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ORIGINAL ARTICLE

Postural Assessment of Students Evaluating the Need of Ergonomic Seat and Magnification in Dentistry

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Abstract Dental students using conventional chairs need immediate change in their posture. Implementing an ergonomic posture is necessary as they are at high risk for developing musculoskeletal disorders. This study recommends the use of an ergonomic seat and magnification system to enhance the visibility and the posture of an operator. The aim of this study is to make a foray into the hazards caused by inappropriate posture of dental students while working. It also aims at creating a cognizance about the related health implications among the dental fraternity at large, and to understand the significance of adopting an ergonomic posture since the beginning of the professional course. In the present study, postures have been assessed by using rapid upper limb assessment (RULA). This method uses diagrams of body postures and three scoring tables to evaluate ones exposure to risk factors. Ninety students from II BDS (preclinical students in the second year of dental school) were assessed in three groups using three different seats with and without magnification system. The results recorded significantly higher RULA scores for the conventional seats without using the magnification system compared to the SSC (Salli Saddle Chair-an ergonomic seat) with the use of magnification system. A poor ergonomic posture can make the dental students get habituated to the wrong working style which might lead to MSDs (Musculoskeletal diseases). It is advisable to acclimatize to good habits at the inception of the course, to prevent MSDs later in life.

Keywords Ergonomics · Health hazards · Human engineering · Musculoskeletal diseases · Magnification · Occupational diseases · Operative dentistry

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Introduction

Musculoskeletal disorders (MSD) are one of the most common and pervasive occupational hazards; and are frequently encountered with the improper postures for a prolonged period of time. Studies have proved that MSDs are commonly found in occupations where people use high apprehension forces, with frequent prolonged awkward postures [1]. Dentistry is a profession where one's professional career can come to a standstill due to the

anticipated occupational hazards related to the posture. Long incessant hours of stressful work may lead to physical and mental trauma. Repeated unilateral twisting in one direction may result in muscle imbalances or structural tissue damage, leading to lower back pain [2]. Dentists should therefore effectively resort to an operatory design which involves minimal twisting of the body.

Dentistry is a physically demanding profession, where the musculoskeletal organs are vulnerable to injury by arduous and lengthy procedures. Research has shown that musculoskeletal pain experienced by dentists is found to be a common complaint; mainly in the neck, shoulder and hand/wrist [3, 4]. Prolonged sitting in a poorly designed chair with inadequate lumbar support or adjustability has been found to be the major contributing factor to muscular fatigue and lower back pain [5].

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 [6]. 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 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. As per a study, 60 % of the students experienced neck or back pain after clinical work (70 % of which were females) [7]. Pynt et al. [8], recommended lumbar lordosed seated posture, regularly interspersed with movement (lordosis to kyphosis) as the optimal sitting posture, which is necessary to maintain lumbar postural health, and the prevention of low back pain [8]. Students spend hours over phantom heads in the preclinical laboratories with incorrect postures on conventional chairs. Prolonged sitting may slacken the abdominal muscles and make the spine slump which in turn strains the spinal ligaments and stretches muscles of the back [9, 10]. Lack of awareness can make the students habitually adopt an improper posture that can foster the MSDs.

MSDs are cumulative over the years in clinical dentistry; care in the early years may impact rest of the life. Poor ergonomic posture might lead to musculoskeletal injuries affecting the productivity and earning potential. An ergonomic posture can be adapted by using an ergonomic seat, magnification and light systems which greatly enhance the posture and the visibility. The magnification can provide a clearer view without twisting the body which can maintain the posture and decrease the prevalence of MSDs. The ergonomic advantages of magnification are increasingly being recognized; students have been found to work in an ergonomically better posture while using magnification lenses when compared to using regular safety glasses [11]. Literature has reported the improvement in posture by using either ergonomic seat or magnification and light systems; the present study is using both the situations and comparing them using the ergonomic (saddle stool) and conventional seats with and without a magnification system.

The aim of the present study is to alert the dental students and professionals about the hazards caused by inappropriate posture. The endeavor is also extended to inculcate the right posture while working on patient, and train the dental students to create the knowledge and awareness about the ergonomic posture. It is an effort to recommend the implementation of right way of practicing dentistry in right time.

Materials and Methods

Study Designing

In the present study, a 'between-subject experimental design' was selected to obtain the scores from three different groups separately. Each group was assigned a different seat that enabled a proper comparison and determination of the most apt posture. This study was conducted on the II year BDS students, as they were involved more in preclinical work requiring at least 4–5 h of work in conservative and prosthetic preclinical laboratories every day. Selection was done by simple random sampling method (lottery method) where 90 students were selected out of 102. Institutional ethical board (Institutional Review Board for Clinical Research) permission was acquired for conducting this study.

