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Postural Evaluation and Related Musculoskeletal Pain Among Under Graduate Dental Students Using Kinovea - Education on Ergonomic Principles

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ABSTRACT

Work-related musculoskeletal disorders (MSDs) have emerged as major health problem among dental workers. Dental practice is a high risk profession and every year a large number of dentists are at risk of job related musculoskeletal disorders often termed as work related musculoskeletal disorders often going un noticed. Ergonomics is the art and science that fits individual's job to the work culture that it enhances human efficiency and well-being. Application of customized ergonomic principles to cater the needs of the dental work culture required immediate attention.

Aim: Assess the prevalence of WMSDs, knowledge of II year dental students on principles of ergonomics and how they can apply this knowledge in order to develop relevant skills which could be followed in their clinical years.

Settings and Design: In this cross-sectional study, 130 dentists (84 male and 46 female) participated. The posture of the subjects during their normal workload was recorded by using the RULA method, and the range of musculoskeletal pains by using the Nordic Musculoskeletal Questionnaire (NMQ), and individual and professional data was assessed by a demographics questionnaire. All tests were performed at $P<0.05$ level of significance.

Subjects and Methods: A total of 98 2nd year dental students from JSS Dental College and Hospital working in preclinical laboratories were included in the study. The procedure was explained, and the questionnaire was distributed and assessment was done using Rapid Upper Limb Assessment (RULA) to investigate the exposure of the individual workers to risk factors associated with work related disorders. The MSDs can be recorded using the standard Nordic questionnaire.

Statistical Analysis Used:

The data were collected from 81 subjects out of the 98 evaluated and was statistically analyzed.

Results: The study sample included 30 male and 51 female dentists. Assessment of the physical status of the subjects showed that 82.8% of subjects were at high risk of musculoskeletal disorders. The majority of musculoskeletal pains were in the neck (88%) followed by upper back and lower back (62%). Moreover, 68.9% of the subjects had experienced pain at least once over the last year.

Conclusion: The students understood the importance of the practical application of the dental ergonomics principles. Registering ergonomic skills is the need of the hour as early as mannequin training. The findings of the research support the argument for integrating ergonomics in dental curriculum. Students should be educated on work related musculoskeletal disorders.

Keywords: Musculoskeletal disorders, posture, Rapid Upper Limb Assessment (RULA), Kinovea soft ware, Photographs, PCP (Preclinical Prosthodontics)

INTRODUCTION

Musculoskeletal disorders (MSD) are common occupational ergonomic hazard and occur due to prolonged faulty posture. According to World Health Organization, it mainly involves muscles, tendons, joints,

intervertebral discs, peripheral nerves, and vascular systems. Dentistry is one such profession where dentists are exposed to such disorders due to as their work is restricted to within the narrow stomatognathic system called the oral cavity. Dentist's work demand high precision and stagnant working posture distorted posture and repetitive movements which could promote to Work related musculoskeletal disorders. [(1)] Researchers have highlighted that strenuous dental procedures, without considering timely breaks between patients, often lead to compromised work efficiency. [(2-5)]

Therefore, proactive measures should be made mandatory as early as in the dental profession such as awareness among non-clinical undergraduate students must be taken into consideration and educate the young crowd about the ill effects of poor working posture, awkward operatory design to prevent early signs and symptoms of MSD which could reduce their work quality. Ergonomics is the art and science of fitting the job to the worker and not worker to the job. It was first coined by Hywell Murrel as early as 1949. [(6)] It mainly deals with the theory of achieving the balance between the job, worker, and work place design.

The aim of the present study was to educate the young dental students about the ill effects of faulty posture. The study aimed at inculcating the right posture at their non clinical level which creates awareness, knowledge and train about concept of ergonomics to carry forward in their clinical postings.

The main objective of this study was to

1. Assess the prevalence of WMSDs among II year dental students of JSS Dental College in their non-clinical years.
2. to assess the level of knowledge of the dental students of the principles of ergonomics and how they can apply this knowledge in order to develop relevant skills to be applied in their clinical years.

Study design& Sampling strategy:

This cross-sectional study was conducted at JSS dental college and hospital, JSS University, Mysuru in 2018-2019.

