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Working postures of dental students: ergonomic analysis using the Ovako Working Analysis System and Rapid Upper Limb Assessment

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Key words

Musculoskeletal disorders; occupational diseases; dental students

Parole chiave

Summary

Background: *As dentistry is a profession that demands a manipulative precision of hand movements, musculoskeletal disorders are among the most common occupational diseases.* **Objectives:** *This study estimated the risk of musculoskeletal disorders developing in dental students using the Ovako Working Analysis System (OWAS) and Rapid Upper Limb Assessment (RULA) methods, and estimated the diagnostic agreement between the 2 methods.* **Methods:** *Students (n = 75), enrolled in the final undergraduate year at the Araraquara School of Dentistry – UNESP – were studied. Photographs were taken of students while performing diverse clinical procedures (n = 283) using a digital camera, which were assessed using OWAS and RULA. A risk score was attributed following each procedure performed by the student. The prevalence of the risk of musculoskeletal disorders was estimated per point and for a 95% CI. To assess the agreement between the 2 methods, Kappa statistics with linear weighting were used. The level of significance adopted was 5%.* **Results:** *There was a high prevalence of the mean score for risk of musculoskeletal disorders in the dental students evaluated according to the OWAS method (p = 97.88%; 95% CI: 96.20–99.56%), and a high prevalence of the high score (p = 40.6; 95% CI: 34.9–46.4%) and extremely high risk (p = 59.4%; 95% CI: 53.6–65.1%) according to RULA method. Null agreement was verified (k = 0) in the risk diagnosis of the tested methods.* **Conclusion***: The risk of musculoskeletal disorders in dental students estimated by the OWAS method was medium, whereas the same risk by the RULA method was extremely high. There was no diagnostic agreement between the OWAS and RULA methods.*

Riassunto

«Posture di lavoro di studenti in odontoiatria: valutazione ergonomica utilizzando il sistema di analisi del lavoro Ovako e quello rapido degli arti superiori». **Introduzione:** *I disturbi muscolo-scheletrici sono tra le malattie professionali più comuni tra gli odontoiatri, la cui attività professionale richiede una manipolazione precisa dei*

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movimenti della mano. **Obiettivi:** *Questo studio ha valutato il rischio di sviluppare disturbi muscolo-scheletrici negli studenti di odontoiatria utilizzando i metodi Ovako Working Analysis System (OWAS) e Rapid Upper Limb Assessment (RULA). E' stata inoltre valutata la concordanza diagnostica tra i due metodi.* **Metodi:** *Sono stati esaminati gli studenti (n = 75) iscritti all'ultimo anno del corso di laurea presso la Scuola di Odontoiatria di Araraquara – UNESP. Sono state scattate fotografie degli studenti durante l'esecuzione di diverse procedure cliniche (n = 283), utilizzando una fotocamera digitale. Le diverse procedure sono state valutate utilizzando i metodi OWAS e RULA ed è stato attribuito un punteggio di rischio dopo ogni procedura eseguita dallo studente. Si è stimata la prevalenza (e gli Intervalli di Confidenza al 95%) del rischio di disturbi muscolo-scheletrici. Per valutare la concordanza tra i due metodi, sono state utilizzate statistiche Kappa con ponderazione lineare. Il livello di significatività adottato era del 5%.* **Risultati:** *È stata rilevata un'elevata prevalenza del punteggio medio per il rischio di disturbi muscolo-scheletrici negli studenti di odontoiatria valutati secondo il metodo OWAS (p = 97,88%; 95% IC: 96,20-99,56%) e una prevalenza elevata di punteggio alto (p = 40,6, 95% IC: 34,9-46,4%) e di rischio estremamente elevato (p = 59,4%, 95% IC: 53,6-65,1%) secondo il metodo RULA. La concordanza verificata nella diagnosi di rischio dei metodi valutati era nulla (k = 0).* **Conclusione:** *Il rischio di disturbi muscolo-scheletrici negli studenti di odontoiatria valutati con il metodo OWAS era medio, mentre lo stesso rischio con il metodo RULA era estremamente elevato. Non è stata rilevata alcuna concordanza diagnostica tra i metodi OWAS e RULA.*

Introduction

Dentistry is a profession that demands a high degree of visual and manipulative precision of hand movements (5, 14, 35). In this profession, musculoskeletal disorders are among the most common and debilitating occupational diseases (10, 14, 24, 31) and must be diagnosed as early as possible.