All the students were given the similar exercise (tooth preparation of lower first premolar), and the postures were compared in three different seats, namely; 'Salli Saddle Chair' (SSC), Conventional chair with back rest (CC1), and Conventional chair without back rest (CC2) with and without using the magnification system. The postures were evaluated while the students were involved in working, by using the 'Rapid Upper Limb Assessment' (RULA). The study was governed and assessed by a team of nine members including six viewers and reviewers and three assistants; the former did the meticulous screening of the videos for the upper limb movements while the latter checked, rechecked and calibrated the movements as 1–8 between the groups as per the RULA score chart. Each group was assessed in three different chairs without the magnification system, followed by assessment with the magnification system, which provided a comparative data of the posture.

Rapid Upper Limb Assessment (RULA)

RULA was developed by Dr. Lynn McAtamney and Dr. Nigel Corlett [12] of University of Nottingham's Institute for Occupational Ergonomics, to investigate the exposure of 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. In addition to these factors McPhee cited other important factors which influence the load, but which may vary between individuals [13]. It refers to the work postures adopted and overuse of muscle work or force. The other important factors are speed and apt movements, as well as the pauses taken by the operator in respect to frequency and duration.

Validity and reliability of RULA was established in a series of studies conducted with VDU (Visual display unit) users and sewing machine operators. McAtamney and Corlett [12] examined the validity and reliability of RULA using a data-entry computer task as a model. They investigated the relationship between RULA's risk categories and psychophysiological measures. They used self-reports of perceived discomfort as a measure of physical risk for validity. Inter-rator reliability indicated "high consistency" of scoring while the construct validity of RULA method has been established with significant associations between RULA scores and reported pain. They observed a high statistical significance of the relation between posture scores A and B with the regional pain, ache and discomfort. It was proved to be a reliable screening tool to be incorporated into a wider ergonomics assessment of epidemiological, physical, mental, environmental and organizational factors [12]. Takala et al. [14] studied 30 eligible observational methods including RULA, but none of them appeared to be generally superior, however, intra-observer repeatability of RULA has been found to be good. There are certain limitations for the application of RULA, it is not applicable for assessing the manual material handling tasks or tasks involving significant moving around the work area; also it is not suitable for assessing tasks with unpredictable work postures. It does not consider the total duration of the task, available recovery time or vibration. As a risk assessment method, it provides a general risk level but cannot predict injuries to the operator. It does not consider individual risk factors in relation to gender, age or medical history [12].

Participants

The selected students were divided into three groups of thirty each, and lectured thoroughly on ergonomic posture. They were informed about the study and importance of posture while working. A proper demonstration was given to them for using the magnification system, with the body erect followed by a training programme for next three days. The postures were assessed throughout the training period, and the assistance was provided wherever it was required. The students were directed to work on their respective seats with and without the magnification system as per their group in their preclinical sessions for almost three months followed by the assessment. All ninety students were given the information sheets and the consent forms which they read, signed and returned.

Materials

- Salli saddle chair (SSC) (NOVO dental products, Pvt. Ltd & Salli system, Finland) (Fig. 2).
- Conventional chair with backrest (CC1) (Fig. 3).
- Conventional chair without backrest (CC2) (Fig. 4).
- Magnification system (loop headband magnifier with double lens:1.7×/2×/2.5×/3.5×) (China—Mainland).
- Phantom Head Apparatus.
- Digital Camera (SLR CANON 1000 D Japan/Taiwan).

Salli Saddle Chair

This ergonomic chair has been specially designed, considering the postural needs of operators. Salli saddle chair (SSC) offers a comfortable and convenient posture with thighs at a 45° downward angle, tilting the pelvis to a near neutral position, as when standing. Legs are well supported with the thighs fitting into the thigh 'channel' of the seat without any gap. This posture provides a natural curve to the lower back and keeps the shoulder–neck area erect.

