Original Article

Correlation between Learning Comfort and the Risk of Musculoskeletal Disorder in Anatomy Laboratorium Activity based on RULA Method

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Abstract

Objective: To describe learning comfort in the anatomy class of the Faculty of Medicine, Universitas Padjadjaran as one of the learning facilities, to assess the risk of musculoskeletal disorders in students, and to observe correlation between learning comfort and the risk of musculoskeletal disorders in students.

Methods: A cross sectional research design conducted to the participants that were students from batch 2017 (second year), faculty of Medicine, Universitas Padjadjaran as the population sample. Data were taken using a Likert scale questionnaire (very uncomfortable–very comfortable) about the comfort aspects in the class, meanwhile the risk of musculoskeletal disorders were assessed by using Rapid Upper Limb Assessment (RULA). After data collection, there were 106 respondents with complete data, then the data were processed by using descriptive statistical analyses. The correlation between the two variables was analyzed using the Gamma correlation test.

Results: Majority of the students were very comfortable with the aspects of learning comfort (majority scale 5), except in aspects of furniture, work area, room aroma, personal storage area, maintenance and repair. A moderate risk level of musculoskeletal disorders (58.5%) was found in the majority of the students. There was a relative significant relationship between learning comfort and the risk of musculoskeletal disorders in the aspect of colors ($\gamma=0.445$, $p<0.01$).

Conclusions: There is a significant relationship between learning comfort in the aspect of colors and the risk of musculoskeletal disorders. Other aspects do not indicate a significant relationship.

Received:
February 7, 2019

Revised:
March 5, 2019

Accepted:
March 21, 2019

Keywords: Learning comfort, risk of musculoskeletal disorders, RULA

pISSN: 2302-1381; eISSN: 2338-4506; http://doi.org/10.15850/ijihs.v7n1.1566
IJIHS. 2019;7(1):16–25

Introduction

Comfort is one of many aspects required in each type of work, non-exceptional to learning. The individual comfort is determined by perception and several aspects of the surrounding environment, namely lighting, temperature, noise, and others. Errors in one aspect of comfort can affect one's perception which is defined as a feeling of "discomfort". If this condition is maintained for a long duration, there will be some changes that are perceived by the individual, whether it is pain or aches. A study stated that discomfort is associated with musculoskeletal disorders.[1]

Musculoskeletal disorders is defined as an abnormality which is frequently caused by a request of activity that exceeds the capacity or limits of the musculoskeletal component.[1] The musculoskeletal component consists of bones, muscles, and joints that interact with each other to produce movement, including

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isometric contractions that form the posture of the human body.[2] A person's posture can be determined by several indicators such as anthropometry, type of work, and the surrounding work area.[3] A study conducted in a school discovered that furniture, seating distance, and vision can affect body posture when sitting.[4] Errors in one of these aspects can cause abnormal posture.[3]

The abnormal body postures maintained for prolonged duration will cause chronic musculoskeletal disorders such as carpal tunnel syndrome, tendinitis, and bursitis.[3] These abnormalities require a long recovery period, even causing permanent disability that may reduce life's potential productivity.[4,5] Therefore, prevention of risk of musculoskeletal disorders is very important to be done in order to reduce the rate of permanent disability.[6] Prevention of musculoskeletal risk can be intervened through approachment of aspect that affects work posture. Screening the risk of musculoskeletal disorders, work environment improvements, and assessing work posture.[3]

The rapid upper limb assessment (RULA) is one of several methods to assess work posture. The results obtained are final scores with recommendations according to the score category; whether the posture is worth maintaining, needs for a change, or changed as soon as possible. The RULA has been widely used by researchers to assess work postures for factory employees, computer users, and other risky jobs that are capable of causing musculoskeletal disorders in the future.[7]

Aspects that affect an individual's posture intersect with several aspects that determine the comfort of an individual. Anatomy class as one of the student learning facilities includes various kinds of activities, such as cadaveric observation, lecture and discussion, and the use of teaching aids. Every job or activity requires different postures, and can pose a risk of musculoskeletal disorders, if done in poor posture and maintained for a long duration.[4]