Among the methods used for risk assessment of upper limb musculoskeletal disorders, the most commonly used method of diagnosis in dentistry are self-reports (1, 3, 13, 25, 32, 34). Although self-reporting provides a large amount of data at a low cost, they are subjective in nature, which makes the reliability and validity of the data difficult to establish (15) and are appropriate only for exploratory studies. Therefore, observational and direct methods are recommended to obtain a better understanding of the effects of body posture on the articulations of the musculoskeletal system. Due to their relatively low cost, in addition to broad capacity, versatility, generality, and acceptable precision, the use of observational methods is widespread (15).

Although there are no observational methods in dentistry designed specifically for the assessment of postural load for the workers in this profession, it has been seen in the literature that the Rapid Upper Limb Assessment (RULA) (28) has been used for the study of this population (4, 11). This method is used for the assessment of upper limb postural stress, normally present in sedentary workers (6, 7, 28). However, as RULA is based on measurements of angular deviations of the upper and lower limbs, neck, and trunk to determine the final risk score, its application requires a longer period of training, which may compromise its systematic use.

Thus, it is desirable to use other observational methods that allow the risk of developing musculoskeletal disorders in dentistry to be assessed rapidly and require a shorter training time.

The Ovako Working Analysis System (OWAS) (18) also assesses the posture of the upper and lower limbs, is relatively simple and offers a more generalized analysis of body movements. This makes it easy to observe a large number of postures (7) and may also be an option for assessing working postures in dentistry.

Both OWAS and RULA are methods that are well adapted to the demands of occupational health, are practical for analyzing the workplace and not only identify observed problems but also provide guidance for their correction (20). OWAS has the additional advantage of requiring only a few seconds to assess and record posture.

Considering that both of these methods may be used to assess postural stress in dentistry, it is important to estimate agreement on the risk diagnosis

of musculoskeletal disorders between these 2 methods and to understand how these different methods detect risk in this population. This concern is justified since OWAS may make it easier and quicker to diagnose risk. This favours the performance of systematic postural evaluations among professionals in the field of dentistry with the intent of preventing musculoskeletal disorders, particularly in those who are still in the student stage. However, there are few studies of this nature in the literature (3, 12, 26, 29, 32).

The aim of this study was to estimate the risk of developing musculoskeletal disorders in dentistry undergraduates using the OWAS and RULA methods, and to assess concordance of the final risk score for the development of musculoskeletal disorders between them.

Method

Study population

This was an observational study and included 75 students of both genders. These students enrolled when they were in their final undergraduate year at the Araraquara School of Dentistry – UNESP – and agreed to participate (CEP-FOAr 40/08) and signed an Informed Consent Form. The study participation rate among these students was 100%. The students were assessed with regard to working postures adopted during the performance of various clinical procedures (n = 283) for a period of 6 months.

The students worked in pairs, one acting as the operator and the other as the assistant, using the philosophy of four-handed work. They worked an average of 3 hours in the morning, and 3 hours in the afternoon. The dental equipment, such as the dental chair, the seat, and the light reflector, were adjusted to the specific measurements of each student.

Recording of working postures

Working postures were recorded by taking digital photographs of the student operator at least 10 minutes after the start of the operative procedure. This procedure was designed to allow the students to feel comfortable in their work positions (11, 12). After the first photograph was taken, photographs of the postures were then taken for approximately 30 minutes in the case of each student (2, 4). The most frequent posture noted while performing a procedure was the one selected for analysis, using both the OWAS and the RULA methods. Overall comparative analysis was performed on 283 procedures.

In a pilot study, 3 strategic points for taking photographs were delimited.