Procedure

After three months of training, the assessment procedure started. All the three groups were taken for assessment, one by one, for three days. Students were directed to do their regular exercise on the phantom heads, with the video cameras set in place. The total recording period was 90 min however, the assessment and calibration of movements was started 15 min after the students started the exercise and settled comfortably in their respective chairs. This provided time for the students to get engaged and concentrate in their work. Each group was assessed without magnification system, followed by with magnification system. The magnifier used in this study was consisting of double lens with a detachable light source device which created a clearer view from a distance. The positions were captured by using a digital camera (SLR CANON 1000 D Japan/Taiwan) from all the angles to examine the movements of all the joints in each particular posture, without

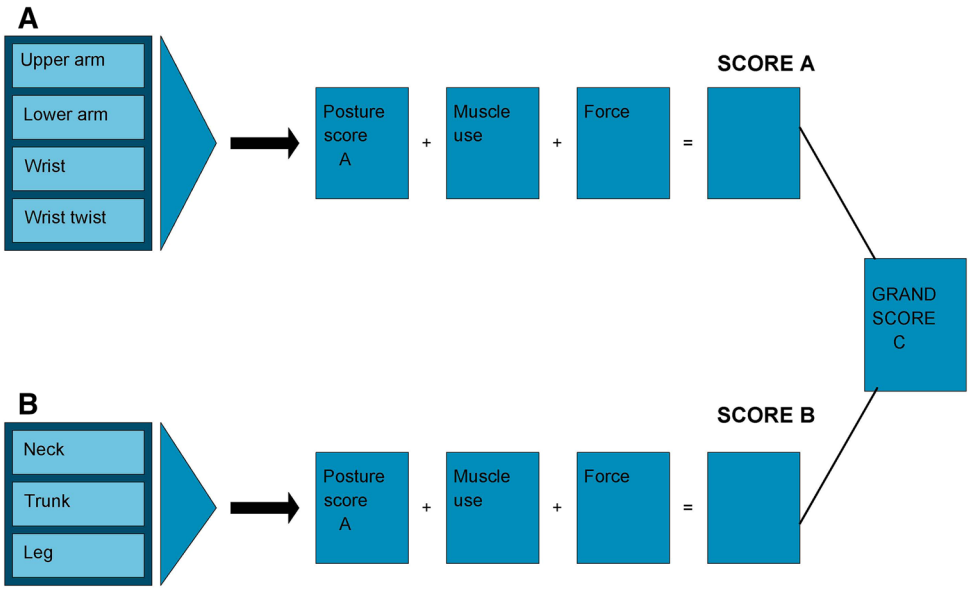

Fig. 1 A score chart for assessing the movements of different body parts as per A, B, & C tables

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 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.

According to RULA, the body is divided and assessed in two segments A (upper arm, lower arm and wrist) and B (neck, trunk and legs). The postures in movements are given the ranges from 1 to 8, or more. Wherever the risk factors are minimal, the range of movement is given number 1. More extreme postures showing an increasing presence of risk factors are given higher numbers.

The numbers are allocated in the charts 'Table A' where the body parts—upper arm, lower arm, wrist and wrist twist, and 'Table B'—neck, trunk and legs are scored and calculated as per the ranges. The legs and the feet are scored as—1, when they are well supported and in an evenly balanced posture; and are scored as—2 if they are not. A and B are then calculated using the final scores and a 'Grand Score' is determined using table C. Muscle use scores are estimated by raising the score by one, for static postures held for longer than one minute or repeated more than four times per minute, and force scores are estimated for postures which exert force or maintain an external load while working (ranges 0–3 as 0 for less than 4 lbs load; 4 for more than 20 lbs load). The assessment was done separately for right and left side as there is difference in the ranges of movements on both the sides and the RULA was analyzed as the minimum scores 1–2 as acceptable conditions, to 7–8 change required immediately [15] (Fig. 1).

Results

Three different groups were compared statistically and *P* values were obtained using 'One Way Analysis of Variance' (ANOVA) with Bonferroni's correction for multiple group comparisons at an $\alpha \leq$ (Table 1). Results indicated that the means and standard deviations of all three groups were different with the significant scores between sally saddle chair and the conventional chairs (Fig. 2, 3, 4). All three groups were again statistically compared with and without the magnification system. The results recorded significantly higher RULA scores for the conventional seats without magnification used (7.03 ± 0.49) as compared to SSC with magnification used (1.57 ± 0.50). The results showed that SSC with magnification scores were extensively acceptable ($P < 0.01$) (Fig. 5).

The scores were higher for right side (2.93 ± 0.69) as compared to left side which was 2.73 ± 0.64. The conventional seats, CC1 and CC2 scored mean 7.07 and 7.03 with standard deviations as 0.45 and 0.49 respectively. On left side the ranges were lower comparatively. RULA ratings on right and left side were significantly different from the ratings for CC1 and CC2 groups on right and left side (Table 2). The comparison of RULA score categories across three study groups with and without magnification is shown in Table 3. It was seen that the magnification improved the posture to a definite level, though it was not of much benefit to students who were habitual to bend and work ($P < 0.01$).

