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The University Desk Chair: Examining the Impact on Learner Comfort and Ability to Focus

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A mismatch between furniture and body characteristics can cause musculoskeletal discomfort during prolonged sitting for a variety of learners. The purpose of this study was to explore university students' perceived changes in pain and/or discomfort, perceived level of comfort, and perceived ability to focus and learn while using four common desk chair styles. After recording standing and seated height, sixty-seven university students completed a survey tool which contained six sections: 1) demographics, 2) type of desk chair used and time in desk chair, 3) pain and/or discomfort rating and location prior to and after desk chair use, 4) impact of desk chair on pain and/or discomfort, 5) rating of desk chair comfort, and 6) rating of desk chair adjustability. A desk chair with padding and a large frame was rated significantly highest in overall comfort. Participants reported significantly increased upper back pain when using a desk chair with minimal arm support. During periods of prolonged seating, desk chairs should accommodate various sized bodies and have cushioning, as well as support for the upper body.

Background and Purpose

Classroom furniture has been reported to impact learning and/or experience of students (Ali et al., 2015; Odunaiya et al., 2014; Saarni et al., 2009; Thariq et al., 2008). Adult learners participating in university classes on campus may be required to sit for prolonged periods while maintaining static and prolonged postures (Ali et al., 2015). The variability between desk chair design and body size and structure may cause awkward or unnatural body positions, leading an individual to have physical discomfort, lack of ability to focus during class (Adu, 2015; Odunaiya et al., 2014), and even lack of interest in subject material (Castellucci et al., 2010; Castellucci et al., 2015(a); Hira, 1980). The classroom is the student's working environment. Thus, utilization and design of the desk chair acts as a conduit for a learner's efficiency in their working environment.

Furniture design which has not been matched to users has been shown to impact fatigue, change postures, and lead to the development of musculoskeletal discomfort and pain (Castellucci et al., 2014; Odunaiya et al., 2014; Parcells et al., 1999; Parvez et al., 2019; Rudolf & Griffiths, 2009; Shinn et al., 2002). A slouched posture, for example, may feel comfortable to seated individuals due to the minimal muscle activity required to maintain this posture. However, vertebral pressure is increased in a slouched posture and muscle length can become imbalanced, leading to the potential for long-term effects and the chance of injury (Rudolf & Griffiths, 2009). Postural dysfunction, when the spine is placed in unnatural positions for prolonged time periods, can cause fatigue, nerve entrapment, and micro tears of the muscles of the upper extremity, neck, and back, eventually leading to inflammatory changes, pain, and impaired function (Shinn et al., 2002). Risk of postural dysfunction increases in positions which cause the body to resist gravity for prolonged periods, with angles further away from neutral, and with pressure/tension on tissues at extreme ranges within the postural spectrum (Straker et al., 2008).

Incompatibility between a learner's body characteristics and chair design can lead to increase in musculoskeletal disorders (Baharampour et al., 2013). Authors from a number of studies have reported student to desk mismatch in areas of seat height, seat depth, backrest height, desk height, and elbow rest height (Adu, 2015; Baharampour et al., 2013; Castellucci et al., 2015(b); Kahya, 2019; Lee et al., 2018; Odunaiya et al., 2014; Parcells et al., 1999; Parvez et al., 2019; Tunay & Kenan, 2008). This mismatch caused the

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individual to sit on seats which were too high (feet could not touch the floor), too shallow (lack of support to the lower thighs), without enough back support (increased flexion of the spine), and with desks which were too low (shoulders were raised or the arm held out to the side in order for the forearm to meet the surface of the desk) (Baharampour et al., 2013).

Determining a desk chair to fit 100% of learners may be difficult, as every individual has a different body size and shape. Among eighth grade students in the United States, researchers reported fewer than 20% of children had acceptable desk/chair combinations for their body size (Parcells et al., 1999). Nineteen percent of 15–16-year-olds and 14% of 17-18-year-olds reported that uncomfortable desks negatively impacted their schoolwork (Saarni et al., 2009). Among eighth graders in Chile, seat to desk height was too high and accounted for a mismatch in 99% of children in one school and 100% of children in a second school. Furthermore, among a sample of 3,078 school aged children from Chile ranging in age from 5-19, researchers found that only 7% of learners fit furniture which was assigned to them (Castellucci et al., 2010).

