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RESEARCH ARTICLE **OPEN ACCESS**

Examining the Concordance between ART and ERIN Methods in the Assessment of Musculoskeletal Disorders in Dental Students of Shahid Beheshti University of Medical Sciences

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Abstract:

Introduction: Choosing the right method for assessing musculoskeletal disorders in work environments can be useful for identifying risk factors and preventing them. Hence, the aim of this study was to examine the agreement between ART and ERIN methods in evaluating skeletal-muscular disorders in dentists.

Method: This cross-sectional study was conducted among 38 dental students of Shahid Beheshti University of Medical Sciences. In order to collect research data, ART and ERIN worksheets were used. Data were analyzed using Stata software (version 14). P<0.05 was considered a significant level for all statistical tests.

Results: The research population included 20 (52.63%) women and 18 (47.37%) men. The mean and standard deviation of the age of women was 29.35 ± 2.68 years with a work experience of 3.2 years, and the mean and standard deviation of the age of men was 31.16 ± 3.25 years with a work experience of 3.33 years. The risk level in the ERIN method was high, and in the ART method, on both the right and left sides of the body was medium. Also, the relationship between the final score of the ERIN method and the final score of the right side of ART with work experience was direct and significant. The level of agreement between the two methods was achieved by using the Kappa coefficient on the right side, which was medium and weak on the left side of the body.

Conclusion: The results showed that the two methods did not have a good agreement; therefore, in order to evaluate discomfort in dentists, it is necessary to choose the appropriate method according to the type of activities performed, the purpose of the study, and the factors influencing the performance of tasks.

Keywords: Musculoskeletal disorders, Dental students, Ergonomics, Assessment, Stata software (version 14), ERIN method.

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1. INTRODUCTION

Ergonomics is a science used to adapt the work environment to the abilities and limitations of humans and prevent occupational injuries and musculoskeletal disorders [1]. Work-related Musculoskeletal Disorders (WMSDs) are damage to muscles, bones, joints, ligaments, tendons, tendon sheaths, and peripheral nerves caused by people's work in the long term or as a sudden injury, which can be caused by repetitive movements, improper body postures, continuous and excessive use of force, psychosocial risk factors, such as occupational stress, lack of support from colleagues or managers, and high mental workload [2, 3]. These disorders are multifactorial diseases in which personal conditions, such as age, gender, and anthropometric characteristics, play a role in their development. Still, most importantly, modifiable risk factors, including biomechanical overuse of organs, organizational and environmental exposures, factors Psychosocial risk, and other lifestyle conditions, are implicated in the prevalence of WMSDs [4].

Due to the financial and human importance of skeletal disorders, they should be prevented through interventions to reduce exposure; the implementation of preventive programs requires the prediction and evaluation of potentially dangerous situations that cause musculoskeletal disorders [5]. Various ergonomic studies have demonstrated that work environments are not properly adjusted to accommodate the evolving technological landscape, leading to a notable impact on both human resource productivity and a country's economy [6]. So, ergonomics can be used as a very effective solution, and assessment methods can be used to solve health problems in the workplace, perform ergonomic interventions, and modify working postures to prevent these disorders to a considerable extent [7, 8]. Ergonomic assessment techniques can be utilized to evaluate work environments in order to efficiently achieve desired outcomes [9].

Evaluación del Riesgo Individual (Individual Risk Assessment) (ERIN) is a method for individual risk assessment that is widely utilized today because of its simple learning curve, practicality, and minimal training requirements [10] and consider the variables of physical condition and the number of times the trunk, neck, shoulder/arm and hand/wrist movements are performed. The rhythm is based on the interaction of the work speed and the duration of each task, the intensity of effort, and self-evaluation [11, 12]. Determination of the final risk level in this method is done after observing the individual's activity, after which the scoring of the studied variables will be done based on the checklist, and at the end, the final score will be the sum of the scores of each variable. The level of corrective measures based on the obtained score is evaluated, which allows professionals to determine which aspects of the work under assessment should be intervened [13, 14].

Another ergonomic evaluation method is the ART method, which was introduced by the Health, Safety & Environment (HSE) in 2007 and is used to evaluate the effects of repetitive work on the upper limbs, especially the hands and arms [15]. In this method, 12 risk factors in 4 groups of frequency and repetition of movement, force, and inappropriate postures are considered so that the length of each period, duration, and external forces applied in each period determine the workload conditions of repetitive tasks [16, 17]. Due to the efficiency and effectiveness of this method, numerous studies have been conducted in this field, such as the study of Bhatia *et al*. (2021) in order to evaluate dentists, the study of Rahman *et al*. (2017) in order to evaluate repetitive work tasks in moulding workers and the study of Zuhaidi *et al*. (2017) conducted among food vendors [18-20].