Posture assessment method

The working postures adopted by each student during his or her time as "operator" were asessed using the Ovako Working Analysis System (OWAS*)* method proposed by Karhu et al. (18) and the rapid upper limb posture assessment method - RULA (Rapid Upper Limb Assessment), recommended by McAtamney and Corlett (28).

The OWAS method consists of a total of 84 working postures at the level of the trunk, upper, and lower extremities, and considers an estimate of the load manipulated in connection with the posture. In OWAS, each posture is classified by means of a 4-digit code that represents the posture of the trunk (neutral, flexion, rotation, flexion, and rotation), upper limbs (both below the shoulders, one above the shoulder, and both above the shoulder), lower limbs (seated, standing up with bilateral support, standing up with unilateral support, knees flexed, unilateral support with knee flexed, kneeling, and walking) and work load (less than 10 kg, from 10-20 kg and over 20 kg). In this study, the lowest possible force/load presented by OWAS was standardized; that is to say, less than 10 kg, due to the low force/load used in dentistry.

After postural assessment a final score is obtained, which falls into 1 of 4 categories: Score 1: acceptable posture, without need for change; Score 2: posture with some harmful effects on the musculoskeletal system, without need for immediate action; Score 3: posture manifesting harmful effects requiring a change in the working method as soon

as possible; Score 4: working posture with an extremely harmful effect requiring immediate changes (16, 27).

The RULA method uses an individual posture assessment diagram that allows for assessment of exposure to risk factors for development of musculoskeletal disorders by using risk scores.

According to RULA, a score is attributed to a region of the body with the lowest value related to postures in which minimal risk factors are present. The regions of the body assessed are the arm (extension from 20° to flexion of 20°, extension greater than 20° or 20° to 45° of flexion, flexion of 45° to 90°, and flexion of 90° or more); forearm (flexion of 60° to 100° and flexion of 90° or more); wrist (neutral position, flexion or extension of 0 to 15°, and flexion or extension greater than 15°); wrist torsion (half distance of torsion and complete torsion); neck (flexion of 0 to 10°, flexion of 10° to 20°, flexion greater than 20°, and if in extension); trunk (seated posture and well supported with the trunk/hips forming a 90° angle with the thighs, flexion of 0 to 20°, flexion of 20° to 60°, flexion greater than 60°) and legs (seated, with legs and feet well supported, with body weight equally distributed; or standing up, with body weight equally distributed between the legs, with space to change position of legs and feet with adequate support or body weight poorly distributed).

After obtaining the postural scores for each body part, the form of the muscular action is also evaluated (posture that is not static and with repetition lower than 4 times per minute; posture that is static for a period of less than 1 minute and posture that is permanently static for a period longer than 1 minute; or posture that is not static repeated more than 4 times per minute) and the force/load to which it is submitted (absence of resistance, intermittent force or load of less than 2 kg, load from 2-10 kg with intermittent force and load of 10 kg or more with static posture, 10 kg or more with repeated force, collision or force with rapid increase). In this study, an intermittent force or load less than 2 kg was standardized.

After assessment, a final score was obtained, which ranged from 1-7. According to McAtamney and Corlett (28) scores from 1 to 2 are considered low risk and are considered acceptable; scores of 3 and 4 are medium risk, with future investigations being necessary in order to make changes in posture in the long term; scores of 5 and 6 indicate high risk, requiring operators to be quickly investigated so that changes can be made in the short term; and a score of 7, which indicates an extremely high risk and requires immediate investigations and changes in these working postures to reduce excessive load on the musculoskeletal system and risk of injury to the operator.

As RULA only assesses 1 side at a time, it was decided for this study that for both RULA and OWAS only the working side of the student would be analyzed in order to standardize the assessments.

Assessment of procedures performed

The photographs of students performing different procedures were assessed after examiner reliability ($\kappa_{OWAS} = 1.00$; $\kappa_{RULA} = 0.76$). The photographs were visually analyzed. To measure the angular deviations of body regions evaluated by OWAS and by RULA, it was necessary to use the Image Tool programme (Wilcox DC, Dove SB, McDavid WD, Greer DB. UTHSCSA ImageTool: Version 3.0. Available at: http://ddsdx.uthscsa.edu/dig/itdesc.html).