Inclusion criteria

Second year undergraduate students attending preclinical Prosthodontics

The students should be exposed to pre clinical setting for at least 12 months.

Exclusion criteria

History of injuries in the past 1-year affecting the posture, deformity affecting the posture,

Subjects who have undergone treatment for musculoskeletal injuries,

Consulted general physician,

physiotherapist.

The data were collected from 81 subjects out of the 98 subjects. Prior information was given to the subjects about the purpose of the study, and an informal consent was collected. Ethical clearance was obtained from institutional ethical committee, JSS Dental College and hospital.

Questionnaire on knowledge and practices to combat musculoskeletal pain

The procedure was explained, and a self-administered questionnaire which was pilot tested and evaluated for reliability and validity was given for data collection. (Table 1) The Questionnaire included Demographic details, Nordic musculoskeletal pain questionnaire (NPQ) and Rapid Upper Limb Assessment (RULA).

Nordic Musculoskeletal Pain Questionnaire (NPQ):

NPQ developed by Kourinka et al [(7)] **was used** to identify the body regions that were affected with musculoskeletal pain. - various body sites like neck, left and right shoulder, upper and lower back, left and right elbow, left and right hands/wrists, hips and legs, knees, and ankles/ feet in the last 12 months.(fig 1)

Rapid Upper Limb Assessment (RULA)

The potentiality of profession related musculoskeletal disorders among the dental

students was determined through RULA observational method that is used for evaluating ergonomic risk of working postures This method was developed by McAtamney and Corlett (1993) for use in ergonomic investigations of workplaces where work related upper limb disorders are reported [(7-14)] (fig 2, table 1)

The assessment of body posture includes two groups [(14)]

Group A includes upper arm, lower arm wrist along with muscle use and force applied by the muscles in these regions gives the posture score A

Group B includes neck, trunk and legs with muscle use and force applied by the muscles in these regions gives the posture score B. RULA proceeds to find action levels, recovery needs and indicates the level of intervention required to reduce the risk of injury due to physical loading on the operator

Four Action Levels are considered from the RULA Grand Score

Level1 (L1); a score of 1or 2 indicates posture is acceptable if it is not maintained for long duration

Level 2 (L2): a score of 3 or 4 indicates that further investigation is needed and changes may be required

Level 3 (L3): a score of 5 or 6 indicates that investigation and changes are required at the earliest

Level 4 (L4) : a score of 7 and above indicates that investigation and changes requiring attention.

Evaluation of risk from working posture by RULA [(11, 14)]

Scoring was done on a determined body positions while the students involved in their pre clinical teeth arrangement and during the conservative pre clinical work by using the 'Rapid Upper Limb Assessment' (RULA) (the student did not notice the scoring stage to negate Hawthorne effect). The study was governed and assessed by the investigators (M,N,N, K) where the former(M) checked, rechecked and calibrated the movements as 1–8 between the groups as per the RULA score chart(Fig2) Before the actual evaluation, the observers were trained in evaluating RULA with an ergonomic specialist(K). After evaluating the kappa statistic of each observer, a score of 1.00 ensured that the observers were in agreement.

Materials used were

Tripod stand
Nikoncamera-DSLR(d90)
Measuring tape
Protractor
Kinovea working posture soft ware
(https://www.kinovea.org)

Students were directed to do their regular exercise of pre-clinical work with the cameras set in place for capturing photographs. The ergonomic posture of students during sitting was examined for 20 minutes, movements of different body parts were observed and recorded, and the worst and most frequent postures were assessed. One tripod with camera was placed at a distance of 3m from the mid portion of the walkway to record anterior and posterior views. This placement ensured a clear visualization. Photography was done at a frame rate of 30 fps (frames per second). The camera had a frame width and height of 1280×720 pixels. The total data bit ranges from 12 megabytes to 40 megabytes. The assessment and calibration of movements was started 15 min after the students started the pre-clinical exercise and settled comfortably in their respective chairs. The positions were captured by using a Nikon camera (DSLR D90) from Lateral/anterior view for upper body, Lateral/anterior view for entire body to examine the movements of all the joints in each particular posture, without disturbing the students. It was then uploaded on the computer system and the postural position at every body movement was paused, assessed and scored on the score sheet. The snap shots from the videos were viewed and reviewed for accuracy by the team and a final RULA score sheet was made separately for each group of participating students compared with RULA

observation already recorded for accuracy. (fig 3).