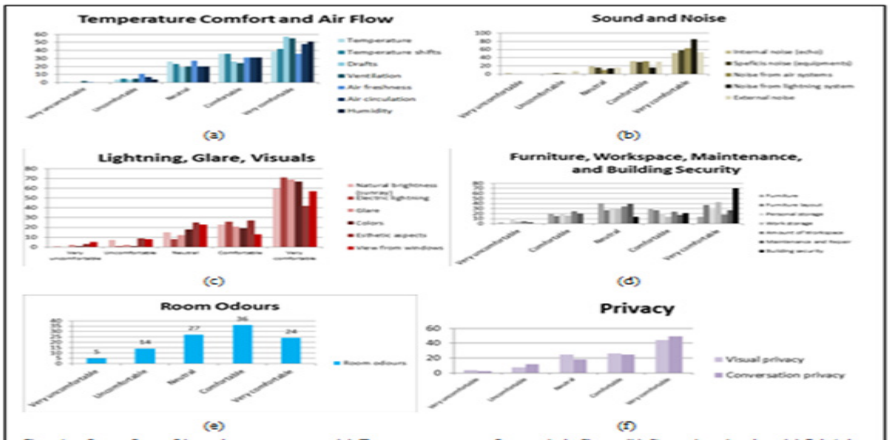
Methods

This study was conducted by using analytical methods with cross-sectional approach. The subjects in this study were students of batch 2017 of the Faculty of Medicine, Universitas Padjadjaran, Jatinangor West Java, Indonesia. The sample size was obtained by using a large proportion estimation formula, with a minimum sample of 97 people. The sample size used for proportions was the same as correlative, because the minimum sample used for correlative research was 60 people, so the largest minimum sample was taken. The inclusion criteria for this study were students who took part in the anatomy laboratory activities in building C.4.1.2 Faculty of Medicine, Universitas Padjadjaran. Exclusion criteria were students who experienced musculoskeletal disorders due to other reasons (for example infection) and incomplete data. The variables in this study were student characteristics (gender, age, and body mass index), a description of comfort in the laboratory aspects, and the risk level of musculoskeletal disorders.Characteristic data in the form of body mass index (BMI) were obtained by filling out questionnaires in the form of height and weight, then measured using the BMI formula. The results by using the formula would be categorized into four groups based on the Asian World Health Organization (WHO) criteria: underweight (<18.5), normal (18.5–22.9), overweight (23–24.9), and obese (≥25). [8]

Comfort features in laboratory aspects were measured by using a comfort questionnaire consisting of twenty-eight aspects of comfort divided into eight major aspects such as temperature, aroma, noise, furniture comfort, lighting, work area, color, and building safety. Every aspect of comfort were measured by Likert scale, ranging from scale 1 (very uncomfortable) to 5 (very comfortable). This questionnaire has been tested for validity (significance level <0.05; rxy> 0.195, n=106) and reliability (Cronbach's alpha=0.928). The results obtained are the score obtained from each aspect, then classified into five categories: (1) very uncomfortable, (2) uncomfortable, (3) neutral, (4) comfortable, and (5) very comfortable. This questionnaire was also equipped with a critic column for each number.

The risk of musculoskeletal disorders was measured using RULA. Assessment of work posture was done by observing the students during the class activity. The RULA sheet was divided into three large tables: table A (assessing the posture of the forearm, forearm, and wrist), table B (assessing the neck, trunk, and legs), and the Grand Score table (final score based on the score of table A and table B). Risk scores are assessed based on the figures provided in each table, then added to the score of muscle use and burden. The final score on the Grand Score table will be categorized into four categories: low risk (1–2), moderate (3–4), high (5–6), and very high (≥7).

Data on respondents' characteristics in the



Graph of comfort of learning on aspects: (a) Temperature comfort and air flow. (b) Sound and noise. (c) Lighting glare, visual. (d) Furniture, work area, mainterance and security. (e) Room odours. (f) Privacy.

Fig. 1 Learning Comfort Aspect Graphics

form of gender, age, and BMI were analyzed using descriptive statistics, presented in the form of numbers and percentages. Data in the form of age were presented in the mean and standard deviation. The correlation between comfort variables and the risk of musculoskeletal disorders were analyzed using the Gamma correlation test.

