ORIGINAL ARTICLE

THE ERGONOMICS OF SEAT DESIGN IN LECTURE HALL AT FACULTY OF MEDICINE AND HEALTH SCIENCES (FMHS), UNIVERSITI PUTRA MALAYSIA (UPM)

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ABSTRACT

This is a cross-sectional study with the objective to determine the association between self-reported musculoskeletal symptoms (MSSs) and mismatch of the seats in lecture hall of Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM). A total of 132 respondents (47 male and 85 female) whom were undergraduate students. Eight anthropometric and five furniture parameter dimensions were measured. Instruments used were questionnaire modified from Nordic Musculoskeletal Questionnaire, Martyn anthropometer set, measuring tape, height scale and weighing scale. Findings showed 51.5% mismatch of seat height, 5.3% mismatch of seat depth, 94.7% mismatch of desk height and 18.2% mismatch of upper edge of back rest. For the prevalence of MSSs in the past seven (7) days, 61.4% reported low back pain followed by neck pain (50%) and upper back pain (43.9%). There was significant difference between genders in anthropometric body measurement. Significant association were found between MSSs and mismatch. Based on the findings, it is recommended that in the event of long lecture hour, intermittent break should be allowed for students to stretch, move or better yet assume different posture such as standing or walking.

***Keywords**: mismatch, seat design, anthropometry, MSDs*

INTRODUCTION

Chair is an essential requirement in the classroom where the learning process takes place. Without proper ergonomics chair, learning process could be affected (Geldhof et al., 2007; Koskelo et al., 2007). The anthropometric data of general population is required to determine the specification of physical dimension for workplace, furniture, equipment and clothing. It is to prevent a physical mismatch between the dimensions of products and equipment and corresponding to the user dimensions (Bridger, 1995).

According to Gouvali and Boudolus (2006), most students have difficulties in finding school chairs and table that appropriate with their body dimension. As a result, there were high prevalence of back pain among high-school students which increases with age whereby the lifetime prevalence of back pain is expected to exceed 50% by 15 years of age (Burton et al., 1996; Grimmer and William, 2000; Hakala et al, 2002; Van Gent et al, 2003; Wedderkopp et al, 2001).

The study from Farahani and Shakib (2009) shows that student that spend about 84% to 88% of their time in sitting position. About 41.6% of the students experience pain while sitting at the classroom and about 69.5% experience back pain that occurred after 1 hours sitting and the pain increases with time as the student is in sitting position in the classroom. (Troussier, 1999). Improper design of furniture will result in the lack of concentration hence reduced efficiency and may cause musculoskeletal disorder (MSDs) (Asif et al., 2012).

Currently, furniture at lecture hall between and within different universities is not standardised in term of sizes and types. There has been many studies which showed that the ergonomics problems are associated with the design and function (Parcells et al, 1999; Milanese, and Grimmer, 2004; Gouvali and Boudolas, 2006). However, only a few of such studies that investigated the lecture hall furniture design in Malaysia (Mohd Asrol, 2009; Aminian and Fairuz, 2012).

The main objective of this study is to determine the association between the self-reported musculoskeletal symptoms (MSSs) and mismatch of the seats in lecture hall of Faculty of Medicine and Health Sciences (FMHS), Universiti Putra Malaysia (UPM).

METHODOLOGY

A cross-sectional study was conducted which involved 132 undergraduates students. Purposive sampling was used to sample the respondents. The respondent name list were obtained from Academic Division, FMHS, UPM. The inclusion criteria of this study were undergraduate student who had a minimum of one hour of lecture per week in the lecture hall. All six lecture halls in Faculty of Medicine and Health Sciences are identical.

Questionnaire

The questionnaire collects information on respondents' socio-demographic background, hours of lecture hall usage, previous history of MSDs and prevalence of MSSs. The questionnaire on prevalence of MSSs was modified from Nordic Musculoskeletal Questionnaire (Kuorinka et al, 1987).