Similar results were reported in the case of university students. Among 225 university learners surveyed in Turkey, the seat was too high for females and too low for males. Furthermore, seat depth was too narrow for either gender (Kahya, 2019). Among 550 learners from Bangladesh, it was reported seat heat was too high, and seat depth was too deep (Parvez et al., 2019). While mounted desk height was usually okay for both males and females, when using a desk with a chair, the desk was usually too high for males (Parvez et al., 2019). To reduce some of these issues, the five main manufacturers of school furniture in the United States utilized design specifications from the American Furniture Manufacturer's Association and National Standards Board to determine the important characteristics of seat width, belly room, and non-combustible materials (Parcells et al., 1999). This research, however, was not incorporated into subsequent furniture design.

As identified in the literature, furniture can have a significant impact on the long-term health of university learners. Although a few authors have examined the match between university student dimensions and desk chair characteristics, most of the studies were conducted outside of the United States or with K-12 age children (Baharampour et al., 2013; Odunaiya et al., 2014; Parcells et al., 1999; Tunay & Kenan, 2008). Because anthropometric characteristics vary among regions, and changes occur over time as populations and environmental conditions evolve, these studies should be conducted specifically with individual populations (Tunay & Kenan, 2008). The purpose of this study was to explore university students' perceived changes in pain and/or discomfort, perceived level of comfort, and perceived ability to focus and learn while using four common desk chair styles with students located in the United States.

Methods

This study utilized a correlational research design aimed at identifying the comfort levels of four newly purchased desk chairs at a Midwestern university. University Institutional Review Board approval was obtained prior to any data collection. The participants were a convenient sample of undergraduate health care students taking in-person courses in classrooms which housed the newly purchased desk chairs.

Outcome Measure

A survey tool was developed by the authors and completed manually by the participants using pen/pencil. The survey tool contained several sections: first, standing and seated heights were recorded by one of the authors. The same author completed both measurements for consistency. Next, the participant completed demographic information about gender, age, weight, and pain location, as well as information about the class the learner attended (type of desk chair used and time in desk chair). The third section focused on identifying pain and/or discomfort prior to and after desk chair use (yes / no) and identifying the location of pain and/or discomfort during the same time periods. In addition, the participant responded to two Likert-type scale questions which focused on how the desk chair affected pain and/or discomfort and how the desk chair affected ability to focus on learning.

The next section contained thirteen visual analog scales related to desk chair comfort. The VAS has been used for subjective phenomena including pain, discomfort, stiffness, and dyspnea (Hawker et al., 2011; Williamson & Hoggart, 2005), and has good reliability (Alghadir et al., 2018; Hawker et al., 2011; Williamson & Hoggart, 2005), construct validity (Alghadir et al., 2018; Hawker et al., 2011; Williamson & Hoggart, 2005), sensitivity (Williamson & Boggart, 2005), and ability to detect change (Alghadir et al., 2018; Hawker et al., 2011). The standard length of 100mm, with anchor words of "very uncomfortable" and "very comfortable" was utilized. Each participant marked the 100mm line where he/she perceived desk chair comfort for each of the thirteen criteria, with each response measured to the nearest tenth of a centimeter (e.g., 9.2 cm).

The last section of the survey tool focused on the adjustability of each desk chair. Likert-type scale responses were selected for the participants' 'attitude' about the adjustable features. Likert responses have been used to quantify individuals' preferred thinking, feelings, and actions about a phenomenon into quantifiable data (Joshi et al., 2015). The five Likert-type scales used in this study were symmetric. Each participant rated the adjustable features of each desk chair using options of "very comfortable, comfortable, no opinion, uncomfortable and very uncomfortable." The participant could check "not applicable" if a feature was missing. Each adjustable feature was mutually exclusive resulting in a separate score for each item rather than a composite score. Consequently, data were considered ordinal and analyzed using non-parametric methods (Joshi et al., 2015).