To estimate the agreement between the OWAS and RULA methods, the individuals were initially classified based on the recommendations for final classification of each method. Then the final scores obtained in RULA were adapted according to the OWAS score as shown in figure 1.

Statistical planning

A. Pilot study

In order to assess the intra-examiner reliability of the postural assessments, a reproducibility study was conducted within the pilot study. In this study, the researcher examined the postures adopted by the undergraduate students in duplicate while performing 50 clinical procedures, with an interval of

Risk Classification	Score OWAS	Score RULA
Absent	1	1 and 2
Low/Medium	2	3 and 4
High	3	5 and 6
Extremely High	4	7

Figure 1 - Classification of subjects for agreement study. Araraquara, 2010

1 week between assessments, for both the OWAS and the RULA methods.

The intra-examiner concordance of the risk score for the development of musculoskeletal disorders was estimated using Kappa statistics with linear weighting (23). Regarding the value of κ obtained, the degree of concordance between the data was scored according to the proposal of Landis and Koch (21). In this study, an intra-examiner concordance level that scored at least "Good" was considered adequate (21).

B. Statistical analysis

Descriptive statistics were performed. The prevalence of the risk of musculoskeletal disorders according to each method was estimated per point and at a 95% confidence interval (CI). To assess the agreement between the methods, Kappa statistics with linear weighting were used (k). The level of significance adopted was 5%.

Results

More than half of the clinical procedures were performed with 4 hands (65.37%); these included rehabilitation treatments (60.78%) and those specifically in the maxillary arch (57.6%).

The prevalence of risk of upper limb musculoskeletal disorders by the different methods is shown in table 1.

The disparity in the risk classification obtained by the different methods was considerable. Agreement between the methods was null (κ = 0).

Table 1 - Prevalence (p($IC_{95\%}$)) of risk of upper limb musculoskeletal disorders estimated by OWAS and RULA. Araraquara, 2010

Risk Classification	p ($IC_{95\%}$) OWAS*	p ($IC_{95\%}$) RULA*
Low	2.1 (0.4-3.8)	-
Medium	97.9 (96.2-99.6)	-
High	-	40.6 (34.9-46.4)
Extremely High	-	59.4 (53.6-65.1)

*OWAS: Ovako Working Analysis System, RULA: Rapid Upper Limb Assessment

Discussion

Early diagnosis of musculoskeletal disorders and the implementation of preventive measures (particularly at the professional training stage) are essential for the maintenance of health and productivity of workers in general (18, 33) and for professionals in the field of dentistry (14, 22, 31,36).

According to Karhu et al. (17), since there are many methods that evaluate the risk of developing these disorders, for early and precise diagnosis the selection of one of the methods must be based on the specific needs of each profession. In dentistry, as there is a high visual demand as well as the need for great precision of hand movements, there is high risk of disorders affecting the upper limbs (9, 22, 30, 31). Therefore, a diagnostic method that meets the requirements of these characteristics should be chosen.

The ISO 11228 Standard, Part 3, cites several methods for detailed assessment of the risk of developing musculoskeletal disorders and recommends the Occupational Repetitive Action (OCRA) method. Although in a superficial analysis, the OCRA method could be indicated to assess the work of the dental surgeon, it was not used in this study because this method assesses a standardized work cycle, which is more easily observed on production lines. In dentistry, due to the high visual demand and need for high precision, in addition to repetitive work, there is also static posture. Additionally, in dentistry there is no work cycle with standardized movements and times; therefore, using OCRA would be too time-consuming, making

it difficult to quickly assess the students during work (14). Furthermore, according to the same ISO 11228 Standard, methods such as the OWAS and RULA are geared more towards work posture, which should be observed during the training stages of a dental surgeon.