Photographic Analysis [12,13]

The photographs of each participant comprising of different views were imported to Kinovea 0.2.5 version video analyzing software. The kinematics of each event, (anatomical position-cervical-cervicis, dorsal, lumbar-lumbus/loin, wrist and shoulder-acromial) was analyzed using cross marker tool, line tool and angle tool of the software (Table 6). The bony landmarks were highlighted using the cross marker tool with bright contrast color for better visualization of the points in the video. Each event was paused and the measurements of angles of all the joints were taken. (fig 4-7)

Statistical Methods

Individual characteristics and RULA scores of dentists were reported by mean, standard deviation, and frequency; To compare the association between the various other risk factors of musculoskeletal pain and prevalence of musculoskeletal pain in the last 12 months, a Chi-square test was used at a 95% confidence interval. to compare two groups, women and men, we used *t*-test. All tests were performed at the $P < 0.05$ level. A descriptive statistics was used to: explore risk action levels from RULA and individual risk factors of musculoskeletal pain. All data analyses were conducted using SPSS V.20.

RESULTS

The data were collected from 81 subjects out of the 98 subjects. After coding the RULA data and Questionnaire information, they were entered to SPSS software (version 18) and included 30 men and 51 women. The rest 17 of the subjects could not be assessed due to reasons like not meeting the inclusion criteria completely and absentia to working hours. The demographic data are summarized in Table 2. On analysis regarding the awareness and knowledge of WMSD 47 students (94%) were aware of it, 36 students (72%) were not aware of any preventive technique (mitigating measures) to reduce the risk of WMSD, 27 students (54%) were not involved in any kind of physical activities, all 50 students admitted that ergonomics was not a taught subject in the dental college, and 44 students (88%), had not attended any workshop on preventing WMSD. (Table 1,3,4)

As per the Nordic Questionnaire, the prevalence of musculoskeletal pain at least one part of the body region in the 12 months period, all students reported prevalence of musculoskeletal pain from clinical practice in at least one part of the body region. The most complaints were reported at the neck 44 students (88%) upper back 36 students (72%), right hand/wrist 33 students (48.53%), right shoulder 19 students(38%), and lower back 31 students (61.5%), left shoulder 06 students (12%), when questioned about pain preventing normal activities, 13 students (26%) reported neck pain, 14 students (28%) with pain the right shoulders, 6 students (12%),with pain in the left shoulders 31 students (62%) with pain in the lower pack and 13 students (26%) with pain in the right wrist and elbows. When questioned regarding their visit to a physician for the same 32 students (64%) gave consent (Fig. 1 Table 2).

Table 1: Self-administered Questionnaire

Self administered questionnaire	Approval rate (Frequency %)	
	Yes	No
Need of evaluation for Work related Musculoskeletal Disorders (WMSD)	47(94%)	3(6%)
Are you aware of any preventive technique to decrease the possible risk of having related Musculoskeletal Disorders (WMSD)?	14(28%)	36(72%)
Do you perform exercise after working hours from your Dental college?	24(46%)	27(54%)
Is ergonomics a taught subject in Dental college?	-	50(100%)
Have you attended any workshop on preventing WMSD?	6(12%)	44(88%)

Table 2: Prevalence of pain with respect to body parts

Nordic pain questionnaire	Region	percentage
	Yes	No
Have you had any pain in the last 12 months in	Neck 44(88%) Rt. Shoulders 19(38%) Lt. Shoulders 6(12%) Upper Back 36(72%) Lower back 31(62%)	6(12%) 31(62%) 44(88%) 19(38%) 19(38%)
In the last 12 months pain prevented normal activities in	Neck 13(26%) Rt. Shoulders 14(28%) Lt. shoulders 6(12%) Lower back 31(62%) Rt. Wrist and elbows13(26%)	37 (74%) 36(72%) 44(88%) 19(38%) 37 (74%)
In the last 12 months visited physician	18(36%)	32(64%)