Desk Chairs

The desk chairs in this study had been newly purchased based upon vendor recommendations and came in four designs: Tuxedo-Lounge, Caper-Stacker, Lab style, and Node style (Figure 1). The Tuxedo-Lounge deck chair was designed with a steel frame, front casters, and satin nickel feet. Padding covered the seat, back and sides, with a swivel tablet arm which served as a desktop (models were available for both right- and left-handed learners). The Caper-Stacker desk chair was made of a molded polypropylene back and seat on a metal frame, with casters for ease of movement. The plastic had small holes for breathability, and the desktop was a separate piece consisting of a laminate flip top with a metal frame. The third design was a Lab style desk chair and had the same molded polypropylene back and seat as the Caper-Stacker. However, this design used a five-pronged base with casters for easy movement and had the ability to adjust up and down along with a footrest. The final design was the Node style desk chair on a tripod base with casters and a molded bucket seat on a swivel base with a desktop attachment. The desktop swiveled for easy adjustment with right and left-handed models available.

Procedures

University professors who used classrooms with one of the identified desk chairs and held class for a minimum of two hours, were contacted to gain written permission to conduct research during their class time. Survey dates which were least disruptive to classroom activities were agreed upon. All data collection occurred within January and February of the winter semester. One week before the survey, the primary investigator attended each class, explained the purpose of the study, and asked for consideration of participation. The consent form was posted to the school's online class site by the professor of the class. Each learner had the opportunity to read it and determine if he or she wanted to participate. The goal was to recruit 20 participants for each style of desk chair, for a total of 80 participants.

On the agreed date, students were provided an opportunity to ask questions and informed consents were obtained. Participants were included if they were going to attend class in one of four classrooms chosen, had signed the informed consent, completed the survey, and had their anthropometric measurements taken of standing and seated height. BMI was calculated for each participant using the following formula: BMI = [weight (lbs.) / height in inches squared] x 703 (*Healthy Weight: About BMI*, 2017). Participants who completed the study were given an opportunity to win a drawing for a $25 gift card.

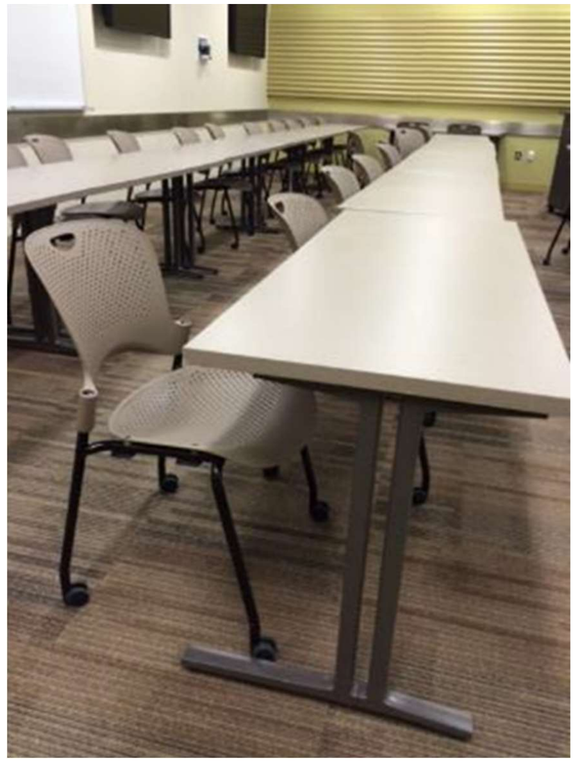
Because the study relied on the willingness of an instructor to allow researchers into the classroom, the selected participants were a sample of convenience. Participants who used the Tuxedo Lounge desk chair (padded) were taking HS450 – "Law, Values, and Ethics," a lecture class held from 8:00 - 9:47 am. Participants who used the Caper-Stacker desk chair (molded propylene with separate desk) also attended HS450 – "Law, Values, and Ethics." However, this class section was held in the evening from 6:30 – 8:50 pm. Participants who used the lab desk chair (propylene with height adjustment) attended MLS417 "Hematological Laboratory" from 12:30 – 2:30 pm, a laboratory-based class which included lecture and some lab work. Finally, participants who used the green node desk chair (molded bucket seat with attached desktop) were attending EXS207 "Safety and First Aid in Exercise Settings" from 2:00 – 3:45 pm. This class was primarily lecture with occasional interactive elements.