Results

Data collection was carried out on the afternoon of class schedule (01.00 PM–03.30 PM) in three different days: day 1 was on Monday, August 27, 2018 there were 54 students who met the inclusion criteria. After data collection and checking, there were 36 incomplete data, so that there were 18 complete data for analysis; day 2 was onn Wednesday, August 29, 2018 there were 49 students who met the inclusion criteria. After data collection and checking, there was 1 incomplete data so that there were 48 complete data for analysis; day 3 was onn Friday, August 31, 2018 there were 41 students who met the inclusion criteria. After data collection and checking, there was 1 incomplete data so that there were 40 complete data for analysis. There were 144 students who met the inclusion criteria. After taking and checking the data, there were 38 incomplete data. Moreover, there were a total of 106 complete data for data analysis.

Number of female participants in this study were larger (67.92%) compared to men (32.07%), with an average age of 18.9 and standard deviation of 0.74. Most participants had a normal distribution in BMI (69.81%).

In this study, majority of students perceived very comfortable in aspects of temperature and air flow comfort (Fig. 1a), shown by the majority scale of 5 (very comfortable) at room temperature aspects (36.8%), temperature shifts (39.6%), drafts (53.8%), ventilation (51.9%), air freshness (34%), air circulation (45.3%), and humidity (48.1 %).

Majority of the respondents perceived very comfortable with all aspects of sound and noise (Fig. 1b), internal noise (48.1%), spesific noise (54.7%), noise from the air system (59.4%), and external noise (50%). The highest aspects of comfort were found in noise from lightning systems (80.2%).

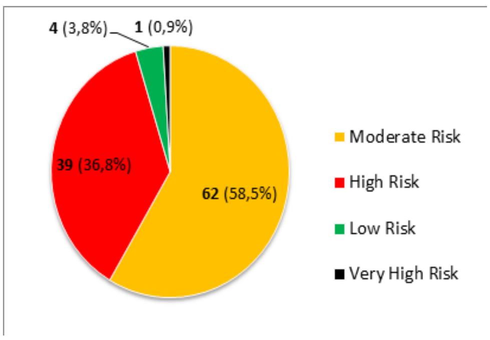


Fig. 2 Distribution of the Risk Degree of Musculoskeletal Disorders in Students

Table 1 Characteristics of Respondents

Characteristics	n=106	Percentage (%)
Gender		
Male	34	32,07
Female	72	67,92
Age (mean, SD)	18.9;0.74	
17	2	0,018
18	26	24,52
19	56	52,83
20	21	19,81
21	1	0,009
BMI (kg/m^2)		
Underweight	17	16,03%
Normal	61	57,54%
Overweight	13	12,26%
Obese	15	14,15%

Note: BMI=Body mass index, SD=Standard deviation

The respondents showed comfortness in the aspect of lighting, glare and visuals (Fig. 1c). In this study, the respondents felt very comfortable with all these aspects: natural brightness (56.6%), electric lighting (67%), glare (65.1%), colors (63.2%), esthetic aspects (39,6%), and views from windows (57%). As with the privacy aspect, respondents felt very comfortable with aspects of visual privacy (41.5%) and conversation privacy (46.2%) (Fig. 1f).

Furniture, work area, and maintenance aspects showed that respondents felt neutral (scale 3) on furniture (38.7%), personal storage (27.4%), amount of workspace (32.1 %), as well as maintenance and repairs (36.8%) (Fig. 1d). In another aspect, the respondents perceived very comfortable with the work storage (40.6%), furniture layout (34.9%), and building security (67%). The room odours aspect, majority of respondents showed comfortable (scale 4) with the room odours (34%) (Fig. 1e).

The majority of students perceived very comfortable with almost all aspects of the room (indicated by a majority scale of 5). There was a downgrade in comfort aspects of furniture, work area, maintenance and safety, and room odours. The highest aspect of comfort was found in the aspect of noise from the lighting (80.2%). The lowest aspect of comfort was personal storage areas (27.4%). Data in the form of reason columns were not presented due to variation of answers, and many participants did not fill the critics column.

The majority of students had moderate risk degrees (58.5%). The rest were at high risk level (36.8%), followed by low risk (3.8%) and very high risk (0.9%), respectively.

Characteristic of gender did not show a significant relationship with the risk of musculoskeletal disorders (Kruskall-Wallis test, $p>0.001$). The characteristics of age were not related to the risk level of musculoskeletal disorders ($r = 0.066$). Body mass index have a weak, non-significant relationship with the risk of musculoskeletal disorders, with a γ value of 0.147.