Working postures and actions with grand score 1–2 were considered most acceptable which were seen only with the group using SSC with magnification. While, the scores of 2 or more than 2 were considered within the suitable ranges

Table 1 The comparison of average RULA score across three study groups

RULA score	SSC ($n = 30$)	CC1 ($n = 30$)	CC2 ($n = 30$)	*P* values (intergroup comparison)	
				SSC v/s CC1	SSC v/s CC2
Right	2.93 ± 0.69	7.01 ± 0.45	7.03 ± 0.49	0.001 (highly significant)	0.001 (highly significant)
Left	2.73 ± 0.64	6.57 ± 0.50	6.96 ± 0.56	0.001 (highly significant)	0.001(highly significant)

CC1 conventional chair (with back rest), *CC2* conventional chair (without back rest), *RULA* rapid upper limb assessment, *SSC* Salli saddle chair

Fig. 2 Working posture of a dental student on SSC (Salli Saddle Chair)

Fig. 3 Working posture of a dental student on CC1 (Conventional chair with back rest)

of motion which were present in SSC without magnification, with no static loading or the exertion of force. While conventional chairs reported comparatively lower scores with magnification (CC1 5.63 ± 0.49 and CC2 5.07 ± 0.46) than the groups without it (6.57 ± 0.50 and 6.96 ± 0.56) respectively. Higher grand scores above 7 with conventional chairs without magnification indicated the working postures with repetitive movements and/or static muscle work and exertion of force, which needed change immediately. The postures were compared on both the right and left side in all the three groups which showed the ranges remarkably lower on left side in SSC than in conventional seats at the same time, the magnification lowered the ranges to some extent in all three seats ($P < 0.01$) (Table 3).

The results suggested that there was a less postural risk with the SSC with proper magnification used while there was a high risk in using conventional chairs with or without backrest and without the use of magnification. When the conventional (CC1 and CC2) chairs were compared, it was seen that the back rest does not really make any difference in improving the posture ($P > 0.05$).

Discussion

The present study showed significant differences between postures in conventional and saddle seats with and without the magnification and light system. Those who had mild form of musculoskeletal pain, agreed to have less or no pain after using SSC for three months as they found it more comfortable to work in ergonomic chair than the other two. Though the participating students were trained to use their chairs right way with body upright, it was observed that the students were twisting their body for getting the direct and clearer view due to the uncomfortable posture in conventional seats, while they were comfortable in ergonomic seat. All the students were using their right hand to hold the

Fig. 4 Working posture of a dental student on CC2 (Conventional chair without back rest)

Fig. 5 Working posture of a dental student on a conventional chair with magnification

handpiece, which was bearing the major force, similarly, the left side of the body was used with comparatively lesser force. The students used their left hand to hold the lower jaw of the phantom head which twisted the wrist and the wrist joint in a remarkable range of movement. Though this was observed on both the seats, the risk scores were comparatively more acceptable on SSC than the conventional chairs. A similar observation was made in a study conducted by Gandavadi, where two different seats were used to determine if any one seat predisposed individuals to a different working posture. RULA method was used to assess the postures and estimate the final results, which identified the Bambach saddle seats to be better than conventional seats [16]. This stresses the benefit of an ergonomic posture over the conventional one.

It has been proved that the use of magnification system provides the working distance that keeps the body upright, reducing awkward working postures specifically forward neck and trunk flexion [17]. Also it provides an increased image size for improved visual acuity and improved posture while practicing [18]. In agreement to this, our study has noticed that the students were more comfortable using the magnification system with an upright posture in the salli saddle chair. A study has concluded that, the dental magnification loupes significantly enhanced student performance during preclinical dental education and were considered an effective adjunct by the students who used them [19]. Our observations have also reported the similar results; the posture of the students while wearing magnification lenses was more acceptable than the traditional safety glasses. It improved the visibility and the posture as the inclination and twisting of body was no longer required to get the clearer view.

The dentists are involved in the tasks where they require steady hands with vibrating instruments in static positions, to be used in limited area which can lead to the muscle fatigue and pain. The present study has reported that, the students, working on the ergonomic chair were more comfortable than those who were using the conventional chairs without magnification system. Thus, with the help of these findings we tried to alert the dental professionals about the hazards related to the wrong postures. It is a known fact that the musculoskeletal disorder comorbidity is considered to be higher in dentists than in the average population, and the problems may start in the student life. Dental students can get victimized if they are not guided and corrected immediately. A study conducted on students, reported that, 59.7 % of them had neck and back pain after clinical sessions [7]. In support to this, our study reported that the students working on conventional chairs faced ailing conditions during the task due to the uncomfortable posture. Studies have shown that there is a higher prevalence of neck pain among dentists due to the unusual body positioning during work [20–22].