Data Analysis

Data were analyzed using IBM SPSS Statistics for Windows, v. 25.0 (IBM Corp., Armonk, N.Y., USA). A priori, two-tailed significance was set at p = .05. Frequency and descriptive statistics were used for all demographic data. Due to the small sample size of the groups, non-parametric tests were selected for all analysis due to their robust features with respect to distribution of the data. Chi-square tests of independence were used to analyze perceived pain and/or discomfort before and after using the desk chair, impact the desk chair had on perceived pain and/or discomfort, and how the desk chair affected the perceived ability to focus on learning. Effect sizes for significant findings were analyzed using Cramer's V with interpretation of 0.1 = small, 0.3 = moderate, and 0.5 = large effect (Cohen, 1988). Thirteen measures of desk chair comfort were analyzed using Kruskal –Wallis tests, with significant findings further analyzed using Mann-Whitney U tests with a Bonferroni adjustment. Effect size for significant findings were calculated using the formula $z/\sqrt{N}$, with interpretation as $r = 0.10$ (small effect), $r = 0.30$ (medium effect), and $r = 0.50$ (large effect) (Field, 2018). Kruskal-Wallis

Figure 1. Desk chairs used in this study

Tuxedo-Lounge desk chair



Caper-stacker desk chair

Lab desk chair

Node desk chair

Table 1. Demographics				
Sample Demographics	**Mean**	***SD***	**Range**	
Age (yrs.)	21.86	2.00	19-32	
Height (in.)	66.35	4.64	57.5–78.0	
Weight (lbs.)	148.87	29.8	95- 229	
BMI	24.25	3.73	17.2–39.02	
Demographics by Gender	**Male**		**Female**	
	Mean ± *SD*	**Range**	**Mean ± *SD***	**Range**
Age (yrs.)	21.68 (±1.04)	20-24	21.95 (±2.37)	19-32
Height (in.)	70.10 (±4.41)	57.5-78.0	64.26 (±2.85)	57.5–69.3
Weight (lbs.)	170.5 (±23.60)	125-220	137.0 (±26.26)	95-229
BMI	24.80 (±2.87)	19.8-31.9	23.95 (±4.13)	17.2-39.0
Frequency Demographics	**Category**		**Sample Size (*n* = 67)**	**Percentage**
Gender	Men		24	35.8%
	Women		43	64.2%
BMI Category	Underweight		1	1.5%
	Normal weight		40	59.7%
	Overweight		17	25.4%
	Obese		4	6.0%
	Missing data		5	7.4%

tests with post-hoc analysis as previously described were also conducted for the five adjustable desk chair features.

Findings

A total of 67 individuals participated in the survey and demographic data can be viewed in Table 1. The subjects were primarily female (64.2%) and had an average age of 21.86 (*SD* = 2.00) years. Tests of normality revealed the participants were younger than the average population ($p \leq .001$) and weighed less than the average population ($p = .001$). BMI findings revealed that the majority of the participants were of normal weight (59.7%). However, it should be noted 31.4% of the participants would be classified as overweight or obese, according to guidelines from the Center for Disease Control and Prevention (*Healthy Weight: About BMI*, 2017).

Data were collected from 20 participants in each of the classrooms where the Tuxedo-Lounge and Caper-Stacker desk chairs were used. However, on the day of data collection, only 13 participants were present in the classroom with Lab style desk chairs and 14 participants in the classroom with the Node style desk chairs.