There was a relative strong significant relationship between aspects of colors and the risk of musculoskeletal disorders (γ=0.445, $p<0.01$). Other aspects showed no significant relationship with the risk of musculoskeletal disorder. However, a weak relationship was found in some aspects: drafts (γ =0.151); ventilation (γ=0.120); air freshness (γ=-0.103); room odours (γ =-0.107); humidity (γ=-0,100); external noise (γ=-0,116); work storage (γ=0.145); amount of workspace (γ=0.159); furniture layout (γ=0.131); conversation privacy (γ=0.139); esthetic aspect (γ=0.175), with the risk of musculoskeletal disorder. Aspect in noise from lightning system (γ=0.225); natural brightness (γ=0,250), electric lighting (γ=0,264); maintenance and repair (γ=0.038) and building security (γ=0.037) shows moderate non-significant relationship (Table2).

Discussion

Learning comfort is influenced by perceptions and the surrounding environment, therefore definition of comfort is different by person. Most of the students felt very comfortable with the condition of the surrounding area that supports their learning indicated by scale 5 in the comfort questionnaire. On the other hand, others felt some aspects were not optimal in their learning environment (1–4 scale). "Neutral" comfort status (scale 3) showed that there was a vague perception of "comfortable" feeling, so it tends to be categorized as uncomfortable. Comfort aspects that are considered less optimal are the room odours, furniture, personal storage, the amount of work space, maintenance and repair.

Thermal comfort is determined by several factors: temperature, air velocity, humidity, solar radiation, type of activity, and type of clothing.[9] In this study, thermal comfort in the laboratory was considered "very comfortable". Two air conditioners were provided on the left side of the room (Fig. 3d). There is a slight difference between "comfortable" and "very comfortable" perceptions due to uneven temperature distribution, that is more dominant on the left side of the room. As a result, some students felt that the room temperature was too cold, and some even thought it was hot. Factors as laboratory coat materials or air conditioners that cannot adjust the temperature to the conditions of the surrounding air temperature may contribute to the thermal comfort as well.

Therefore, thermal comfort in this room depends only on air conditioning, namely air flow, air freshness, air circulation, and air humidity. It is a room without the presence of ventilation with only one entrance to the laboratory room. Windows cannot be opened, yet some of them found damaged. Changes in room temperature are considered "very comfortable" because the air conditioner is turned on throughout the learning activities, and remote control is available to regulate the temperature of the air conditioner. Predicted Mean Vote (PMV) is one method to objectively assess thermal comfort by measuring quantitative aspects. The advantage of this method is that it can directly determine the factors that affect thermal comfort and do immediate intervention. However, this research is limited by qualitative measurement.[9]

Room odours aspect in the anatomy class was considered as "comfortable". The participants who filled out the critics column state that the decrease in the comfort aspect was caused by the smell of formalin from the cadaveric room, next to anatomy classroom. The cadaveric room and clasroom are separated, but the mull post is not covered by a door panel. Therefore, formalin odours infiltrate the classroom (Fig. 3b). Some of the participants were comfortable with the scent, and some didn't smelt the formalin at all. The distance from the source of odor, the amount of formalin inhaled, and the amount of inhalation in one breath are other factors, but these variables are not measured.[10]

Aspect of sounds and noise in this clasroom are "very comfortable". None of echoes (internal noise) were heard, noises from the air and lightning systems were low, and the sound coming from outside the room is barely heard. Few of the students felt uncomfortable with internal noise due to chatting during class, because they could not hear what the lecturer said. This is anticipated by the availability of a microphone with speakers placed in the front center of the room. However, lecturers rarely use this media due to the frequent microphone feedbacks, making them "uncomfortable". The majority of students feel "very comfortable" and assume because it is still in reasonable condition. Some important factors such as the distance of the loudspeaker, the distance of the listener, the angle between the listener to the wall and the size of the outdoors were not measured.[11]

The lighting system in the anatomy class depends on the 17 lamps in the room. As a class, the lightning power needs to range from 200–800 lux, estimated by measuring room size, light flux, armature efficiency, and room utilization factors.[12] Based on a previous study, light intensity is influenced by the color and size of the walls of the room. The color in this classroom is dominant with light colors; lilac on the front side and pale green on the other side, resulting considerable reflected light.[13] Intensity of light is enough and didn't cause glare. The view from outside the window was limited by the opaque window glass on the lower half of the window, but students still feel "very comfortable" with this. Natural brightness in the form of sunlight can still enter the room through the reflection of light from the canopy outside the laboratory room, therefore glare does not arise directly. Despite natural brightness, the room was dark without the presence of electric lightning (Fig. 3h).