Given that dentists engage in upper limb activities throughout their work shift, which are repeated multiple times in a day or work shift, and considering their frequent use of manual tools in treatment, it becomes crucial to select suitable approaches for assessing musculoskeletal disorders [21], Also choosing an appropriate method to evaluate musculoskeletal disorders, in order to determine the individual and environmental conditions of work, can lead to better interventions to improve work potential [21, 22].

Therefore, the objective of the current research was to investigate the concordance between ART and ERIN techniques in assessing skeletal-muscular issues among dental students at Shahid Beheshti University of Medical Sciences.

2. MATERIALS AND METHODS

In this cross-sectional study that was conducted on the students of the Faculty of Dentistry of Shahid Beheshti University of Medical Sciences in 2023, the required data were collected by visiting the Faculty of Dentistry and observing the work status of 38 resident dental students who are performing tasks, such as surgery, orthodontics, endodontic and etc. The sample size was determined using a pilot study on 7 dental students and considering the probability of type I error (α) = 0.05 and power of the study (1-β) = 90%. The lowest correlation between the two tools, ART and ERIN, obtained from the pilot study (r=0.5) was determined using the following formula:

1. $N = [(Z_{\alpha}+Z_{\beta})/C]^2 + 3$

N: The sample size needed for the study

Zα: The confidence level (usually 1.96 for a 95% confidence level)

Zβ: The statistical power (usually 0.8 for 80% power)

C: The margin of error (usually 0.05)

3: A constant to account for unexpected factors such as non-response

2. $C = 0.5 * \ln [(1+r)/ (1-r)] = 0.5493$

C: This represents a coefficient related to the expected correlation coefficient (r) between two variables.

ln: This represents the natural logarithm function.

r: This represents the expected correlation coefficient between the two variables

This research has ethical approval with code IR.SBMU.RETECH.REC.1402.233 at Shahid Beheshti University of Medical Sciences. To ensure the study's quality, the personnel conducted all necessary measurements and data collection during non-interfering hours of the day. Prior to commencing the research, informed consent was obtained from the participants, with a strong emphasis on maintaining the anonymity and confidentiality of their information. This study employed two posture analysis methods, namely ART and ERIN, to assess musculoskeletal disorders in the upper limbs. The risk level associated with each job was determined based on the scores obtained from these methods. The ART method investigated 12 risk factors grouped into frequency and number of movements, force, inappropriate postures (neck, back, shoulder/arm, wrist, and hand), as well as additional factors, such as duty duration, recovery, work speed, and work environment. The evaluation results of this method were categorized into three levels: low-risk level (0-11), medium-risk level (12-21), and high-risk level (more than 22).

In the ERIN method, in which the inter-rater reliability was evaluated by Rodríguez and Monsalve in 2021, was expressed as acceptable (62%) [23], 7 variables, including the body position and the number of times the trunk, neck, shoulder/arm and hand/wrist, as well as the rhythm caused by the interaction of work speed and duration of each task, intensity of effort and self-evaluation were evaluated. Also, the scoring levels and risk levels in this method are in 4 levels, including 7-14 points, which show a slight risk level; 15-23 points, which show a medium risk level; 24-35 points, which show a high-risk level, and >36 points, which show very high-risk level and requires immediate changes.

The mean and standard deviation were used to describe the quantitative variables, while the number (percentage) was reported for the qualitative variables. To determine the relationship between different variables and risk levels obtained from two methods, Chi-square, t-test, and ANOVA tests were used. Pearson's correlation coefficient, Kappa, and weighted Kappa were also used to determine the correlation and agreement between the two methods. Data were analysed using State software (version 14). $P<0.05$ was considered a significant level for all statistical tests.

3. RESULTS

In this research, 38 resident dental students of Shahid Beheshti University of Medical Sciences were examined. Their average age was 30.21 ± 3.06 years, and their work experience was 3.26 ±1.79 years. Other demographic information is given in Table **1**.

The highest tendency of the field was related to the prosthetics group with a frequency of 10, and the lowest was related to the Endodontic, Orthodontics, and surgery group with a frequency of 5 (Fig. **1**).