On the survey tool, participants rated pain and/or discomfort before and after using the desk chair and in which body region(s) the pain was located. Data were entered for each participant as pain or no pain in five regions (low back, upper back, hip, neck, and shoulder) *before* using the desk chair and *after* using the desk chair. A new data column was calculated for each of the five body regions as pain increased (no pain prior to desk chair use with pain after desk chair use), pain unchanged (no change in pain), or pain improved (pain prior to desk chair use with no pain after desk chair use). The percentage of learners reporting pain and/or discomfort and no pain and/or discomfort can be viewed in Table 2. In all five body regions, most of the learners reported no pain and/or discomfort both pre (86.6% - 100 %) and post (88.1% - 95.5%) use of the desk chairs. Prior to desk chair use, the regions with the greatest percentage of participants reporting pain were the low back (13.4%) and neck (6%). After the class finished, the regions with the

Table 2. Percentage of Students Reporting Pain/No Pain by Body Region and Desk Chair Type

Body Region	Pain	Desk Chair Style									
		Tuxedo-Lounge		Caper-Stacker		Lab		Node		Total	
		Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Low Back	*No*	95% (*n*=19)	100% (*n*=20)	95% (*n*=19)	95% (*n*=19)	76.9% (*n*=10)	92.3% (*n*=12)	71.4% (*n*=10)	92.9% (*n*=13)	86.6% (*n*=58)	95.5% (*n*=64)
	Yes	5% (*n*=1)		5% (*n*=1)	5% (*n*=1)	23.1% (*n*=3)	7.7% (*n*=1)	28.6% (*n*=4)	7.1% (*n*=1)	13.4% (*n*=9)	4.5% (*n*=3)
Upper Back	*No*	95% (*n*=19)	100% (*n*=20)	100% (*n*=20)	100% (*n*=20)	92.3% (*n*=12)	84.6% (*n*=11)	92.9% (*n*=13)	57.1% (*n*=8)	95.5% (*n*=64)	88.1% (*n*=59)
	Yes	5% (*n*=1)				7.7% (*n*=1)	15.4% (*n*=2)	7.1% (*n*=1)	42.9% (*n*=6)*	4.5% (*n*=3)	11.9% (*n*=8)
Hip	*No*	100% (*n*=20)	100% (*n*=20)	100% (*n*=20)	95% (*n*=19)	100% (*n*=13)	100% (*n*=13)	100% (*n*=14)	100% (*n*=14)	100% (*n*=67)	98.5% (*n*=66)
	Yes				5% (*n*=1)						1.5% (*n*=1)
Neck	*No*	100% (*n*=20)	100% (*n*=20)	90% (*n*=18)	100% (*n*=20)	100% (*n*=13)	92.3% (*n*=12)	85.7% (*n*=12)	92.9% (*n*=13)	94% (*n*=63)	97.0% (*n*=65)
	Yes			10% (*n*=2)			7.7% (*n*=1)	14.3% (*n*=2)	7.1% (*n*=1)	6.0% (*n*=4)	3.0% (*n*=2)
Shoulder	*No*	100% (*n*=20)	100% (*n*=20)	100% (*n*=20)	100% (*n*=20)	100% (*n*=13)	100% (*n*=13)	85.7% (*n*=12)	92.9% (*n*=13)	97% (*n*=65)	98.5% (*n*=66)
	Yes							14.3% (*n*=2)	7.1% (*n*=1)	3% (*n*=2)	1.5% (*n*=1)

*Statistically significant difference p ≤ .001

greatest percentage of participants reporting pain were the upper back (11.9%) and the neck (3%). No significant relationships were found between pain/discomfort prior to and after desk chair use in the regions of the low back [X^2 (6, N=67) = 8.197, p = .224], hip [X^2 (3, N=67) = 2.386, p = .496], neck [X^2 (6, N=67) = 7.332, p = .291], and shoulder [X^2 (3, N=67) = 3.843, p = .279]. The relationship between upper back pain and/or discomfort and desk chair type was significant, X^2 (6, N=67) = 18.469, p =.005. The effect size was moderate with Cramer's V = .37. The percentage of participants who utilized the Node style desk chair reported pain which increased from 7.1% before class to 42.9% after class, a level not seen with any other style of desk chair or any other region of the body.

No statistical significance was found when learners were specifically asked "What effect does the desk chair have on your pain and/or discomfort?" X^2 (6, N=67) = 11.576, p = .072. There were also no significant differences reported by participants on their perception of "How does the desk chair affect your ability to focus on learning?" X^2 (9, N=63) = 13.482, p =.142. More participants perceived an increased ability to focus on learning when using the Tuxedo-Lounge desk chair (47.4%) compared to any of the other desk chairs (Caper-Stacker = 23.1%, Lab style = 23.1%, and Node style = 35.7%). However, data were not found to be statistically significant.

