Four chairs from major manufacturers were used in this study: the Leap (Steelcase Inc.), Aeron (Herman Miller, Inc.), Freedom (Humanscale), and the Headline (Vitra Inc.). All four chairs were equipped with carpet casters. Arm support was removed.

Chair Adjustments

Each chair was adjusted once at the beginning of the experiment. When possible, the chair pan height was adjusted so that the ischial tuberosities were approximately one centimeter above the participant's popliteal height; seat pan depth was set so that the leading edge was 4 cm from the back of the knee; seat pan angle was set to a neutral angle, back supports were adjusted in height to support the apex of the lumbar curve in neutral posture; and recline tension was adjusted so that participants would be supported for upright tasks when their heads were neutral or tilted forward, and leaning back would cause the chair to recline.

Chair Recline Force Measurement

A method was developed to adjust the chair back recline stiffnesses so that it was similar for a subject across chairs. To facilitate repeatability and better understand the chairs' kinematics, the force required to recline the back support was measured directly after configuration by having the participant slide forward on the seat pan so that their back was 25.4 cm from the base of the back support. The highest connection on the backrest of each chair was pulled backward, normal to the back support with a force gauge (Chatillon model DPPH 250, Ametek Inc.) until the back support angle (observed using a metal bar attached to the back of each chair such that it was vertical at rest) was approximately 30° from vertical. The measurement was repeated three times and the average was reported. The spacing of 25.4 cm from the back of the chair was chosen because as some chairs articulate backward they force the seat up or down. This would lead to a large variability in force due to body weight of the participant. By having participants sit near the center of the seat pan, we were able to mitigate this problem.

Posture Measurements Using Optotrak

An active marker motion analysis system (2 Optotrak 3020 sensor banks, Northern Digital) was used to continuously record the participant's postures during the tasks. Infrared emitting diode (IRED) markers were secured to small thin plastic plates, and the plates were secured to the skin using double sided tape (Figure 1). The following postures were calculated: head rotation and forward flexion, thoracic cage posture, pelvic rotation, pelvic flexion, and ankle flexion. Neutral posture was recorded for comparison to other postures.

Participants were provided with cotton clothing which was modified to expose the participant's right iliac crest, right lateral malleolus, femoral epicondyle, sternal angle, and acromion process.

Markers based on those used by Keshner (2003) were placed on the head at the lateral canthus, along the tragus, to measure head rotation. Markers based on those used by Hirose (2005), were placed on the chest to measure thoracic cage angle. For ease of marker placement, the sternal notch and sternal angle were palpated and marked, and a line was drawn with a ruler joining the two. A three-marker plate was then taped on to the participant with its center line along the drawn line.

Single markers were also placed on the lateral femoral epicondyle and lateral malleolus to measure knee flexion. Foot position and changes in ankle angle were recorded by taping a two IRED marker plate along the top edge of the participant's shoe, roughly parallel to the ground. Lower limb marker placement was based on that used by Nadeau (2003).

In conjunction with the lower and upper limb markers, pelvic posture was recorded by taping a rigid plastic three IRED marker plate to the participant's Anterior Superior Iliac Spine (ASIS) and Posterior Superior Iliac Spine (PSIS). The plate, which spanned the ASIS and PSIS, was a curved plastic band that weighed 13g, and was 30.2 cm long, .1cm thick, and varied between 1.9 cm and 5.1 cm wide.

Figure 1. Participant performing one of the typing tasks while posture is being recorded by camera banks in corners of the room.

Calibration

After all IRED markers were attached, participants sat on a 35.3 cm diameter hard adjustable stool, with the pan height adjusted to one centimeter above the popliteal height. Participants were seated in a neutral, upright reference posture: feet flat on the floor, lower legs vertical, torso upright, hands relaxed in their lap, and looking straight ahead. Posture data were recorded for 15sec. The height of the ASIS/PSIS marker plate was recorded so that the chairs could be adjusted to match the height of the ischial tuberosities on this hard-surface stool without having access to them later.

Tasks

Four tasks were performed by each participant for each chair. The tasks were designed to mimic a range of common office postures. Each task ran for 10 minutes. Starting 2 minutes into each task, posture data was collected continuously for 6 minutes. All tasks were performed with the chair backs locked upright when possible, and the desk height fixed at 73.7 cm (29”) unless otherwise noted.