Table 3: demographic data of the study participants

Indices	Age (years)	Height (m)	Weight (kg) BMI (kg/m2)
Women	21±1.2years	155.59 ± 1.2	66.13 ± 1.2
Men	22±1.6years	170.0.2 ± 0.2	81.33 ± 0.5
Total	23.21 ± 2.07	166.56 ± 3.61	73.33 ± 1.02

Table 4: Prevalence of pain with respect to gender

Reported region	men	Women
Neck	29.6%	33.7%
Shoulders	41.2%	43.9%
Back	53.2%	56.6%
Wrist	25.9%	41.2%

Table 5: RULA scores in groups of body limbs for students working in preclinical prosthodontics

GROUP	Rula score (mean±SD)
GROUP A	1.01 ± 4.49
GROUP B	6.90 ± 1.02
Grand score	6.50 ± 1.43

Table 6: anatomical landmarks considered for kinvoea analysis

Segment	Bony prominence
Cervical	Cervicis
lumbar-	lumbus/loin
shoulder	Acromial

Table 7: Final scores and action levels.

RULA score (level)	Percentage	Required action
1 & 2 (action level 1)	12%	Posture is acceptable not repeated for long duration
3 & 4 (action level2)	57%	Further analysis needed requiring modifications
5 & 6 (action level3)	24.8%	Analysis and immediate adoption of changes of posture
7 and above (action level 4)	6.2%	Exploration of possible causes and immediate implementation of postural changes

Table 8: Correlations between group A, Group B and RULA

		Group A	Group B	RULA
group_A	Pearson Correlation	1	.255*	.483**
	Sig. (2-tailed)		.034	.000
	N	69	69	69
group_B	Pearson Correlation	.255*	1	.797**
	Sig. (2-tailed)	.034		.000
	N	69	69	69
RULA	Pearson Correlation	.483**	.797**	1
	Sig. (2-tailed)	.000	.000	
	N	69	69	69
*. Correlation is significant at the 0.05 level (2-tailed).				
**. Correlation is significant at the 0.01 level (2-tailed).				

Table 9: Independent Samples Test

	t-test for Equality of Means			
	T	df	Sig. (2-tailed)	Mean Difference
Pre clinical prosthodontics	-2.367	138	.019	-.40000

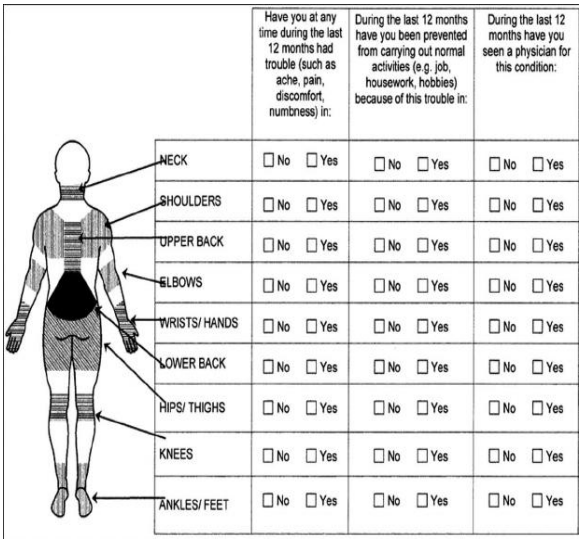

Figure 1 NORDIC QUESTIONNAIRE.