Statistically significant differences were found between the four desk chair types in overall comfort as well as the 12 individual areas of comfort (e.g., seat height), with p values which ranged from < .001 to .040 (Table 3). Ratings of each individual desk chair can be found in Table 4. Post hoc analysis revealed which specific desk chairs were significantly different in all of the comfort levels (Table 5). The Tuxedo-Lounge desk chair was rated significantly higher than all other tested desk chairs in overall comfort, stability, and padding. It also rated significantly higher than both the Caper-Stacker and Lab style desk chairs in seat width, seat length, back rest, space for legs and space for feet. Finally, comfort of the Tuxedo-Lounge desk chair was significantly rated higher than the Lab style desk chair in seat height and desk table height, and significantly higher in arm rest when compared to the Caper desk chair. For the remaining two areas of comfort, the Caper desk chair was reported to have a significantly more comfortable desk size than the Tuxedo-Lounge desk chair, and the Node style desk chair had a significantly more comfortable footrest than either the Tuxedo-Lounge or Caper desk chairs. These results ranged from medium to very large effect sizes (r = -0.42 to -0.91).

The perceived comfort of adjustable desk chairs features (swivel, adjustable height, etc.) were compared, and the swivel feature varied significantly among the four desk chairs, H(3) = 18.6, p = 0.001. The Node style desk chair had a significantly more comfortable swivel (Mdn = 5.00) than when compared to both the Tuxedo-Lounge (Mdn = 3.00, p = 0.001, r = -0.58) and the Caper-Stacker desk chairs (Mdn = 4.00, p = 0.003, r = 0.56). These results represent a medium effect size.

Discussion

The purpose of this study was to evaluate participants' perceptions of four different desk chairs on level of pain and/or discomfort, ability to focus on learning while using the desk chair, ratings of 13 aspects of desk chair comfort, and ratings of five adjustability features. The Tuxedo-Lounge desk chair was significantly perceived as the most comfortable desk chair across 11 of 13 areas of desk chair comfort, including overall comfort, despite learners attending a lecture class with no interactive elements. Although not statistically significant, the Tuxedo-Lounge desk chair was also reported to increase focus for nearly half of the participants in the study (47%). The Tuxedo-Lounge desk chair was the only padded design in this study: the rest of the desk chairs were made of hardened plastic. While plastic may be easier to clean and less costly, these results suggest padded furniture may be better suited for environments where users must sit for extended periods of time. Approximately 75% of the body's weight is supported on the ischial tuberosities, an area of approximately 4 cm^2. Therefore, purchasers of desk chairs should consider using

Table 3. Results of Kruskal Wallis ANOVA for Perceived Comfort Levels

	Overall comfort	Seat height	Seat width	Seat Length	Stability	Padding	Back rest
H	23.87	8.73	14.50	11.61	20.55	34.68	19.50
df	3	3	3	3	3	3	3
p	<.001	.003	.002	.009	<.001	<.001	<.001
	Arm rest	**Footrest**	**Space for legs**	**Space for feet**	**Table height**	**Table size**	
H	47.20	56.72	16.49	17.772	8.31	19.08	
df	3	3	3	3	3	3	
p	<.001	<.001	.001	.001	.040	<.001	

Table 4. Perceived Desk Chair Comfort (Mean VAS Ratings)

Category	Tuxedo-Lounge	Caper	Lab	Node
Overall comfort	***9.08***	6.40	6.38	6.86
Seat height from floor	***8.35***	7.28	6.50	7.71
Seat width	***9.05***	7.75	7.25	7.68
Seat length	***8.48***	6.70	6.65	8.00
Stability of chair	***9.03***	7.23	6.29	7.15
Padding	***9.33***	4.50	3.73	4.41
Backrest	***8.76***	5.45	6.58	7.18
Armrests	***8.38***	N/A	6.77	6.15
Footrest	N/A	N/A	4.15	***6.82***
Space for legs	***9.03***	7.40	6.58	7.61
Space for feet	***9.03***	7.82	5.73	7.39
Desk table height	***7.95***	7.23	6.46	6.96
Desk table size	4.23	***8.23***	6.88	5.54

*Shaded areas indicate the highest comfort rating across the four desk chair types
**1 is low comfort, 10 is high comfort

seat cushioning to absorb some of the body's weight (Parcells et al., 1999). In addition, instructors should encourage the use of padding when individuals report discomfort during prolonged periods of sitting.