The furniture used by students in the anatomy class was folded chair with fixed tables. A table that could not be shifted causes an "obstacle" for students to move or change their sitting position. This raises the perception of a narrow work area, resulting uncomfortable feeling, illustrated by the majority of the score "neutral". Personal storage in the form of lockers and others were not provided. Students tend to put their bags and personal belongings on the back of the chair or the floor. A lack in maintenance and repair of furniture in the anatomy class was a chair that loses its seat cushion, a chair does not stand upright, or a tilted table was shown, by not repairing or replacing the defects with a new one (Fig. 3e, f).

The thin comfort response between "neutral" and "comfortable" is found in the privacy aspects of the room. The layout of the furniture (seats) were too close making the area less private, both in visual and auditory (Fig. 3e). Many of the students felt

Fig. 3 Anatomy Laboratory Room, Front View (a), Lecturer's Point of View (b), Right Back View (c), Left Back View (d), Facility: Chair and Space between Chairs (e), Position of Student's Table (f), Lecturer's Area (g), Condition of the Room without Lightning Systems (h)

that this was reasonable because of the many discussion activities in the anatomy class. Building security was still considered "very comfortable" by the majority of students, although in reality it was difficult to assess the robustness of the building, given that the anatomy laboratory was established since 1957. Improvements may have been made to maintain building security, but the details were not explained.

Comfort aspects such as furniture, work area, room aroma, personal storage area, and maintenance and repairs show that they were still not optimal. This comfort status affects the modification of the work area, because it was not possible to create a perfect work area for each individual personally for a small fee. To create a good work area, objective measurement in every aspect of comfort is recommendable.[3] This study was only limited to subjective measurements, so further research on these aspects is needed, hopefully that the comfort level of learning can achieve maximum results.

A decrease in the level of comfort aspects will signal the central nervous system. The central nervous system will conduct the signal as a disruption in body homeostasis, so that the body will send effects such as pain or aches. Attitude changes will be made to overcome this.[14] Changes in sitting posture that was originally done on the college chair, turned

Table 2 Correlation between Learning Comfort Aspect with the Risk of Musculoskeletal Disorder

Comfort aspect (1-5)	γ*	p	Interpretation
Temperature comfort	0.036	0.805	Negligible
Temperature shift	0.051	0.737	Negligible
Drafts	0.151*	0.321	Weak
Ventilation	0.120*	0.427	Weak
Air freshness	-0.103*	0.457	Weak
Air circulation	0.025	0.868	Negligible
Room odours	-0.107*	0.469	Weak
Humidity	-0.100*	0.533	Weak
Internal noise (echoes)	-0.055	0.736	Negligible
Specific noise (equipments)	-0.037	0.821	Negligible
Noise by cooling devices	0.000	1.000	Negligible
External noise	-0.116*	0.463	Weak
Noise from lightning system	0.225*	0.319	Moderate
Furniture	-0.054	0.712	Negligible
Work storage	0.145*	0.286	Weak
Personal storage	0.091	0.482	Negligible
Amount of workspace	0.159*	0.264	Weak
Furniture layout	0.131*	0.365	Weak
Visual privacy	-0.017	0.907	Negligible
Conversational privacy	0.139*	0.341	Weak
Natural brightness	0.250*	0.192	Moderate
Electric lightning	0.264*	0.155	Moderate
Glare	0.050	0.790	Negligible
Colors	0.445*	0.008**	Relatively strong
Esthetic aspect	0.175*	0.202	Weak
View from windows	-0.006	0.968	Negligible
Maintenance and repair	0.280*	0.038	Moderate
Building security	0.347*	0.057	Moderate

Note: *Gamma's correlation test (γ<0.01)

into sitting with a cross-legged position on the floor to expand working area.

