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Using Electromyography to Assess Postural Load in Dentistry: A Literature Review

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Authors' contributions

This work was carried out in collaboration between both authors. Author JMP conducted the literature search and review and wrote the first draft of the manuscript and author PPNSG designed and supervised the study and also revised the draft. Both authors read and approved the final manuscript.

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ABSTRACT

This study sought to perform a review of the literature on the use of electromyography to assess postural load in dental work. The literature used in this review was obtained from databases and only articles published published between 1991 and 2019 were considered. The main keywords were "electromyography," "working posture", "ergonomics" and "muscle activity". Each abstract was read to determine whether the information in the article included discussions on the use of electromyography to assess postural load in dental work (n=27). It was found that electromyography is beneficial to assess the influence of different devices used in dental work, however, as it has limitations, researchers must be aware of them to seek alternatives to circumvent them.

Keywords: Electromyography; working posture; ergonomics; muscle activity.

1. INTRODUCTION

Among the occupational diseases that affect dental surgeons, musculoskeletal disorders are one of the most prevalent [1]. According to Presoto and Garcia [2] this is a type of degenerative disease that causes problems such as

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pain, tingling, decreased productivity, and stress.

The main risk factors for the development of these disorders are related to the adoption of inappropriate postures for long periods of time due to the difficulty of access and visualization of the operative field, as well as making precise movements [3,4,5].

The use of a reliable risk assessment method can prevent the development of these disorders [6]. Among the existing methods we can mention the self-reports, observational methods and direct methods. Self-reports are composed of questionnaires or interviews with individuals of interest, observational methods include observation of the operator during the performance of their activities and direct methods use devices fixed on the operator's body, providing a more accurate measurement [7].

A direct assessment method that has been used in several areas of dentistry is electromyography, a non-invasive method that allows the assessment of the neuromuscular system [8]. This tool is widely used to assess the physiology of masticatory muscles [9] and has also been gaining space in the operator's postural assessment during his clinical practice [10]. However, there are few studies in the literature that evaluate the benefits and limitations of the use of electromyography in the evaluation of the ergonomic posture of dentists. Therefore, the aim of this study was to perform a literature review of the use of electromyography to assess postural load in dental work.

2. MATERIALS AND METHODS

This literature review was performed using the Science Direct, Scientific Electronic Library Online (SCIELO) and National Library of Medicine (MEDLINE) databases, which were searched to find articles published between 1991 and 2019. This period was chosen because it was in the last decades that the greatest emphasis has been placed on occupational studies in Dentistry. The search was focused on electromyography. The main keywords were “electromyography,” "working posture”, “ergonomics” and “muscle activity”. A total of 43 articles were collected.

Articles were included in the review being the majority complete articles published in English and if they addressed electromyography assessment on dentistry working posture. A total of 27 articles were included.

3. RESULTS AND DISCUSSION

The papers evaluated are presented in Table 1.

The current study evaluated the use of electromyography assessment on dentistry working posture. This review revealed that most studies on the topic have used surface electromyography. Some authors have defended the use of this type of electromyography as it is a non-invasive, safe, reliable and easy-to-use method that allows objectively assessing responses to muscle stimulation [10,15,17, 25,34].

In the studies found, it was observed that the dorsal trunk region was the most evaluated, with the trapezius muscle, both in its ascending and descending portion, being the most studied muscle [10,11,12,15,18,19,24,27,28,30,35]. Akesson et al., [18] used surface EMG for evaluation of the demands experienced by dental hygienist during their working routine, recording the descending part of the upper trapezius muscle bilaterally. Rolander et al., [15] also recorded the EMG activity of the upper trapezius muscle of 27 dentists to evaluate the association between perceived physical load and real physical load. Haddad et al., [19] analyzed the activity of the upper and middle trapezius muscles of 12 dentists to evaluate the effect of using two different types of dental stools (a ergonomic one, with forward leaning chest and arm supports, and the conventional one) during simulated dental tasks.

