Research Square

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Impact of early ergonomics exposure on awareness and postural assessment in second year pre-clinical undergraduate dental students

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Abstract

Background and objectives:

Dental health professionals are commonly associated with the development of musculoskeletal pain and soreness, which often progress gradually. Early introduction to right posture habit according to ergonomics is very important, so that can be practiced and followed in future work. Objective of the study was to compare the awareness and postural assessment related to dental operatory position among second-year preclinical undergraduate students before and after early exposure to ergonomics in dentistry.

Materials and Methods:

A prospective interventional study was conducted involving 60 second-year Bachelor of Dental Surgery (BDS) students recruited through simple random sampling. Each participant performed a standardized tooth preparation task in a simulated environment. During the procedure, ergonomic assessment was conducted using the Rapid Upper Limb Assessment (RULA) method by three trained observers. RULA scores were calculated by evaluating posture, muscle use, and force related to the upper limb, neck, trunk, and legs. The RULA scores and test scores (Pre and post awareness scores) obtained were then statistically analyzed.

Results:

There was a statistically significant improvement in both ergonomic awareness and postural scores following the intervention. Mean awareness scores decreased significantly across all observers ($p < 0.001$). Inter-observer reliability was high (Cronbach's alpha: pre 0.793, post 0.890). Most questionnaire and RULA items showed highly significant improvement ($p < 0.001$), except for questions related to attitudes toward continuing dental education and stretching exercises, which were already positive at baseline.

Conclusion:

A structured, simulation-based ergonomic awareness program significantly improved both knowledge and practical application of ergonomic principles among dental students. These findings support the integration of ergonomics into dental education to promote healthier work practices and reduce the risk of musculoskeletal disorders.

Introduction

Ergonomics as defined by the International Ergonomics Association (IEA) is the scientific discipline concerned with the understanding of the interaction between humans and as a profession that applies relevant theories, principles, data, and methods to design in order to optimize human well-being and

overall system performance.[1,2] The application of ergonomics has become a focal point across various fields promoting the overall well-being and safety of workers in the workplace.[1]

Dentistry is a profession commonly associated with the development of musculoskeletal pain and soreness, which often progress gradually. These symptoms are frequently overlooked until they become chronic and lead to permanent damage. Poor ergonomic practices, high workloads, and lack of awareness contribute to the high prevalence of MSDs, particularly neck and lower back pain, among dental students and professionals.[3,4]

Early introduction to right posture habit according to ergonomics is very important, so that can be practiced and followed in future work. Second-year students as they just started their work on mannequins, must be properly exposed to term ergonomics and proper postural habits. So, the early exposure of ergonomics in the second-year pre-clinical students' needs time.[9] Given the growing concern over work-related musculoskeletal disorders among dental professionals and students, there is a clear need to assess the impact of early ergonomics education. Also, there is a gap between theoretical knowledge and practical application of ergonomics. Therefore, proper work-related posture is important to reduce musculoskeletal pain, improve clinical efficiency and longevity of the dentist.[5–9]

This study aims to evaluate the effect of introducing ergonomic principles to second-year pre-clinical students by assessing their awareness and postural behavior before and after early clinical exposure. The findings may support the integration of ergonomics training early in the dental curriculum.

Material and methods

Study design

An educational interventional prospective study was conducted on second year pre-clinical students in the Department of Prosthodontics and Crown and Bridge.

Ethical Considerations

The study was approved by MGVs KBH dental college and hospital, Nashik; Institutional Ethical Committee ((MGV/KBHDC/897/2020-21) This study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Participation for the research study was voluntary and anonymous, with no incentives provided. Informed written consent was obtained from all the participants before start of study including the publication of results of the study.