Anthropometric measurement

The anthropometric measurement in this study were based on methods detailed in MS ISO 7250-1:2008 (Malaysian Standard, 2008) using a Martyn type anthropometer, height scale and weighing scale as follow:

i) Elbow sitting height (ESH). The vertical distance from the bottom of the tip of the elbow (olecranon) to the subject seated surface taken with 90º elbow degrees of flexion.

ii) Buttock-popliteal length (BPL). The horizontal distance, from the posterior surface of the buttock to the posterior surface of knee or popliteal space taken with 90º knee flexion.

iii) Popliteal height (PH). The vertical distance measured with 90º knee flexion, from the foot that is resting on the surface to the posterior surface of the knee (popliteal space).

iv) Subscapular height (SUH). Vertical distance of the scapular to the seat surface.

v) Hip width (HW). Horizontal distance between the widest points of the hip in sitting position.

vi) Shoulder height (SHS). The vertical distance from a horizontal sitting surface to the acromion.

vii) Subscapular height (SUH). Vertical distance of the scapular to the seat surface.

Measurement of Seats in Lecture Hall

The dimension of the seat in the lecture hall taken were as follow:

i) Seat height (SH). Vertical distance from the floor to the front edge of the seat surface.

ii) Seat depth (SD). The distance from front to back of the sitting surface.

iii) Seat width (SW). Vertical distance of the seal surface.

iv) Desk height (DH). The horizontal distance from upper desk surface to the seat surface.

v) Upper edge of backrest (UEB). Vertical distance between middle points of the upper edge of the backrest and the top of the seat.

Data Collection Procedure

Before field data collection, the researcher and the assistants (a male and a female) were briefed to provide standardized responses should any question arise from the respondents. After that, the researcher and assistants were trained on standardized procedures and methods for anthropometric measurement of respondents.

Each assistant were assigned to cater for the different gender respectively in order to address the cultural sensitivity based on recommendation by UPM's Ethic Committee for Research Involving Human Subjects. However, intra-tester reliability test was not carried out.

Each respondent were briefed on the details of the study and consent for participation was obtained from all respondents which was followed by administration of questionnaire.

Subsequently, the dimension of seats in the lecture hall were measured for at least 3 times to obtain the average.

Finally, the anthropometric measurement of the respondents were carried out. Respondents were instructed to sit upright on a flat surface without backrest (Figure 1) as per MS ISO 7250-1:2008 (Malaysian Standard, 2008).

Data analysis

Data collected were analysed using Statistical Package for Social Science version 21 (SPSS). The seat dimension were matched with user anthropometry. Table 1 shows the reviewed criteria for the computation of mismatch based on a systematic review by Castelucci et al. (2015).

Table 1: Computation for mismatch

Parameter	Computation for mismatch
Seat height against popliteal height	$(PH + SC)\cos 30^\circ \leq SH \leq (PH + SC)\cos 5^\circ$
Seat depth against buttock popliteal	$0.8BPL \leq SD \leq 0.95BPL$
Seat width against hip width	$HW < SW$
Desk height against Elbow Sitting Height	$(SH - (\sin 5^\circ SD)) + ESH \leq DH \leq (SH - (\sin 5^\circ SD)) + 0.8517ESH + 0.1483SH$
Upper edge of backrest against subscapular height	$SUH \geq UEB$

RESULTS

A. Background information of respondent

As tabulated in Table 2, the mean age of the 132 respondents were 21.18 ± 0.86 years old where the youngest respondent was 20 years old while the oldest was 24 years old. Most of the respondents took part in the study were female (64.4%) compared to male (35.6%). The mean height of the respondent were 160.19cm ± 7.46cm where the minimum height was 147.00cm while the maximum height was 177.00cm.

In terms of weight, the mean was 56.01kg ± 9.04kg with minimum of 35 kg while the maximum was 80kg. Majority of the respondent have normal (77.3%) category of BMI while the rest were underweight (10.6%), overweight (10.6%) and obese (1.5%).