1. Fixed desk height typing. This task involved performing a computer typing test. One of ten randomized excerpts from a freely available book (Williamson, 2006) was transcribed. These excerpts included all of the letters of the alphabet, numbers and punctuation. Participants used a typing program (Typing Workshop Deluxe, Valusoft Inc.).

2. Adjusted desk height typing. This task was the same as the fixed desk height task except the desk height was adjusted such that the top of the home row keys was 8 cm above the participant’s elbow (olecranon).

3. Reclined movie watching. Participants watched a short video which was followed by a short quiz on the movie. Quizzes were scored, and the score was reported to the participant. If possible, the chair’s tilt lock was disengaged. Participants were encouraged to “sit back and relax” or “recline in a comfortable position” to encourage the participant to assume a passive task posture.

4. Forward leaning writing task. To simulate forward leaning active tasks, a mixed reading/writing task was selected. Participants were given sheets of paper with a paragraph of “words” made of nonsensical strings of letters. The participant was asked to circle every instance where the last letter of a “word” was the same as the first letter of the following “word” (for example: kafiera werkjvl lberafpg). Participants were asked to leave the paper flat on the table. After each task, the number of sheets of paper completed and the number of errors were recorded and announced to the participant.

Study Procedures

Practice session. When a participant arrived on the testing day, the study was explained to him or her. The typing software was explained, and the participant performed the fixed desk height typing task for 10 minutes in a random chair to become familiar with the software. If the participant was able to type 25 wpm or more, they were considered qualified; if not, they were given a second chance. Failing the second chance excluded them from the study.

Qualified participants’ anthropometric data was collected, and IRED markers were placed. After IRED maker placement, the participant’s reference posture was measured. Participants completed all four tasks in each chair with the order of both chair, and task within chair, randomized for each participant.

Before each chair was used, it was tested and configured for that participant and the chair’s configuration was recorded.

Posture Calculations

Calculations were performed using First Principles (Northern Digital), and Excel (Microsoft Corporation). First Principles was used to calculate the knee angle (the angle made by crossing the vector of the ASIS plate and the femoral epicondyle and the vector of the lateral malleolus and the femoral epicondyle) and the ankle angle (the angle made by crossing the vector of the femoral epicondyle and the lateral malleolus with the vector made by the two markers on the shoe). The data recorded by First Principles in the reference position and during the test was used to calculate pelvic forward rotation, pelvic tilt angle, thoracic cage forward rotation, and head forward rotation. Pelvic forward rotation was defined as the rotation of the pelvis in the coronal plane relative to the reference posture. Pelvic tilt angle was defined by the rotation of the pelvis in the sagittal plane relative to the reference posture. These were calculated by creating a local coordinate system based on the marker plate spanning the ASIS and PSIS and comparing it to the global coordinate system for the room.

Thoracic cage forward rotation was defined as the rotation of the thoracic cage marker in the coronal plane corrected by the reference posture, and compared to both the global coordinate system to relate it to gravity and the local-pelvic coordinate system to relate it to the pelvic angle.

Head forward rotation was calculated using the vector created by the markers on the lateral canthus and the top of the tragus of the ear. This data was also compared to the reference posture.

Data Analysis

Posture differences between the tasks were evaluated using SAS (SAS Institute Inc.) using Repeated Measures ANOVA. Significant findings were investigated with Tukey test for multiple comparisons. Subjective rating differences were examined using Friedman’s chi-square test with a Tukey test follow-up for significant findings.

RESULTS

A total of 25 people (13 females, 12 males) participated in the study. The mean age was 26 years (SD = 12; range 18 to 60). Participants were from the university staff and student population as well as the general public. The mean participant height and weight were 169.7 cm (±8.2) and 63.3 kg (± 10.0), respectively.

Mean postures by task are listed in Table 1 and shown in Figure 2 and Figure 3. Head angle, pelvis-to-head angle, thoracic cage angle, and pelvis angle were all significantly different between tasks (p=<0.0001). Knee angle was also significant (p=0.07). Ankle angle did not show a significant difference between tasks.