Study population and settings:

This study was designed as an educational interventional study and included 60 second-year undergraduate dental students aged 18 years and above. The participants were selected using a simple random sampling method. (Clinical trial number: not applicable) Only second-year students attending

pre-clinical postings were included, while students from other years, interns, and postgraduates were excluded. A written informed consent was obtained from all participants prior to inclusion in the study. All participants completed a standardized assignment (maxillary central incisor tooth preparation). The questionnaire format was made to evaluate awareness among the students and postural assessment is performed by using the RULA method.

Study intervention:

First Phase- Postural assessment from video recordings was assessed by RULA methodology and analysis of knowledge about ergonomics was checked by using questionnaire format of the preclinical undergraduate student before awareness program. (Fig. 1)

Second Phase- After the first visit awareness program was conducted. The ergonomics term was explained and the application of ergonomics in dentistry was discussed in a broad sense. The correct ergonomic posture was shown to students practically. The wrong postures reduce the working efficiency and longevity of dentists, how? Such questions were discussed. Also, a question-answer session was conducted at the end of the awareness program.

Third Phase- After the awareness program knowledge of students was checked by using the same questionnaire response format and also standardized video (visuals) recordings were taken while participants were performing given exercise.

Fourth Phase- Comparison of questionnaire response format and visual assessment before and after awareness program was done. The comparison was done for-

1. Questionnaire response format scores were compared (First score).
2. Visual recordings were obtained before and after the awareness video, and RULA scores were calculated from these recordings and subsequently compared (Second score) (Fig. 2).

Body is divided into two different sections (Section A –upper arm, lower arm and wrist. Section B – neck, trunk and legs

For each section three scores were calculated

Posture score

Muscle use score

Force score

Assessing the movements, postures are given scores in the range of 1 to 7 or more. If minimal risk factor given a lesser number and as risk factors or deviation from standard ergonomic posture increases, posture score shifts to higher number. It was a final score obtained from RULA assessment

sheet. From that score level of MSD risk detected. The muscle use score is estimated by increasing the score by 1. The force score was then calculated for postures which exert force or maintain external load while working, the force score ranges from 0 to 3 (according to the external load value range).[6] The questionnaire response format results (both pre as well as post awareness programme) were analyzed quantitatively for awareness of ergonomics.

By using section A and B scores, grand score from section C was determined that grand score was the final RULA score for that posture (RULA sheet).[6] Comparison of postural assessment were performed by statistical analysis of collected pre and post-awareness postural scores.

Statistical analysis

Paired T-test for statistical analysis, Inter-observer One-way ANOVA.

Results

The study highlighted a notable enhancement in ergonomic awareness and postural practices among second-year dental students following an educational intervention. As shown in Table 1, paired t-test analysis revealed a significant decrease in mean awareness scores from pre- to post-awareness across all three observers (Observer 1: 6.33 to 5.72; Observer 2: 6.42 to 5.72; Observer 3: 6.42 to 5.75; all $p < 0.001$), indicating increased awareness and understanding after the intervention. One-way ANOVA showed no significant differences between observer scores either before or after the awareness program, supporting the assessment process's standardization and objectivity (Table no 1 Graph no 1 to 3). The use of a standardized operative task (maxillary central incisor preparation) ensured procedural uniformity, thereby isolating posture as the primary variable. The integration of standardized visual recording further enhanced objectivity and reproducibility.

Observer variation was one of the most important aspects. Pre and post inter observer variation for the postural assessment was not significant (Table 2) which showed the importance a prior training of all three observers for the research work. The postural assessment analysis and reporting in the form of RULA score was very precisely covered during structured training of observers.

The reliability of the awareness questionnaire was assessed using Cronbach’s alpha. The pre-awareness scale demonstrated good internal consistency ($\alpha = 0.793$), while the post-awareness scale showed improved reliability ($\alpha = 0.890$) (Table 3). Values above 0.70 are generally considered acceptable, while values approaching 0.90 indicate strong internal coherence among items. The inter-observer reliability was high, with Cronbach’s alpha values of 0.793 pre-awareness and 0.890 post-awareness, confirming the questionnaire's good internal consistency.