Table 2: Socio-demographic background

Variable(s)	Mean ± SD	Freq. (%)
Age	21.18 ± 0.86	
Height	160.19 ± 7.46	
Weight	56.01 ± 9.04	
Gender		
Male		47 (35.6)
Female		85 (64.4)
BMI		
Underweight		14 (10.6)
Normal		102 (77.3)
Overweight		14 (10.6)
Obese		2 (1.5)

N = 132

B. Anthropometric measurements of the respondents and differences between male and female

Table 3 shows the anthropometric measurements between male and female. There were significant differences in anthropometric data between male and female ($p < 0.05$) for all the anthropometric measurement. The difference was highest for popliteal height ($t = 8.905$, $p < 0.05$).

C. Seven (7) days prevalence of MSSs among lecture hall users in FMHS.

Based on Table 4, the total prevalence of MSSs is 51.77% where the highest prevalence of MSSs was lower back (LB) (61.4 %), followed by neck (50.0%) and upper back (UB) (43.9%). Based on gender, male have higher prevalence of LB as compared to female. On the contrary, the female had higher prevalence of UB and neck pain as compared to male.

D. Mismatch between furniture at the lecture hall with sitting anthropometric measurement

From the results (Table 5), there were 94.7% mismatch of the desk height with the overall respondents' anthropometry. This was followed by upper edge of back rest (51.5%) seat depth (15.2%) and upper edge of backrest (5.3%).

Table 3: Anthropometric data based on gender

Variable(s)	Mean ± SD		t-value
	Male (N = 47)	Female (N = 85)	
Shoulder Height Sitting	59.29 ± 3.83	54.72 ± 2.05	7.605**
Subscapular Height	42.85 ± 2.97	38.85 ± 2.62	8.025**
Elbow height	24.03 ± 1.72	21.94 ± 2.31	5.422**
Popliteal height	44.97 ± 2.25	41.45 ± 2.00	8.950**
Buttock Popliteal height	46.09 ± 3.88	44.68 ± 2.93	2.342*

df = 130
* significant at $p < 0.05$
** significant at $p < 0.01$

Table 4: Seven days' prevalence of MSSs among lecture halls user in FMHS, UPM

Variable(s)	Frequency (7 days prevalence) (%)	Male (%)	Female (%)	Total MSD
Low back	81(61.4)	64.1	35.9	
Upper back	58(43.9)	41.4	58.6	51.77
Neck	66(50.0)	40.9	59.1	

N = 132

Table 5: Mismatch between sitting anthropometric measurement with furniture at the lecture halls

Variables(s)	Frequency of Mismatch (%)		
	Overall	Male	Female
Seat height against popliteal height	68 (51.5)	6 (8.8)	62 (91.2)
Seat depth against buttock popliteal	7 (5.3)	3 (42.8)	4 (57.2)
Seat width against hip width	0 (0)	0 (0)	0 (0)
Desk height against Elbow Height Sitting and Shoulder height	125 (94.7)	43 (34.4)	82 (65.6)
Upper edge of backrest against subscapular height	24 (18.2)	3 (8.3)	22 (91.7)

N = 132

Table 6: The association between seven (7) days prevalence of MSSs and anthropometry mismatch

Prevalence of MSDs	Match	Mismatch	χ^2	*p* value
Yes	25	14	5.406[a]	0.02
No	39	54		

Phi (φ) = 0.02 (small to medium strength according to Cohen's Rule of Thumb)

Table 7: Factors Associated with MSSs

Variables		Crude OR (95% CI)[a]	Wald Statistics (df)	*p*-value
Age		0.867 (0.56,1.34)	0.415 (1)	0.519
Gender	Male	0.174 (0.77,0.39)	17.94 (1)	0.0001**
	Female	1		
BMI	Underweight	1		
	Normal	2.5 (0.24, 50.55)	0.86 (1)	0.550
	Overweight	2.29(0.14, 37.81)	0.34 (1)	0.562
	Obese	3.67 (0.17,77.55)	1.56 (1)	0.404
Hours of lecture		1.8 (0.66, 0.98)	4.51 (1)	0.034*
History of MSDs	Yes	1		
	No	0.47 (0.19, 1.19)	2.528 (1)	0.112

[a] Simple logistic regression
* significant at $p < 0.05$
** significant at $p < 0.01$

The seat width were on the other hand match with all the respondents' anthropometry. Comparing between gender, the mismatch showed that female experienced higher prevalence of mismatch as compared to male.