Another reason the Tuxedo-Lounge desk chair may have received such significant comfort ratings is its potential to accommodate a variety of body sizes. Because the ischial tuberosities alone cannot provide full stabilization to the body, contact with other body surfaces and muscle activity in the legs, feet, and back is necessary (Parcells et al., 1999). The Tuxedo-Lounge desk chair has several options to accommodate individuals of various girths, including a wide seat depth and an adjustable table which allows the desk surface to be brought closer or further from the user. The user's arms can also be supported by armrests which run the entire span of the desk chair, another feature found only in the Tuxedo-Lounge desk chair. Participants did rate this desk chair higher in many 'sizing' categories, such as seat width, seat depth, armrests, space for legs, and space for feet. Because anthropometric sizes vary drastically among students, selecting a desk chair which can comfortably accommodate a variety of sizes, while allowing the surface of the legs, feet, and back to contact the chair, may be beneficial to groups of individuals who are sitting for extended periods of time. If a learner is in a classroom with a desk chair which does not fit well, adjustments can be made to help ensure the feet and back touch a support surface, such as placing a box under the feet and pillows behind the back.

A secondary finding from this study was the significantly increased upper back pain reported among participants who used the Node style desk chair, a change of 7.1% (pre-class) to 42.9% (after class). Previous authors reported a significant mismatch between desk chair design and learner characteristics, especially in the areas of the upper and low back. (Baharampour et al., 2013: Castellucci et al., 2010; Parcells et al., 1999; Saarni et al., 2009). The upper back, in particular, is subject to significant stress, especially if the table surface is too high or low causing the user's shoulders to be raised or the arm held out to the side in order for the forearm to meet the surface of the desk (Adu, 2015; Castellucci et al., 2015(a); Castellucci et al., 2015(b); Lee et al., 2018; Parvez et al., 2019; Tunay & Kenan, 2008). Changing shoulder and forearm postion could cause more muscle work and discomfort and/or pain in the shoulder region (Parvez et al., 2019). As mentioned, participants who used the Node style desk chair reported a significant increase in upper back pain from the beginning to end of class. Participants who used this desk chair were attending a lecture class which may have required note taking. While three of the desk chairs in this study had minimal arm support (Caper, Lab, and Node), the Node style desk chair

Table 5. Significant Findings from Post Hoc Analysis Comparing Desk Chairs

Tuxedo-Lounge vs.	**Overall Comfort**				**Stability**			
	U	z-score	2 tail sig.	r	U	z-score	2 tail sig.	r
Caper	52.00	-4.197	< .001	-0.66	69.00	-3.622	< .001	-0.57
Lab	25.00	-4.007	< .001	-0.70	24.50	-3.784	< .001	-0.60
Node	56.50	-3.008	.003	-0.52	52.50	-2.969	.003	-0.51
Tuxedo-Lounge vs.	**Padding**				**Seat Width**			
	U	z-score	2 tail sig.	r	U	z-score	2 tail sig.	r
Caper	5.50	-5.087	<.001	-0.80	89.00	-3.087	.002	-0.49
Lab	3.50	-4.495	< .001	-0.78	43.00	-3.067	.002	-0.53
Node	19.00	-3.849	< .001	-0.66				
Tuxedo-Lounge vs.	**Seat Length**				**Backrest**			
	U	z-score	2 tail sig.	r	U	z-score	2 tail sig.	r
Caper	103.50	-2.660	.008	-0.42	47.50	-4.037	<.001	-0.69
Lab	55.00	-2.813	.005	-0.49	44.50	-3.060	.002	-0.53
Tuxedo-Lounge vs.	**Space for Legs**				**Space for Feet**			
	U	z-score	2 tail sig.	r	U	z-score	2 tail sig.	r
Caper	84.00	-3.168	.001	-0.50	94.00	-2.745	.006	-0.43
Lab	34.50	-3.569	< .001	-0.62	27.50	-3.830	< .001	-0.67
Tuxedo-Lounge vs.	**Seat Height**				**Desk Table Height**			
	U	z-score	2 tail sig.	r	U	z-score	2 tail sig.	r
Lab	54.50	-2.888	.004	-0.50	59.50	-2.621	.008	-0.46
Tuxedo-Lounge vs.	**Arm Rest**							
	U	z-score	2 tail sig.	r				
Caper	.000	-5.801	< .001	-0.91				
Caper vs.	**Table Size**							
	U	z-score	2 tail sig.	r				
Tuxedo	263.50	-3.980	<.001	-0.63				
Node vs.	**Footrest**							
	U	z-score	2 tail sig.	r				
Tuxedo	94.00	-2.745	.006	-0.43				
Caper	210.00	-5.312	<.001	-0.91				