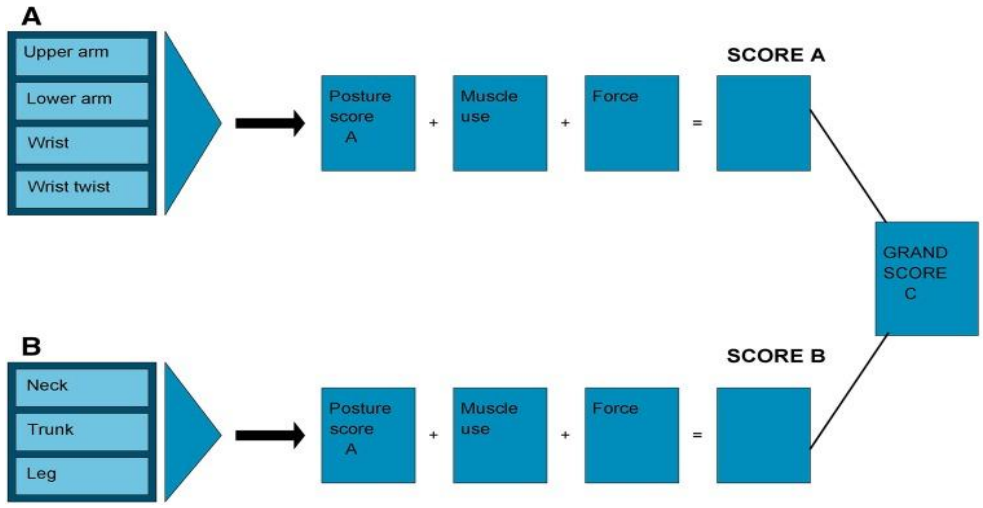

Figure 2: RULA SCORING CHART

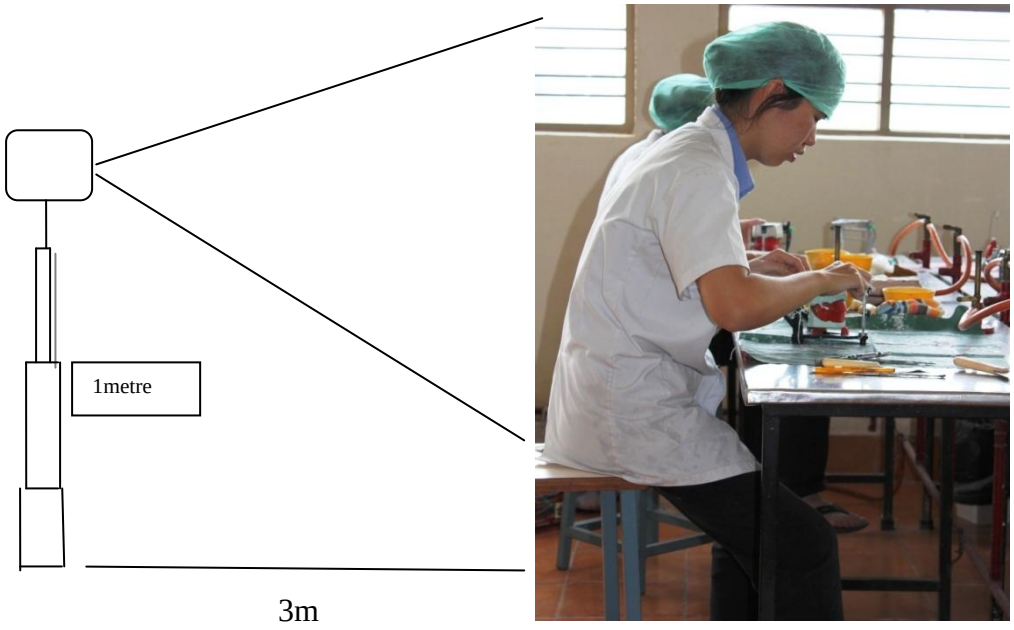

Figure 3: Stabilization of tripod stand with camera placed at a distance of 3 meters.