E. Association between seven (7) days prevalence of MSSs with mismatch of seat-anthropometry

Based on Table 6, the result reported that, there is significant association between the total prevalence of MSSs with mismatch, 2= 5.406, ($p < 0.05$) but were small in terms of effect size. In further analysis (Table 7), only two (2) variables were significantly associated with MSDs; gender and hours of lecture.

Specifically, the male was slightly less likely of reporting MSSs as compared to female (OR = 0.174; CI = 0.77,0.39) and every additional hours of lecture increases the odds by almost twice of MSDs being reported (OR = 1.8).

DISCUSSION

The study found that there are significant differences in anthropometric data between genders among the university's student corresponding to study by Karmegam et al. (2011), Mirmohammadi et al. (2011) and Dawal et al. (2012) where the male had larger anthropometry body dimension as compared to their female counterpart.

The higher frequency of MSSs being reported in this study by the female could be attributable to physical and physiological characteristic between male and female (Azuan et al., 2010). Generally, male tends to have higher muscle strength as compared to female particularly in upper limb (Katzmaryk et al., 1998). Besides that, Cardon et al. (2004) also described that the female has heightened body awareness and lower pain threshold which is why female tend to complaint more than male.

In terms of mismatch, various studies has shown that there were significant mismatch between user anthropometric body dimension and their seat (furniture). Specifically, the study from Aminian and Romli (2012) has also indicate mismatch between seat height against popliteal height. In addition, mismatch between seat depth against buttock-popliteal length, similarly findings were also shown in various other studies (Ismaila, Musa, & Adejuyigbe, 2013; Amanian & Fairuz, 2013; Asif et al., 2012). Besides that, mismatch of desk height and elbow sitting height were also corresponding with the previous studies (Baharampour et al., (2013), Asif et al., (2012), Qutubudduin et al., (2013), Ismaila et al., (2013) and Aminian and Romli (2012).

Milanese and Grimmer (2004) describes that the mismatch between seat height and popliteal height can potentially cause the user unable to rest their feet on the floor entirely resulting in compression of vascular and neural structures going along popliteal space. Besides that, Chaffin et al. (2006) also cautioned the mismatch may prevent the thighs from supporting the weight of the lower leg.

On a different anatomical body part, Grimes and Legg (2004) elaborated that mismatch between elbow height and desk height were related with neck and shoulder pain while mismatch between thigh lengths against seat depth is significantly related to the general sitting discomfort.

In combination with mismatch, prolonged sitting has been identified as the ergonomics risk factors for MSDs (Lis et al. 2007). Prolonged sitting could potentially increase the spinal compression load (Callaghan & McGill, 2001) and the activity of paraspinal muscles (Harrison et al., 1999). Besides that, prolonged sitting which puts the leg muscles to be in static inactive position cause reduced blood flow of the legs (Winkel and Jorgensen, 1986; Thosar et al., 2015). This explains the increase of odds of MSSs' complaint by almost double corresponding to increasing hours of lecture attended by students which was similarly found in a study by Nordin et al., (2014) and Nyland and Grimmer (2003).

No significant association was shown between BMI and MSDs which was similarly found in previous studies (Nordin et al, 2014; Chung et al, 2005; Grimmer & Williams, 2000; Levangie, 1999) including a prominent systematic review from Leboeuf-Yde (2000) which concluded weak association between BMI and MSDs. It is believed that, the rapid changes of weight within a short period of time may not have an effect on the low back of younger adult (Grimmer & Williams, 2000) and concluded that the BMI does not affect MSDs. The majority of respondents in this study were within normal BMI range.

CONCLUSION

Based to the data obtained, it can be concluded that the furniture at the lecture halls does not fit the students based on their anthropometric body measurement. The results shows that the recommended anthropometry body dimension measurement for the seat design should have been as follow: a) Seat height = 38.0 cm b) Seat depth = 38.0 cm c) Seat width = 48.0 cm d) Desk height = 83.0 cm.

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