*Statistical significance with a Bonferroni adjustment at .05 / 6 = .008

r = effect size

also did not have a table or other large desk surface to support the arms. Arm support has been found to lower the risk of neck and/or shoulder symptoms and disorders (Straker et al., 2008), and appropriate desk heights have been recommended to avoid discomfort in the shoulder region (Adu, 2015). The results of this study suggest adequate arm support may be necessary to help prevent increase in upper back pain. When choosing furniture for adult learners select options with arm support if possible. When arm support is not available, considerations should be given to provide access to tables for temporary arm support.

A third finding from this study was a decline in the number of participants who reported having lower back pain at the beginning of class (13.4%) compared to the end of class (4.5%). Lower back pain is a common occurrence across the United States with an incidence rate of 1.39 per 1,000 persons (Williamson & Hoggart, 2005). The incidence of lower back pain peaks between the ages of 25-29 (Waterman et al., 2012), which is older than the mean age of participants in this study (21.86 years of age). The six participants whose lower back pain decreased used three different desk chair styles. Therefore, desk chair type did not appear to contribute to this finding. However, because the participants were younger, it could be speculated that the lower back pain came from muscle strain from sports and other activities, which responded to rest while seated. The general population may have more incidences of disc injury, stenosis, arthritis, and other conditions which accumulate as individual's age. These types of injuries may be inflamed by prolonged sitting (observed as increased stiffness / pain or radiating pain from disc compression). Previous authors reported that pain from acute muscle injury may decrease with inactivity as part of the RICE (rest, ice, compression, and elevation) treatment (Baoge et al., 2012). If participants were sore from muscle use, prolonged inactivity (such as sitting) could make the injury feel better. A second theory may be the use of proper sitting posture among the study's participants. Postural dysfunction has been correlated to a number of musculoskeletal problems including low back pain (Rudolf, 2009; Straker et al., 2008). Low back pain, can be increased by slouching in a chair or leaning forward on the arms, thereby increasing flexion of the spine (Baharampour et al., 2013; Thariq et al., 2008). Perhaps the participants in this study avoided a flexed posture due to prior knowledge about sitting upright: all participants were studying for careers in health sciences at the time of the study.

There are a number of considerations for future studies: first, research could be replicated with individuals of a wider age range and larger sample size to determine if the incidence of low back pain increases or decreases when using desk chairs, especially among populations of older adults. Second, when working with adult learners, consideration should be given to work environments where individuals sit for extended periods of time. When possible, it is recommended to change from desk chairs with molded construction to those with fabric construction, as padded seats may be more comfortable for long-term sitting. In addition, select chairs which can accommodate a wide range of body types.

Limitations to this study included a small sample size for each desk chair design, lack of diversity in learner age, lack of diversity in learner weight and height, utilization of only one university site for data collection, and not collecting data on learner comorbidities may have contributed to perceived comfort and learning.

Conclusion

Desk chair design may change learner comfort during prolonged sitting, as well as increase or decrease musculoskeletal pain. When selecting a desk chair for an adult classroom, selection of designs which accommodate the greatest variety of individuals with cushioning may be optimal, as well as ensuring arm support is available during upper extremity tasks. In addition, when designing work and learning environments for individuals who sit for prolonged periods of time pilot testing of desk chairs may be warranted prior to purchase.

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