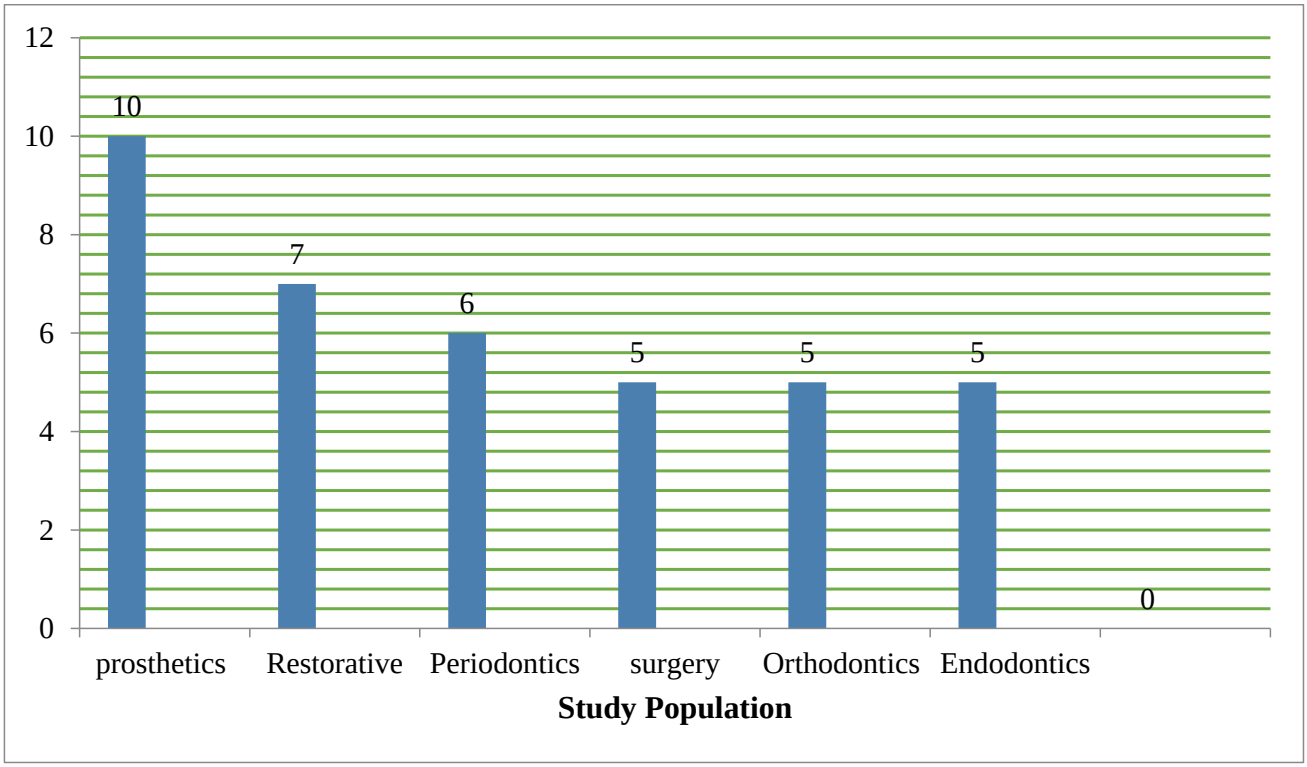

Fig. (1). Frequency of dental students according to major.

Based on the results of the table, the risk level in dental students using the ERIN method was high, and using the ART method on both the right and left sides of the body was an average level (Table **2**).

Table 1. Demographic Variables of the studied population.

Variables	Total (38)	Male(n=18)	Female(n=20)
Marital status			
Single	(73.68) 28	12 (66.67)	16 (80)
Married	(26.32) 10	6 (33.33)	4 (20)
Hand			
right	(78.95) 30	15 (83.33)	15 (75)
left	(21.05) 8	3 (16.67)	5 (25)
Exercise			
yes	12 (31.58)	3 (16.67)	9 (45)
no	26 (68.42)	15 (83.33)	11 (55)
Interested in job			
yes	33(86.84)	15 (83.33)	18 (90)
No	5 (13.16)	3 (16.67)	2 (10)
Age (Mean±SD)			
	3.06 ±30.21	3.25 ±31.16	2.68 ±29.35
Work history(y) (Mean±SD)			
	1.79 ± 3.26	1.64 ±3.33	1.96 ±3.2

Note: Qualitative variables are reported as numbers (percentages).

Table 2. Final score and risk level of ART and ERIN methods in participants.