This change in attitude causes sitting posture to be more bent because the back was not supported (Fig. 4a). Normally, the lumbar curve is in a neutral position (0^o), with the cervical and lumbar regions are convex shaped anteriorly and concave posteriorly (lordosis), while the thoracic and sacrococygeal regions are kyphotic shaped. Based on the data obtained, almost all students have a trunkal position of 20–60^o with a degree of risk of +3 when scored using RULA (Fig. 4b). A bending position (columnar vertebral flexion) causes reduced lordosis in the cervical and lumbar regions, also the thoracic region will become more kyphotic. The form of an abnormal curvature will change the relationship

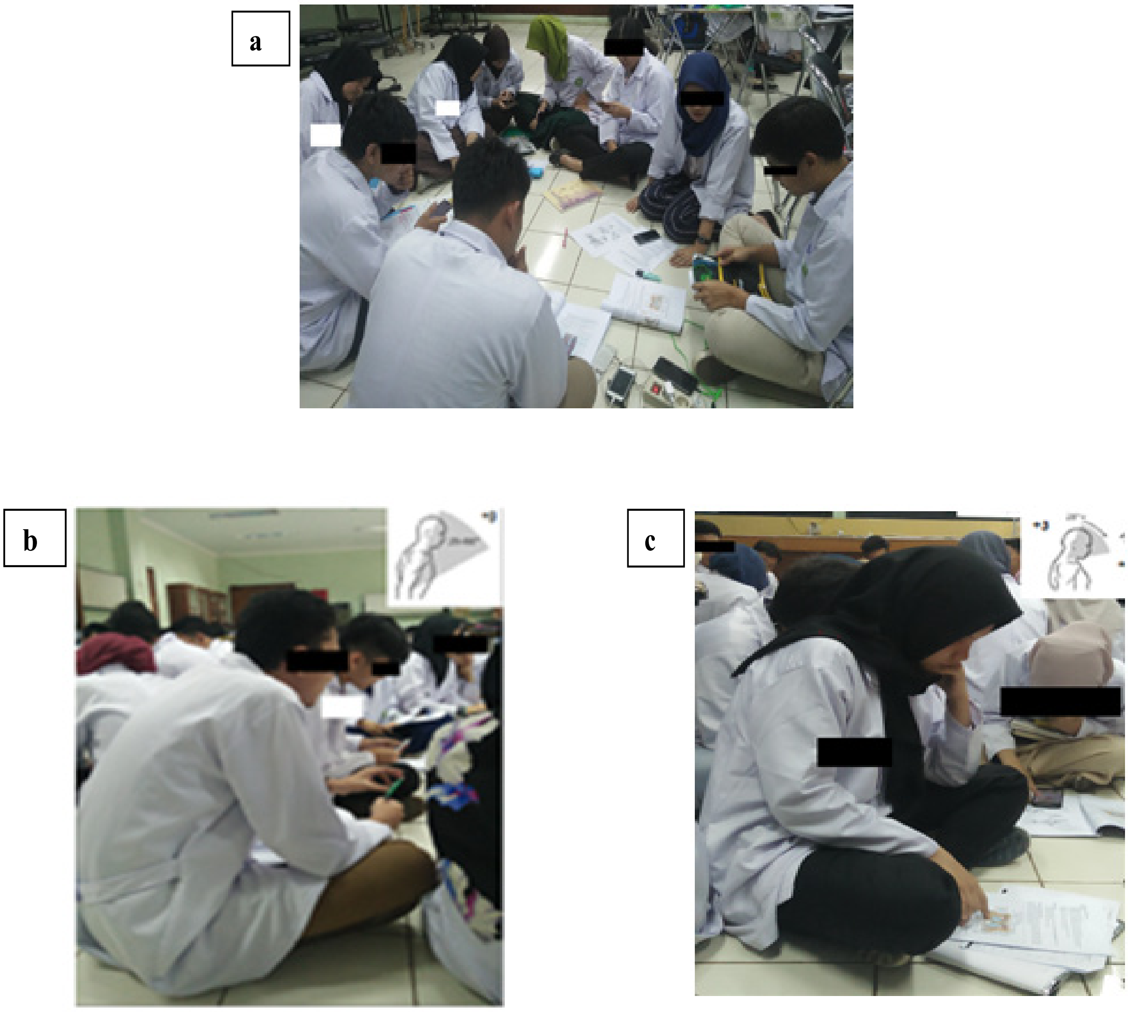


Fig. 4 Sitting Posture of the Students (a), Sitting posture and Risk Score of Musculoskeletal Disorder (b, c)

between the gravitational line and each region of the spine, which can increase stress in the muscles, ligaments, bones, joints, and spinal nerves.[15]