Postural assessment using the Wilcoxon Signed Ranks test demonstrated statistically significant improvements across multiple components following intervention ($p < 0.001$ for most paired

comparisons) (Table 4). The dominance of positive ranks and absence of negative ranks in several domains indicate a clear directional improvement in ergonomic posture. These findings align with previous studies reporting that early ergonomic sensitization significantly improves working posture among dental students.[7–13]

Discussion

This study confirms that a structured awareness program can significantly enhance both the theoretical understanding and practical application of ergonomic principles among dental students. The use of the RULA method provided objective, reliable postural assessment, with inter-observer agreement ensuring consistency. The significant improvement in post-intervention scores aligns with previous findings that targeted ergonomic education and hands-on demonstrations are effective in improving ergonomic behaviour and reducing risk factors for musculoskeletal disorders.1

The lack of significant change in some attitude-based questions suggests that students already recognized the importance of ongoing education and stretching exercises prior to the intervention, reflecting a generally positive baseline awareness. However, the marked improvement in knowledge and practical application underscores the need for integrating ergonomics into the dental curriculum, as students initially demonstrated limited understanding of ergonomics and its implications in dental practice. The results echo earlier studies emphasizing the gap between theoretical knowledge and its practical implementation, and the value of continuous ergonomic training in dental education. Overall, this study highlights the effectiveness of simulation-based ergonomic training in promoting safer work habits and reducing the risk of musculoskeletal disorders among dental students, supporting recommendations for the inclusion of ergonomics as a core component of dental education.

Observer calibration is central to minimizing measurement bias in ergonomic research. In this study, inter-observer variability was assessed both before and after intervention. One-way ANOVA revealed no statistically significant differences among the three observers in pre-awareness scores ($p = 0.667$) and post-awareness scores ($p = 0.927$) (Table 2). The absence of significant variation indicates strong agreement and confirms the effectiveness of prior structured training.

All observers underwent standardized calibration sessions focusing on accurate interpretation of the Rapid Upper Limb Assessment (RULA) scoring criteria. The RULA method has been widely validated as a reliable ergonomic assessment tool in occupational and clinical settings. By ensuring uniform understanding of joint angles, trunk inclination, neck posture, and upper limb positioning, subjective interpretation bias was minimized.The consistency observed across observers strengthens the internal validity of the study. Improvements in postural scores following intervention can therefore be attributed

to the ergonomics training rather than assessor variability. In educational intervention research, especially when observational tools are employed, such calibration is critical for methodological rigor

McAtamney and Corlett et al introduced the Rapid Upper Limb Assessment (RULA) method, a practical and equipment-free tool for evaluating work-related upper limb disorders.[10] The method assigns risk scores to various postures, where higher scores indicate greater risk, making it a valuable and accessible screening tool for workplace assessments. Gandavadi et al used RULA to compare dental students' postures on conventional versus ergonomic seats, finding that conventional seating led to higher RULA risk scores and thus greater predisposition to MSDs, while ergonomic seating like the Bambach Saddle Seat promoted healthier postures.[11,12] Dental professionals are known to be at high risk for work-related musculoskeletal disorders (MSDs), often beginning during undergraduate training. Early correction of postural habits may therefore serve as a preventive strategy rather than a remedial one.

In our present study RULA (rapid upper limb assessment) is a survey method developed for use in ergonomics where work-related upper limb disorders are reported.[6] The postural assessment was done by comparison of pre-awareness and post-awareness postural RULA scores. For the standardization of results and to avoid bias in study three trained observers were appointed to watch the recorded postural videos and give the scores accordingly. A similar process repeated after the awareness program i.e. recording of posture observation of recorded videos by three observers and scoring were done. Both the scores pre-awareness and post awareness were compared by statistical tests. The improvement in Cronbach's alpha following intervention suggests not only enhanced knowledge but greater conceptual clarity among participants. Post-intervention responses appeared more aligned, reflecting a more structured understanding of ergonomic principles. This pattern indicates that the educational exposure strengthened cognitive integration of concepts such as chair positioning, operator posture, instrument handling, and stretching practices.