Method	Mean Total Score	Risk Level
ERIN	25.28	High
ART Right	16.5	Medium
ART Left	15.42	Medium

The work experience had a significant correlation with the final score of the ERIN method and the right side of ART ($P<0.05$). Interestingly, the final score of both methods did not have a significant relationship with the age, sex, and type of occupation of individuals ($P>0.05$). Furthermore, the findings indicate that individuals encountered a considerable level of stress in certain job scenarios (Table **3**).

Table 3. Results of self-assessment of stress based on the ERIN method.

Self-assessment	Gender		Total (%)
	Female	Male	
Without stress	6	5	11 (28.95)
Partly stressful	7	7	14 (36.84)
Stressful	6	6	12 (31.58)
Very stressful	1	0	1 (2.63)
Total	20	18	38 (100)

Based on the results obtained (Table **4**), in some cases, people reported their environmental conditions as relatively stressful.

So, in 39.47% of cases, the need for corrective measures was obtained, and in 60.53%, the need for corrective measures was obtained in the near future. Also, the agreement between the two methods was obtained using the kappa coefficient of 0.25 for the right side and 0.12 for the left side.

Table 4. corrective measures level based on the ERIN method.

Valid	Frequency	Percent
Need to research	15	39.47
Correction in a short time	22	60.53
Emergency correction	1	-

4. DISCUSSION

Nowadays, we are witnessing an increasing diversity in the methods for assessing the risk of disorders and diseases in work environments. This diversity makes it difficult to choose the right method for each specific work environment and doubles the importance of examining the degree of agreement and correlation between different methods, so examining the degree of agreement and correlation between risk assessment methods is an important step in improving the accuracy, efficiency, and effectiveness of risk assessment and control programs in occupational environments. Therefore, this study was conducted with the aim of examining the agreement between ART and ERIN methods in evaluating skeletal-muscular disorders in dentists.

According to the risk level evaluation results of the two methods, the ERIN method's final score indicated a high-risk level, while the ART method's final score indicated a medium-risk level. Pratiwi *et al*. (2024) conducted a study titled “Ergonomic Risk Assessment” using ERIN and LUBA methods, and their findings revealed that the ERIN method primarily focused on situations with a high-risk level [24]. In the research conducted by Hosseini *et al*. (2019), the focus was on assessing the ergonomic risks faced by dentists. The findings revealed that the majority of dentists' postures were identified as requiring immediate corrective actions [25]. Similar results were obtained in Turkman *et al*.'s study (2015), which showed that the results of the ergonomic assessment by ART in most workers are at the medium risk level [25]. The survey conducted by Jafari *et al*. (2021) aimed to explore the relationship between different methods of evaluating repetitive tasks. The ART method revealed a moderate level of risk during task analysis, as highlighted in the study [26].

Another result of the study is that there was a significant correlation between the final score of the two methods and the work history, which can be justified considering the chronic nature of musculoskeletal disorders, so that the longer the work history of the Dentist, the more likely the disease will occur and there will be more disruption. This result is in line with other similar studies, such as the study of Ebrahimi *et al*. (2023), where people with a long work experience had more

severe injuries and had a higher score from the evaluation method [27]. Khandan *et al*. (2020), in a study among dentists to evaluate personal and occupational risk factors of musculoskeletal disorders using the BPAI method, showed that there is a significant relationship between the final score of this method and the occurrence of musculoskeletal disorders with the work history of the people [28]. Similar results were obtained in the study of Younis *et al*. (2022), so the severity and frequency of musculoskeletal disorders are related to demographic characteristics, and the number of years of work and working postures are the two main reasons for musculoskeletal disorders in dentists [29].

In addition, another result of the study is no significant relationship between the scores of the methods and the demographic indicators, such as age, sex, and type of occupation of the dentists with the same working conditions and the fact that the age of the individuals is in a similar period, which is justifiable. In this connection, there are similar studies in this field which can be referred to as similar studies. Bakhsh *et al*. (2021), in a study conducted among dentists in Saudi Arabia, showed that the occurrence of musculoskeletal disorders has no significant relationship with sex, height and weight, working hours, and working environment [30]. Khayati *et al*. (2014) conducted a study titled “Exploring Predictors of Neck Pain in Dentists” and found that there is no significant correlation between neck pain and factors such as height, weight, gender, type of job, and expertise [31].