The neutral position of the cranio-cervical (neck) region posture is a slight extension (30–35 degrees). Range of Movement (ROM) of neck flexion and extension involve several joints and muscles, namely: atlanto-occipital, anlanto axial, and intracervical articulation (C2–C7), sternocleidomastoid, longus colli and longus capitis. The writing posture on the low surface causes neck flexion that exceeds the neutral angle, so that the anterior longitudinal ligament relaxes, and the distance between the lamina widens.[15] Most students positioned their neck in a flexed position, more than 10 degrees (+2 and +3 risk degrees). Although the risk obtained is at a moderate level, but the correlation with the work storage and the amount of workspace is still weak, and has not shown a significant correlation.

Overall, no significant relationship was discovered between the learning comfort and the risk of musculoskeletal disorders.[16] Although there are several aspects that show a weak to moderate correlation, the number of significance has not been achieved. Aspects of changes in drafts, ventilation, air freshness, humidity, external noise, esthetic aspects, and conversation privacy indicate a "very comfortable" comfort level, but almost of the entire population have a moderate level of musculoskeletal risk. In addition, aspects in the form of work storage, work space, furniture layout, and room odours with a "neutral" or "comfortable" comfort level also have a weak but not significant correlation to the risk of musculoskeletal disorders. The results obtained are in contrast to studies conducted by Chiasson, that those who reported musculoskeletal pain, assessed their work area more negatively.[17] One of the comfort aspect that has a relative strong significant relationship is colors (Table 2), but there are no studies that can support this findings yet.

Anthropometry by measurements of body dimensions and body mass index is an aspect that is needed to form an ergonomical work area. Height measurements namely sitting height, popliteal height, and knee height affect the approximate design of chair height. Knee-knee length, distance between thigh and table, and body mass determine the area of the chair with the table. As a result of diverse human anthropometry, the determination of furniture dimensions is based on the population's percentile. If the user had anthropometry measurements outside the average percentile, the position will change.[3] Abnormal positions may increase the risk of musculoskeletal disorders, as well as the appearance of pain.

The results obtained did not show a significant association between BMI with musculoskeletal risk. This occurred because the BMI is only measured using height and weight data, while to assess ergonomic risk data is needed in the form of body dimensions as described previously. The findings were contrary to a previous study which stated that BMI has a relationship with the risk of musculoskeletal disorders. The modifications to class furniture, especially dimensional measurements in the form of seat height; seat depth and height; backrest; corner of the back with a chair; table height, width and depth can increase learning comfort and reduce the risk of musculoskeletal disorders.[18]

In this study, age and sex also showed no significant difference with the risk of musculoskeletal disorders. Theoritically, age affects the amount of risk, because age shows the duration of work. In accordance with the previous statement, that musculoskeletal risk will occur if a bad posture is maintained for a long duration. This study states the opposite, similar to the research conducted by Collins.[19] In the study, the range of ages between 18–51 years did not show a significant difference. The narrow age range into a factor is the reason why the results obtained are not significant. Men and women have biological features that are different in shape, size, and musculoskeletal components so the expected results are a large amount of musculoskeletal risk.[19] However, in this study there were no significant differences between the gender with the risk of musculoskeletal disorders, in contrast to the statements of several studies that showed that women had a greater risk than men due to hormonal effects and psychosocial symptoms such as stress.[19,20]

In conclusion, the study shows that learning comfort relate to the risk of musculoskeletal disorders even though not all parameters have been proven but still hiding a potential risk in occurring the musculoskeletal disorders in students.