Improved internal consistency post-intervention has been reported in similar educational intervention studies, where structured training enhances both knowledge levels and response stability.

The pre and post questionnaire shows highly significant results except for question 7 & 10 which shows no significant results. This could be due to the students having some knowledge regarding continuing dental education and the importance of stretching exercises in the dental profession. So, statistically, it is not significant but students have some knowledge about following topics before awareness program is the positive aspect related to our research work.[13–17]

The correct ergonomic posture was shown to students practically. The wrong postures reduce the working efficiency and longevity of dentists, how? Such questions were discussed. Also, a question-answer session was conducted at the end of the awareness program.[2,8] This is following the study by Gupta S et al and Patrica P who co-related the theoretical knowledge and its practical applications.[2,8] Each student responded to a multiple-choice questionnaire on the requirements of ergonomic posture.[8]

The questionnaire format is designed for the assessment of the knowledge of the students before and after awareness about ergonomics in dentistry. In the questionnaire response sheet, the questions are attitude-based, theoretical knowledge-based, and practical knowledge base.[12–19] For the assessment of knowledge pre-awareness and post-awareness questionnaire responses were compared and the significance of theoretical explanation of the concept by lectures, by video demonstration, by a practical demonstration was checked. The questionnaire response sheet comparison shows highly significant results.

For the knowledge assessment questionnaire response sheet was used and for postural assessment, RULA's postural assessment methodology was used. And both knowledge, as well as the practical implication, were checked by comparing before and after awareness program questionnaire responses and RULA score.[18,19] The findings highlight the importance of introducing ergonomics training during the pre-clinical phase. Postural habits formed early in professional education tend to persist into clinical practice. Integrating ergonomics into the undergraduate curriculum may therefore reduce long-term musculoskeletal morbidity among dental practitioners.

Importantly, the study demonstrates that structured training influences not only awareness but also observable behavioral outcomes. The simultaneous improvement in RULA scores and questionnaire reliability suggests that knowledge translation into practice occurred effectively.

Novelty of present study

Students were at high risk of MSD when they were not aware of standardized ergonomic posture. After awareness of students about standardized ergonomic posture, potential risks were relatively least found. Early awareness is the best solution for almost every problem, so the early ergonomics exposure of the second-year pre- clinical students is considered in the present study.

Strengths of the study

Strengths of the study include observer calibration, use of a validated ergonomic assessment tool, objective visual documentation, and reliability testing of the awareness instrument. These methodological elements enhance internal consistency and reproducibility.

Limitations of the study

The training for postural assessment by RULA method is very crucial aspect for the study. Training of all three accessors and procedural recording of each participant may be overlooked with the digital way to make it simpler and time bound. However, the study was conducted within a single institutional cohort and evaluated short-term outcomes. Longitudinal assessment would be valuable to determine sustainability of ergonomic improvements during clinical postings.

Conclusion

Within the limitations of the study, results demonstrates that a focused awareness program-combining theoretical knowledge, practical demonstrations, and interactive discussions-significantly improves students' understanding and application of ergonomic principles, as reflected by highly significant improvements in both questionnaire and RULA postural assessment scores. There is a need for the inclusion of ergonomics in the dental curriculum in a more sophisticated manner than the dental student can understand in a better way, also stressing not only on the theoretical knowledge but more on practical implication is need of time. Second-year students as they just started their work on the mannequin, should be properly exposed to the term ergonomics. Ergonomics awareness helps in the application and contributes significantly to the safety of dentists as per the results of the study.

Declarations

Ethical approval

The study received approval from the Institutional Ethics Committee of MGV's KBH Dental College and Hospital, Nashik (Approval No: MGV/KBHDC/897/2020–21). All procedures carried out in this research were performed in accordance with the ethical standards outlined in the Declaration of Helsinki.