Fig4: Analysis using Kinovea software

Fig 5: Line joining digital markers using Kinovea

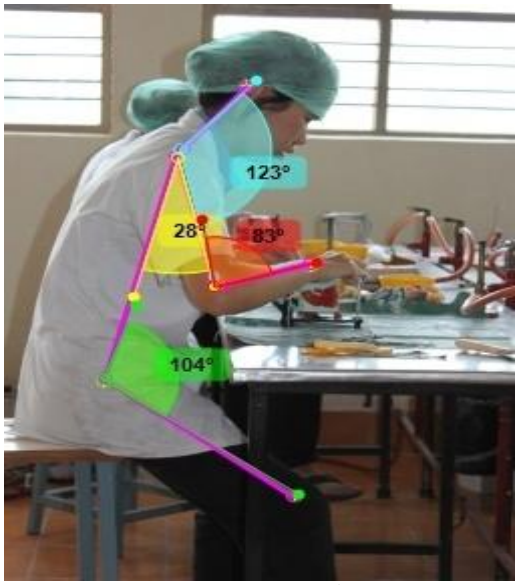

Figure 6: Measurements of angles

Figure 7: Line joining digital markers

Lower Arm Flexion: range: 25°-30° Ideal-<10°
Upper Arm Abduction: range:max.35° Ideal-<10°
Upper Arm Flexion:range max. 30° Ideal-<15°
Wrist Abduction: range max. 20° Ideal-<10°
Wrist Flexion: range: max. 45° Ideal-<15°
Head inclination: range: max.30° ideal-<10°
Neck Rotation:range: max..45° ideal-<5°
Trunk Rotation:range: max.30° ideal-<10°
Trunk Sideward Inclination:range: max.20° ideal-<10°
Knee Flexion :range: MAX. 95°-135° ideal-<115°
Leg Splay Angle :range:MAX.2 30°-45° ideal- 30°-40°

Fig 8: key points on ideal operatory positioning

Postural assessment using RULA indicated that 57% of the subjects were at action level 3; that is, they soon required further investigation and action. Further, 24.8% of the subjects required immediate change (Table 5)

On the whole more L3 levels was observed followed by L2 and L1.Region wise in the increasing order we noticed more number of students with upper back pain followed by neck and lower back pain followed by pain in shoulders.(Table 7)

Scores of group A correlated significantly and positively with the final RULA scores where co-efficient of 0. 255 and 0.483 for groups A and B with final RULA were found to be significant at 0.001 levels.

Scores of group B correlated significantly and positively with the final

RULA scores where co-efficient of 0.483 and 0.497 for groups A and B with final RULA were found to be significant at 0.001 level (Table 8)

When the difference between groups A&B were verified significant mean difference existed for both the parameters in PCP (Pre clinical Prosthodontics) (t=-2.367; p=0.019) Group B had higher RULA scores than Group A (mean RULA score 6.90 ± 1.02) (Table 9)

DISCUSSION

Current literature deals with the assessment of posture of an individual either by photographic method or frame grabbing. Similarly, RULA (Rapid Upper Limb Assessment) is a survey method developed and adopted for use in investigations of workplaces where work-related upper limb disorders are reported. The hallmark of this tool is it requires no special equipment and provides a quick assessment of postures of the neck, trunk, and upper limbs along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list which indicates the level of intervention required to reduce the risks of injury due to physical loading on the operator. Dr. Lynn McAtamney and Dr. Nigel Corlett from Nottingham's Institute for Occupational Ergonomics developed RULA to investigate the exposure of the individual workers to risk factors associated with work-related upper limb disorders. The method uses diagrams of body postures and three scoring tables to provide evaluation of exposure to risk factors. Standard Nordic questionnaire (SNQ) was used to record and detect the severity and duration MSDs. [15, 16]

In this article, we discuss the possibility of using Kinovea, a video based software tool, on videos taken with easily available recording devices for posture analysis of dental students. Each event was paused and the measurements of angles of all the joints were taken. The detection and analysis using Kinovea with position markers to measure angular positions of posture is simple. [17] Spatiotemporal parameters can also be appraised using the software. The software is easy to understand and apply, and is freely available. The recorded video can be calibrated to international standards using a simple grid with known measurements.[18]

Follow up of ergonomic guidelines is vital in dental work station regarding tools, machines and equipments. These factors need to be considered for the comfort of the subjects. [19] Individual adjustment of dental chairs in relation to seat, arm, and back needs special attention. The RULA score gives the information about the posture and the angulations of the spine in relation to the stresses faced.

In dentistry, ergonomics plays a crucial role throughout a professional's life which makes it mandatory to inculcate it right from the inception of the course. Given the pressures of university education, and the physical burden of clinical training, it is essential to understand the prevalence of MSDs and factors associated with them among the dental students. [20] Therefore occupational health training and MSD prevention programs related to ergonomic science must be conducted by the institutions for the benefit of the students.