Students need to be taught the right way of using their chairs by adjusting their features to obtain maximal ergonomic benefits [23]. During the study, it was found that the students were unaware of the correct position of the operator and the chair. Efforts were taken to make the students understand the importance of right use of chair to

Table 2 The comparison of RULA score categories across three study groups

RULA score categories	SSC ($n = 30$)	CC1 ($n = 30$)	CC2 ($n = 30$)	*P* values (intergroup comparisons)		
				SSC v/s CC1	SSC v/s CC2	CC1 v/s CC2
Right						
Acceptable conditions (RULA score 1 OR 2)	8 (26.7)	0	0	0.001 (highly significant)	0.001 (highly significant)	0.640 (non significant)
Change may be required (RULA score 3 OR 4)	22 (73.3)	0	0			
Change required soon (RULA score 5 OR 6)	0	2 (6.7)	3 (10.0)			
Change required immediately (RULA score 7 OR 8)	0	28 (93.3)	27 (90.0)			
Left						
Acceptable conditions (RULA score 1 OR 2)	11 (36.7)	0	0	0.001 (highly significant)	0.001 (highly significant)	0.047 (significant)
Change may be required (RULA score 3 OR 4)	19 (63.3)	0	0			
Change required soon (RULA score 5 OR 6)	0	13 (43.3)	5 (16.7)			
Change required immediately (RULA score 7 OR 8)	0	17 (56.7)	25 (83.3)			

Table 3 The comparison of average RULA score across three study groups with/without using the magnification system

RULA score	SSC ($n = 30$)	CC1 ($n = 30$)	CC2 ($n = 30$)	*P* values (intergroup comparison)	
				SSC v/s CC1	SSC v/s CC2
With magnification	1.57 ± 0.50	5.63 ± 0.49	5.07 ± 0.46	0.001 (highly significant)	0.001 (highly significant)
Without magnification	2.73 ± 0.64	6.57 ± 0.50	6.96 ± 0.56	0.001 (highly significant)	0.001 (highly significant)

get the maximum ergonomic effect. This suggests the right use of operatory and the importance of correct posture to be stressed upon in the dental schools. It has been noticed that, although most schools teach the correct and ideal dentist posture and positions, it is not always applied by the dental students [7]. It was reported that neither the students had any knowledge about the ergonomic posture nor they knew anything about the musculoskeletal hazards. After the training sessions many of them acknowledged that they experienced mild form of headache and back pain in between the working sessions. This proves that, musculoskeletal lesions could begin to appear at the beginning of their clinical practice as students, by acquiring inadequate postures and working habits that will accompany them for the rest of their professional life acquiring an unhealthy lifestyle in their work environment [24].

Implementation of ergonomics should be given due importance in the very primary stages of dental education. Only the practical prudence and foresight can bring about a revolution in the field of dentistry. Especially in a country like India, where ergonomics is considered a secondary issue and therefore neglected, there is a need for a widespread awareness in this regard. It has been stated by Biswas et al., that Ergonomics as a subject is still not widely prevalent in India; it therefore appears that the Dental Council of India should take interest in ergonomic issues. An initiative needs to be taken to include the subject as a part of dental curriculum particularly at the bachelor level [25]. The results of this particular study also echo a similar need and inclusion of this topic in the curriculum and it will definitely make the students understand and realize the importance of ergonomics.

Conclusion

The students are at high risk to develop MSDs if they are not corrected and guided to use the right posture at right time. The students need to know the importance of right posture in the beginning of the professional course which will enable them to work in the ergonomic workplace within the prescribed ranges. In dentistry, adequate equipment design with proper anthropometric requirements is obligatory to avoid the unhealthy postures. Ergonomics is the science of fitting work environment to the worker which demands more attention and focus on the students. Until the dental schools begin to train students a proper ergonomic technique we cannot expect the change in the present status. Manufacturers are developing the ergonomically designed equipments to prevent the musculoskeletal injuries which would help the dentists to work without restrictions. The present study has reported that, the use of ergonomic saddle stool could support the lumber region and maintain the natural curvature of the lower back at the same time magnification could bring the clearer view near to the operator instead of operator hunching over to get the view.

More research needs to be done to understand the role of ergonomics in dentistry. At the same time institutional interventions for ergonomic implementation and practice are anticipated for the benefit of the students.

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