Consent to participate

Written informed consent was obtained from all participants before their inclusion in the study. Participation was entirely voluntary, and the responses were recorded anonymously. No incentives or compensation were provided to the participants.

Consent to publish

All participants provided written informed consent for the publication of data and any identifiable images included in this study.

Competing interests

The authors declare that they have no competing interests related to this study.

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Author Contribution

AT conceived and designed the study, supervised the overall research process, carried out the statistical analysis, and prepared the initial manuscript draft.SB assisted in data collection and conducted the literature review.TK contributed to the study design, development of the methodology, and interpretation of the findings.MB supported data compilation and assisted in manuscript preparation.MS contributed to statistical validation and critically reviewed the manuscript for important intellectual content.AD assisted in data analysis and helped refine the manuscript through editing.All authors reviewed and approved the final version of the manuscript.

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Data Availability

The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.

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Tables

Table 1: Paired T-Test: Pre and post awareness assessment showing the post assessment awareness was highly significant.

Awareness of ergonomics						
	Mean score	N	SD	T	Df	P value
Pre-awareness OBSERVER 1	6.33	60	0.542			
Post-awareness OBSERVER 1	5.72	60	0.524	8.6	59	< 0.001; Highly significant
Awareness of ergonomics	Mean score	N	SD	T	Df	P value
Pre-awareness OBSERVER 2	6.42	60	0.619			
Post-awareness OBSERVER 2	5.72	60	0.555	9.7	59	< 0.001; Highly significant
Awareness of ergonomics	Mean score	N	SD	T	Df	P value
Pre-awareness OBSERVER 3	6.42	60	0.591			
Post-awareness OBSERVER 3	5.75	60	0.541	10.1	59	< 0.001; Highly significant

Table 2: Inter-observer One-way ANOVA

Awareness of ergonomics		N	Mean score	SD	F	df	P value
Pre-awareness score	Observer 1	60	6.33	0.542	0.406	2	0.667; Not significant
	Observer 2	60	6.42	0.619			
	Observer 3	60	6.42	0.591			
	Total	180	6.39	0.583			

Awareness of ergonomics		N	Mean score	SD	F	df	P value
Post-awareness score	Observer 1	60	5.72	0.524	0.076	2	0.927; Not significant
	Observer 2	60	5.72	0.555			
	Observer 3	60	5.75	0.541			
	Total	180	5.73	0.537			

Table 3: Cronbach's Alpha is a measure of internal consistency of a questionnaire that is made of multiple Likert-type scale/items. The internal consistency of the awareness questionnaire was assessed using Cronbach's alpha. The pre-awareness scale demonstrated good reliability (α = 0.793), while the post-awareness scale showed better reliability (α = 0.890), indicating improved internal consistency following the intervention.

Scale	Cronbach's Alpha	Number of Items (Observers)	Interpretation
Pre-awareness Score	0.793	3	Good reliability
Post-awareness Score	0.890	3	Better reliability

Table 4: Wilcoxon Signed Ranks Test: Postural Assessment- Pre and post analysis.