The very nature of dental practice due to improper faulty posture would result in Prevalence of pain in the neck and shoulders. Slouching at an angle of 15◦ or sometimes 30◦ and assuming this posture for a long period of time along with elevating the shoulders (with more than 30◦ abduction or flexion) exerts much pressure on the neck and the shoulder. [21-24] Prevalence of musculoskeletal disorders was generally higher in women than men, which may be associated with the lower muscle volume and strength of women and female hormones. This result correlates with the results of Leggat et al. [4] Garcia et al., [25] Coury et al., Kerosuo et al., Akesson et al., and Diaz- ˚ Caballero et al. [26-29] prolonged static contractions lead to accumulation of lactic acid, reduction of oxygen levels, and fatigue and pain. This finding is inconsistent

with the results of Marshall et al,. [30] Chamani et al. [31] and Al Wazzan et al. [32]

Personal characteristics and work profile of subjects are listed in Table 1. RULA scores are reported in Table 2; the final score obtained (6.90 ± 1.02) was most affected by the high rating of group B (neck, shoulder, wrist)

In the present research, a significant relationship was observed between RULA scores for different regions of the body and the pain reported by the subjects. In a similar study, Seraji [33] found that the pain reported in different body parts was related to the working conditions associated with the same body parts, while in the research of Varmazyar [34] no significant relationship was observed between REBA scores and the pain related to the same body part. In the present 64% of the students had not taken any action to alleviate the pain similar to a study done by Harutunian, 66.2% had taken no action to improve their problem. [35] Reporting of the most severe pain in the neck and shoulder and the high RULA grand score (6.90) indicated that the subjects were mostly affected by the high group A score (i.e., the neck, shoulder, and back). This finding is consistent with the results of Varmazyar et al., [34] Choobineh et al. [36,37] and Garcia et al. [25]

The inconvenient posture necessarily adopted by dentists by hunching over patients, adjusting their hands to reach into the mouth, leads to undesirable stress on the muscles of the lower back. [9.35,36,38] lumbar lordosed seated posture, regularly interspersed with movement (lordosis to kyphosis) as the optimal sitting posture, is necessary to maintain lumbar postural health, and the prevention of low back pain. [39] Students spend hours in the preclinical laboratories with incorrect postures on conventional chairs. Prolonged static positioning may loosen the abdominal muscles and make the spine slump which in turn strains the spinal ligaments and stretches muscles of the back. [40,41] Lack of awareness can make the students habituated to faulty slouched posture triggering WMSDs.

The need of the hour is to inculcate the importance of ergonomics and work place principles at infancy which is 1st and 2nd year of dental carrier, where in dental students are educated through lectures and seminars on work related musculoskeletal disorders professional risk factors and means of preventing it by incorporation of concepts of dental ergonomics needs to be sensitized.

Sensitization of the students on ergonomic principles would be updating the curriculum on dental equipment in clinical environment. Organizational measures for improving the general conditions for clinical work and education such as: dental operatory ergonomics, balanced movement during working, motion economy must be taught before the students enter the clinics. Another favorable prerequisite is the research on the needs and advantages of working environment improvement and postural strategies to improve musculoskeletal health.

Previous studies results indicated that the dentist using the conventional seat recorded significantly higher risk scores. [42-45] New technologies and changes in dental care, aimed at providing students with greater comfort and better health needs to be implemented.

The inference we get through this study is that sedentary nature of work together with faulty posture –fewer repetitive motions, work place constrictions and lack of application of ergonomic principles can result in the imbalance of specific group of muscles. Operators strive to maintain a balance posture while 50% of their body's muscles are made to contract to hold the body motionless. The awkward posture retained for prolonged periods of time can cause irreversible damage to the muscles thus causing a threat to dentist's career. Work posture of dentists plays an important role as a risk factor for the development of work-related disorders.

Future directions

In view of the information gathered, social preventive mediations can likewise be arranged, which include, an ergonomic Training. Ergonomic training plans to build up safer stances, and reinforce the concept for clinical scenario. The ergonomic approach could positively affect work conduct and in this way on the reduction of MSD. Ergonomic training of dental students has barely been investigated up until now. In this manner ergonomic intervention together with cognitive domain would enhance the overall health for effective delivery of dental treatment for patients.

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