In their study, Gothey *et al*. (2022) found similar results to this research, indicating that there is no significant association between the occurrence of musculoskeletal disorders among dentists and the age and gender of individuals [32]. In the research conducted by Figas *et al*. (2024), aimed at examining the clinical pattern of musculoskeletal disorders in the neck region, no notable distinction was found between neck stimulation and the number of affected neck areas concerning the gender of the participants [33]. However, it is worth noting that certain studies have reported varying outcomes regarding the significant association between age, gender, and the occurrence of musculoskeletal disorders [34-36]. This discrepancy can be attributed to variations in sample size, alterations in age range, disparities in study design, and other influential factors. One more finding from the research is the self-reporting of stress among dentists, which is not surprising given the demanding work environment and the nature of the profession. Dentists strive to perform their duties meticulously, minimize errors, and ensure patient satisfaction.

Additionally, receiving academic grades and feedback on clinical performance from professors at the end of a hectic day are also significant contributing factors. Other studies support this conclusion as well, such as the research conducted by Marklund *et al*. (2020), which highlighted that work-related stress is a contributing factor to decreased work efficiency among dentists [37]. Garavand and colleagues (2023) in their research showed that stressful conditions in the dental profession, including economic and financial concerns, working with toxic substances, unpleasant sounds and smells in the workplace, facing emergencies, and physical fatigue due to poor posture, can cause stress and many mental and physical complications in dentists [38]. Keikavoosi-Arani *et al*. (2020), in their study with the aim of assessing the occupational stress level of clinical dental students, showed that dentists suffered from moderate to severe occupational stress and based on the results of the risk assessment level, there is a need for corrective measures in the work situation [39].

The results of the agreement between the two methods used in this study using weighted kappa indicate that the agreement on the right side is moderate and shows that the two methods have achieved somewhat similar results. In comparison, the agreement between the two methods on the left side of the body was poor, which requires further investigation. The results can be due to differences in priorities and focus points in both methods. For example, each method focuses on certain factors that are not present in the other, which leads to less agreement. In a similar study, Motamedzadeh *et al*. (2019) showed that regarding the agreement and correlation between ergonomic methods, the difference between the risk classification results of the studied methods can be caused by the difference in the definitions of risk variables [40]. In their study, Yarandi *et al*. (2020) aimed to determine the agreement between different methods of evaluating musculoskeletal disorders. The findings revealed that none of the assessed methods demonstrated adequate comprehensiveness in assessing all four levels of risk [40]. In the research conducted by Nowara *et al*. (2023), the objective was to assess the agreement level between two methodological approaches for rapidly evaluating the upper limb in dentistry. The findings of this study revealed similar results, indicating a weak level of agreement between the two methods. This weak agreement suggests the presence of a systematic difference between the two approaches [41]. Kee (2022), in his study, which was conducted entitled Systematic Review Between Ergonomic Methods, showed that there is no consistent trend between the correlation coefficients of the used methods, and the reasons for the agreement or low correlation may be the difference in the ability to assess musculoskeletal loads and risk levels, such as the level of action and classification between the three methods and the different weights assigned to the risk factors when calculating the score [42].

CONCLUSION

In this study, the agreement between two ergonomic assessment methods in dentists was investigated, a profession that needs to be given special attention due to the sensitivity of its tasks and practicality. Although the level of agreement obtained in this study was low, to improve the agreement between these two methods, there may be a need for more interaction and coordination in the methods used, with attention to their common points

and differences. Furthermore, considering the objectives of the investigation and other variables in forthcoming studies, all of these techniques can be employed to analyze musculoskeletal ailments and irregularities within various healthcare disciplines.

LIMITATIONS

The present study was conducted with a limited sample size, so it is suggested to conduct studies with larger sample sizes and stratified random sampling methods.

AUTHORS' CONTRIBUTIONS

A.S.S. and H.V. study concept or design.

V.F.: Paper written.

A.F.K. and S. M.K.: Data collection.

N.I.: Data analysis or interpretation.

All authors reviewed the results and approved the final version of the manuscript.

LIST OF ABBREVIATIONS

WMSDs	=	Work-related Musculoskeletal Disorders
ERIN	=	Individual Risk Assessment
HSE	=	Health, Safety & Environment
ART	=	Assessment of Repetitive Tasks

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study protocol was reviewed and approved by the Research Ethics Committees of the School of Public Health & Neuroscience Research Center - Shahid Beheshti University of Medical Sciences, Tehran. Iran" with the Approval ID: IR.SBMU.RETECH.REC.1402.233.

HUMAN AND ANIMAL RIGHTS

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

CONSENT FOR PUBLICATION

Prior to commencing the research, informed consent was obtained from the participants, with a strong emphasis on maintaining the anonymity and confidentiality of their information.

STANDARDS OF REPORTING

STROBE guidelines were followed.

AVAILABILITY OF DATA AND MATERIALS

The data and supportive information are available within the article.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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