Pairs		N	Mean Rank	Sum of Ranks	Z	P value
PostQ2 - PreQ2	Negative Ranks	$_{0}$a	0.00	0.00	-6.41	< 0.001; Highly significant
	Positive Ranks	51^{b}	26.00	1326.00		
	Ties	$_{9}$c				
	Total	60				
PostQ3 - PreQ3	Negative Ranks	$_{0}$d	0.00	0.00	-4.90	< 0.001; Highly significant
	Positive Ranks	24^{e}	12.50	300.00		
	Ties	36^{f}				
	Total	60				
PostQ4 - PreQ4	Negative Ranks	$_{0}$g	0.00	0.00	-4.24	< 0.001; Highly significant
	Positive Ranks	18^{h}	9.50	171.00		
	Ties	42^{i}				
	Total	60				
PostQ5 - PreQ5	Negative Ranks	$_{0}$j	0.00	0.00	-6.9	< 0.001; Highly significant
	Positive Ranks	56^{k}	28.50	1596.00		
	Ties	$_{4}$l				
	Total	60				
PostQ6 - PreQ6	Negative Ranks	$_{1}$m	20.50	20.50	-6.4	< 0.001; Highly significant
	Positive Ranks	49^{n}	25.60	1254.50		
	Ties	10^{o}				
	Total	60				
PostQ7 - PreQ7	Negative Ranks	$_{0}$p	0.00	0.00	0.00	1.000; Not significant
	Positive Ranks	$_{0}$q	0.00	0.00		
	Ties	60^{r}				
	Total	60				

PostQ12 - PreQ12	Negative Ranks	$_{0}$ae	0.00	0.00	-7.13	< 0.001; Highly significant
	Positive Ranks	$_{60}$af	30.50	1830.00		
	Ties	$_{0}$ag				
	Total	60				

b. PostQ2 > PreQ2; e. PostQ3 > PreQ3; h. PostQ4 > PreQ4; k. PostQ5 > PreQ5; n. PostQ6 > PreQ6; q. PostQ7 > PreQ7; af. PostQ12 > PreQ12

Pairs		**N**	**Mean Rank**	**Sum of Ranks**	**Z**	**P value**
PostQ8 - PreQ8	Negative Ranks	$_{0}$s	0.00	0.00	-4.00	< 0.001; Highly significant
	Positive Ranks	16^{t}	8.50	136.00		
	Ties	44^{u}				
	Total	60				
PostQ9 - PreQ9	Negative Ranks	$_{0}$v	0.00	0.00	-7.14	< 0.001; Highly significant
	Positive Ranks	51^{w}	26.00	1326.00		
	Ties	$_{9}$x				
	Total	60				
PostQ10 - PreQ10	Negative Ranks	$_{0}$y	0.00	0.00	-1.73	0.083; Not significant
	Positive Ranks	$_{3}$z	2.00	6.00		
	Ties	$_{57}$aa				
	Total	60				
PostQ11 - PreQ11	Negative Ranks	$_{0}$ab	0.00	0.00	-7.75	< 0.001; Highly significant
	Positive Ranks	$_{60}$ac	30.50	1830.00		
	Ties	$_{0}$ad				
	Total	60				

t. PostQ8 > PreQ8

w. PostQ9 > PreQ9

z. PostQ10 > PreQ10 ac. PostQ11 > PreQ11

Pairs		N	Mean Rank	Sum of Ranks	Z	P value
PostQ13 - PreQ13	Negative Ranks	28ah	14.50	406.00	-5.29	< 0.001; Highly significant
	Positive Ranks	0ai	0.00	0.00		
	Ties	32aj				
	Total	60				
PostQ14 - PreQ14	Negative Ranks	0ak	0.00	0.00	-4.12	< 0.001; Highly significant
	Positive Ranks	17al	9.00	153.00		
	Ties	43am				
	Total	60				

ah. PostQ13 < PreQ13 ai. PostQ13 > PreQ13 aj. PostQ13 = PreQ13 ak. PostQ14 < PreQ14 al. PostQ14 > PreQ14 am. PostQ14 = PreQ14

Graphs

Graphs 1 to 3 are available in the Supplementary Files section

Figures



Fig 1: Representative pre- and post-awareness images of the same participant illustrating significant improvement in postural alignment following the ergonomics awareness intervention.