References

1. Bazley C, Nugent R. Patterns of discomfort. J Ergonom. 2015;5(1):1–7.
2. Wilson A, Lichtwark G. The anatomical arrangement of muscle and tendon enhances limb versatility and locomotor performance. Philos Trans R Soc Lond B Biol Sci. 2011;366(1570):1540–53.
3. Helander M. A guide to human factors and ergonomics. 2th ed. London: Taylor & Francis; 2006.
4. Pîrvu C, Pătraşcu I, Pîrvu D, Ionescu C. The dentist's operating posture – ergonomic aspects. J Med Life. 2014;7(2):177–82.
5. Shaik AR, Rao SBH, Husain A, D'sa J. Work-related musculoskeletal disorders among dental surgeons: a pilot study.Contemp Clin Dent. 2011;2(4):308–12.
6. Shiri R, Heliövaara M, Ahola K, Kaila-Kangas L, Haukka E, Kausto J, *et al*. A screening tool for the risk of disability retirement due to musculoskeletal disorders. Scand J Work Environ Heal. 2018;44(1):37–46.
7. Jain R, Meena ML, Dangayach GS, Bhardwaj AK. Risk factors for musculoskeletal disorders in manual harvesting farmers of Rajasthan. Ind Health. 2018;56(3):241–8.
8. Flegal KM, Kit BK, Graubard BI. Body mass index categories in observational studies of weight and risk of death. Am J Epidemiol. 2014;180(3):288–96.

9. Carera A, Prianto E. Karakter Kenyamanan Thermal pada bangunan Ibadah di Kawasan kota Lama, Semarang. Proceedings of the Seminar Nasional Sains dan Teknologi; 2016 August 3; Semarang. Indonesia: Universitas Wahid Hasyim; 2016.
10. Enrique Cometto-Muñiz J, Abraham MH. Dose-response functions for the olfactory, nasal trigeminal, and ocular trigeminal detectability of airborne chemicals by humans. Chem Senses. 2016;41(1):3–14.
11. Gunawan H, Aditanoyo T. Study of the Effect of Splaying Wall to Modify Acoustic Modes Distribution in Small Room. J Phys [serial on the internet]. 2018 April [cited 2018 Aug 20];2018(6):[about 6p.]. Available from: https://iopscience.iop.org/article/10.088/1742-6596/1075/1/012049/meta.
12. Lusijarto TT, Subekti RA, Susanti V. Economic analysis and energy consumption approaches for lighting improvement of government building facilities. Proceeding of International Conference on Sustainable Energy Engineering and Application; October 23 2017; Jakarta. Continuous Improvement of Sustainable Energy for Eco-Mobility; 2018.
13. Azis M, Supriadi B, Lesmono A. Analisis Pengaruh Warna Dan Ukuran Dinding Ruangan Terhadap Intensitas Pencahayaan. J Pembelajaran Fis. 2017;5(1):35–40.
14. Apostolico A, Cappetti N, D'Oria C, Naddeo A, Sestri M. Postural comfort evaluation: Experimental identification of Range of Rest Posture for human articular joints. Int J Interact Des Manuf. 2014;8(2):109–20.
15. Mirbagheri SS, Rahmani-Rasa A, Farmani F, Amini P, Nikoo MR. Evaluating kyphosis and lordosis in students by using a flexible ruler and their relationship with severity and frequency of thoracic and lumbar pain. Asian Spine J. 2015;9(3):416–22.
16. Chinyere N I. Influence of workstation and work posture ergonomics on job satisfaction of librarians in the federal and state university libraries in Southern Nigeria. IOSR J Humanit Soc Sci. 2014;19(9):78–84.
17. Chiasson ME, Imbeau D, Major J, Aubry K, Delisle A. Influence of musculoskeletal pain on workers' ergonomic risk-factor assessments. Appl Ergon. 2015;49(1):1–7.
18. Taifa IW, Desai DA. Anthropometric measurements for ergonomic design of students' furniture in India. Eng Sci Technol Int J. 2017;20(1):232–9.
19. Collins JD, O'Sullivan LW. Musculoskeletal disorder prevalence and psychosocial risk exposures by age and gender in a cohort of office based employees in two academic institutions. Int J Ind Ergon. 2015;46(1):85–97.
20. Higgins DM, Fenton BT, Driscoll MA, Heapy AA, Kerns RD, Bair MJ, *et al*. Gender differences in demographic and clinical correlates among veterans with musculoskeletal disorders. Women's Heal Issues. 2017;27(4):463–70.