Thus, in this study, the OWAS and RULA methods were used to evaluate the risk of musculoskeletal disorders among dentistry undergraduates (4, 11). These methods belong to the observational category and were chosen because they are practical, relatively inexpensive, easy to use, and do not interfere in the work process (2). In the present study, postural evaluation was made by means of taking photographs over a certain period of time. However, both OWAS (17) and RULA (28) allow postural evaluation by means of filming, in which a specific part of the film may be selected for evaluation. Therefore, it is suggested that future research should be conducted using this methodology.

Using the OWAS method, it was shown that the students presented a medium risk of developing musculoskeletal disorders during performance of the procedures evaluated. Whereas the RULA method showed a high prevalence of high and extremely high risk scores, which resulted in null agreement between the methods.

This may be explained by examining the characteristics inherent to each method. The work of developing the OWAS method was started in Ovako Oy, which is a private company producing steel bars, profiles, wire and pig iron (17). Although the context in which OWAS was developed and validated differed from that of dentistry, its easy, fast and practical application encouraged its use in the work of dentistry (17, 18). After conducting this study, it was found that this method provides a more generalized analysis of movements of the trunk and upper and lower limbs, which made it difficult to obtain more specific results for dentistry. When using the OWAS method, the maximum score was observed for the trunk; that is to say the most serious situation in terms of working posture occurs when the trunk is rotated and flexed (17, 18). However, in dentistry, the position that normally occurs most frequently is flexion of the trunk and torsion of the neck. Therefore in the postural evaluation by OWAS the professional ends up receiving a low score for the trunk. Similarly, in the minimum OWAS score, the scores attributed to the upper limbs consider only whether the limbs are in a position below the shoulder, without considering whether the arm is next to the body, whether the shoulders are not raised, or whether the wrist is in a neutral position, which are recommendations for the ergonomic posture of the dental surgeon (36). The same occurs with regard to the lower limbs, in which the lowest score is attributed to work performed when seated, without considering how the feet are supported on the floor and formation of a 90° angle between the thighs and legs (36).

The fact that OWAS was originally developed to evaluate heavy work involving a wide range of movements and handling of loads (17-19) may make it difficult to perform a meticulous postural analysis, which is preferable when evaluating dental professionals.

RULA was developed with the goal of facilitating the rapid observation of a population of workers in order to identify risks of upper limb occupational diseases, as well as muscular efforts associated with working posture, when using force and doing static or repetitive work (28) (as is the case with dental surgeons). Although RULA presents the same advantages as OWAS, such as not requiring specific instruments for its application, and absence of interference while work is being done (18, 28), its application does demand more time and training to qualify assessors to use it. This is because risk scores are based on measurements of angular deviations of the body segments assessed (2), which requires the observer to pay greater attention.

In the RULA method, the movement of each body region, from the shortest to the most ample is considered, providing richer details that favour a risk evaluation for musculoskeletal disorders in dentistry, in which the movements are generally more precise.

In this study, it was verified that there was no agreement between OWAS and RULA in the classification of the risk of musculoskeletal disorders in dentistry undergraduates. Kee and Karwowski (19)

also observed a low percentage of agreement (29.2%) between these methods when they assessed different categories of work in industry.

A high prevalence of high-risk classification for the development of musculoskeletal disorders in RULA does not mean to say that it is superior to OWAS because, in order to prove its superiority, some measures of morbidity must be included in the analysis (19). However, as there are no articles in the literature that show which of the two methods is the most suitable for dentistry, it could be suggested that, in spite of RULA not allowing for as rapid an evaluation as may be desirable, from the theoretical point of view, it appears to be better suited to meet the requirements of risk assessment of musculoskeletal disorders in professionals in the dentistry field.

Nevertheless, future studies must be conducted with the purpose of verifying the efficacy of RULA for the dentistry population, in addition to considering the prevalence of pain and osteomuscular symptoms, absenteeism, and reduction in productivity and psychosocial problems in the assessment of risk for musculoskeletal disorders in dentistry.

A greater prevalence of medium risk of musculoskeletal disorders was observed with the use of OWAS, whereas with RULA the greatest prevalence observed was of high and extremely high risk, thus conferming the disagreement between the methods.

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