Figure 1

See image above for figure legend

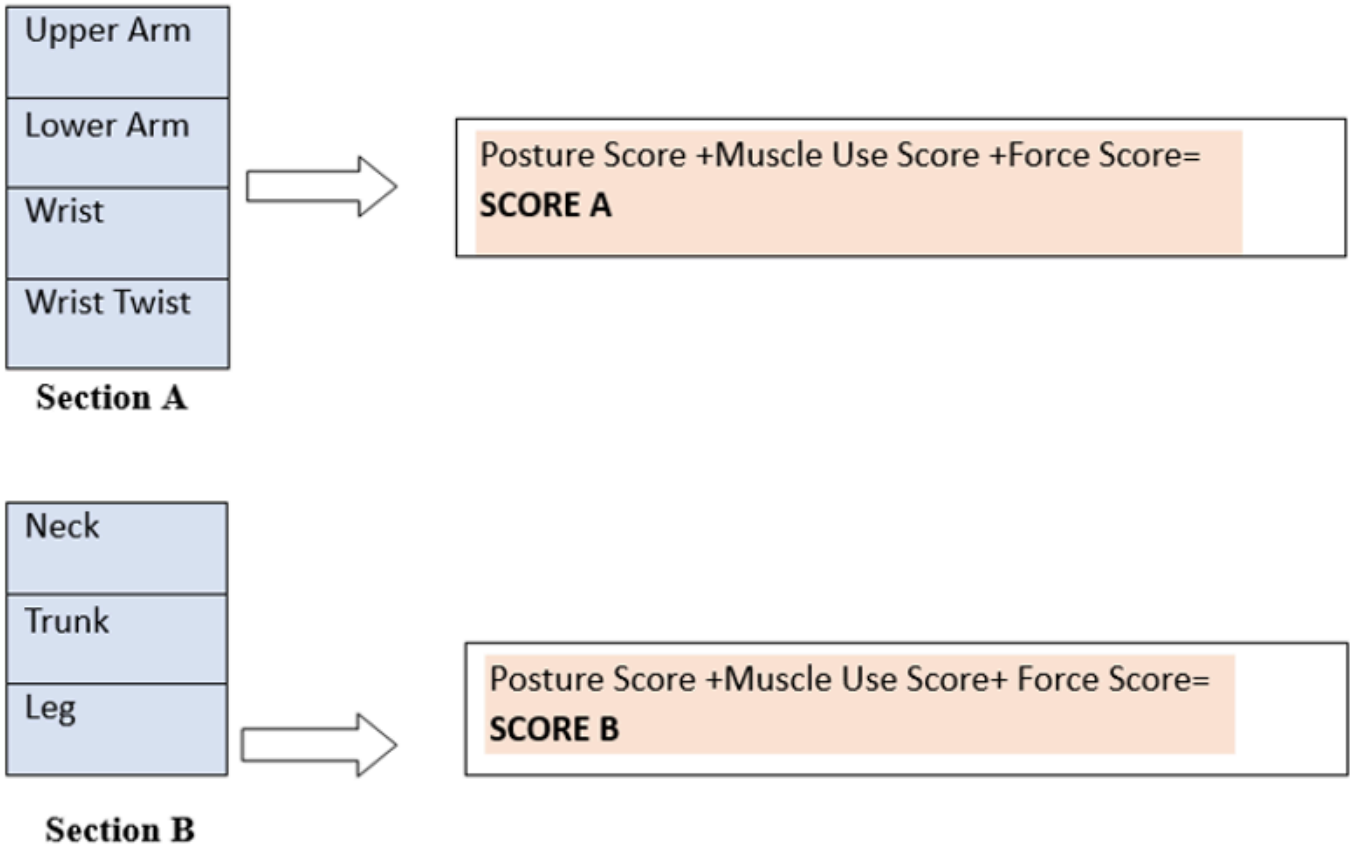


Fig 2 Schematic representation of the Rapid Upper Limb Assessment (RULA) scoring system showing Section A (upper arm, lower arm, wrist, and wrist twist) and Section B (neck, trunk, and leg) components with calculation of score A and score B. (Total Score= Score A + Score B)

Figure 2

See image above for figure legend

Supplementary Files

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