Table 1. Mean (SD) angles by task averaged across all chairs

	Typing Tasks		Other Tasks		
	Fixed Height	Elbow Height	Movie Watching	Writing	*p*-value
Head	-4.2 (5.9)[a]	-5.7 (6.3)[b]	-3.2 (5.7)[c]	-42.3 (10.2)[a,b,c]	<0.0001
Pelvis-to-head	2.5 (6.2)[a,b]	0.3 (6.3)[c,d]	12.7 (7.4)[a,c,e]	-19 (11.9)[b,d,e]	<0.0001
Thoracic cage	-2.3 (7.5)[a,b]	-4.5 (7)[c,d]	10.5 (10.1)[a,c,e]	-18.1 (11.3)[b,d,e]	<0.0001
Pelvis	8.7 (7)[a,b]	7.9 (6.2)[c,d]	20.9 (10.6)[a,c,e]	3.3 (6.1)[b,d,e]	<0.0001
Knee	3.5 (11.6)	3.7 (9.4)	6.8 (9.5)	3.8 (11.2)	0.0662
Ankle	1.6 (6.5)	2.3 (5.5)	0.7 (5)	-0.1 (5.9)	0.1562

*Significant pair-wise comparisons indicated by paired superscripts within each row.

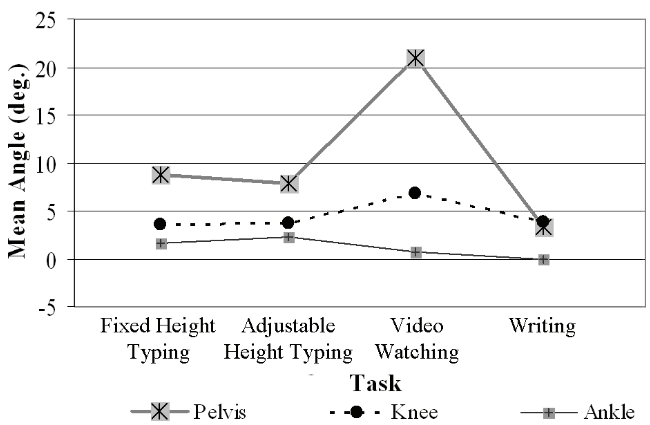

Figure 2. Graph showing change in pelvic, knee, and ankle angle from reference posture by task. Positive values indicate increased pelvic and knee extension, and more plantar-flexion compared to the reference posture. (Pelvis angle is included in both figures for reference)

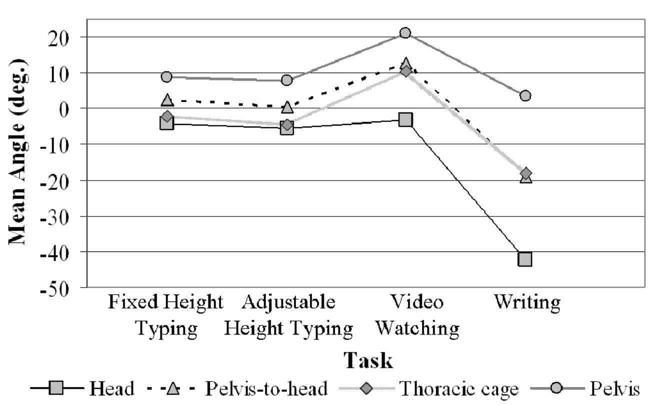

Figure 3. Graph showing change in head, pelvis-to-head, thoracic cage, and pelvis angle from reference posture by task. Positive values indicate increased extension compared to the reference posture. (Pelvis angle is included in both figures for reference)

Significant findings were followed up with pair-wise comparisons. Pair-wise p-values were <0.001, except for pelvis angle comparisons between fixed height typing and writing, and elbow height typing and writing. The p-values for these comparisons were 0.005 and 0.023 respectively.

DISCUSSION

There was little difference in body postures between the two typing tasks. However, the writing task was associated with increased head, thoracic cage, and pelvis flexion compared to the other tasks. Video watching was associated with increased thoracic, head, and knee flexion compared to the other tasks. For the writing task it was common to see a participant hunched forward, directly above their paper. For writing, these postures are likely due to the lower visual target activities, while for video watching the postures are due to the use of the chair support and recline mechanism.

Full body posture measurement of seated subjects provides researchers insight in to differences between tasks. The full body posture measurement method developed demonstrated significant differences between pelvis (hip) angles.

While research has been conducted to characterize differences between chairs (e.g., Michel, & Helander, 1994), little has been done to characterize differences between tasks independent of chair. This study showed that task type can have a significant impact on posture, which in turn can affect performance and the occurrence of musculoskeletal disorders.

In conclusion, these findings emphasize the need to consider a range of common tasks during the chair design process to realize healthy work practices and postures.

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