In addition to the dorsal part, the frontal part of the trunk and the neck were also evaluated. García-Vidal et al., [10] recorded EMG signals of the Upper Trapezius, Lateral Deltoid and Anterior Deltoid muscles in a study that verified the influence of different ergonomic supports (ergonomic dental stool and loupes) and their combination on the muscular activity of the dominant upper extremity. La Delfa et al., [30], in addition to the muscles already mentioned they also included m. cervical erector spinae and m. pectoralis major, to assess the biomechanical load in the neck and shoulder region during a 30-minutes dental scaling, as well as the postural variations in the different dental work positions according to the imaginary clock. The erector spinae was also studied by Pejčić et al., [27] that evaluated the back inclination and muscle activities of the m. erector spinae, m. trapezius descendens, m. sternocleidomastoideus and m. splenius capitis of dentists during a typical dental examination of patients in standing and sitting positions. Likewise, the m. erector spinae, m. trapezius descendens, m. sternocleidomastoideus and m. splenius capitis during sitting and standing position was evaluated in another study to assess ergonomic risk level in dentistry by performing typical dental examination on the patients in standing and sitting positions [28].

The upper limb and hand regions have also been extensively studied in the literature [1,14,16,17,21,22,23,25,31]. One study evaluated the influence of the instrument handle on the muscle activity of the hands. For this, the activity of m. flexor digitorum superficialis, m. flexor pollicis longus, m. extensor digitorum communis and m. extensor carpi radialis brevis was recorded during the use of 10 different handles designs of periodontal instruments [16]. Another study also evaluated the ergonomics and efficiency of five differently designed handles of instruments during a simulated dental scaling and root planning, by recording the muscular activity (EMG) of the m. flexor pollicis brevis, m. extensor digitorum, m. flexor carpi radialis, and m. trapezius pars descendens [22]. The m. extensor digitorum, m. flexor pollicis brevis, and m. flexor digitorum superficialis were analyzed by surface EMG in a study that evaluated the effect of differences in dental mirrors handles on muscle activity during simulated dental hygiene procedures [17]. McCombs et al., [25] compared the effect of cordless and corded handpieces on the muscular load (EMG) of the m. flexor digitorum superficialis, m. flexor pollicis longus, m. extensor digitorum communis and m. extensor carpi radialis brevis during simulated tooth polishing. In addition to the influence of instruments on muscle activity, Dong et al., [14] compared the effects of three different finger rest positions on hand muscle activity of the m. flexor digitorum superficialis, m. flexor pollcis longus, m. extensor digitorum communis and m. extensor carpi radialis.

One region that apparently was not much explored was the abdominal (part of the frontal trunk) and lower body region. Although some studies have evaluated muscle activity related to sitting work [10,19,27,28,29], few considered this region [5,20,32,33]. De Bruyne et al., [5], evaluated the effect of 3 different types of dental stools on the muscular activity (EMG) of the m. latissimus dorsi, m. iliocostalis lumborum thoracic part, m. multifidus, m. gluteus maximus, m. rectus femoris, m. internal abdominal oblique and m. external abdominal oblique. O'Sullivan et al., [20] also evaluated the effect of 2 different dental stools on the muscular activity (EMG) of the m. superficial lumbar multifidus, m. iliocostalis lumborum pars thoracis, m. thoracic erector spinae, m. external oblique, m. internal oblique and m. rectus abdominis. Wong et al., [33], on the other hand, studied the impact of 3 different sitting postures on muscle activity of bilateral obliquus internus/transversus abdominis, obliquus externus and lumbar erector spinae muscles.

It was possible to observe that the use of electromyography collaborated positively and brought benefits to the analysis of the influence of different instruments and equipments commonly used in dental work on the muscular activity of different regions of the body [17,18]. Despite this, some limitations on its use were reported by the literature and should receive attention. The presence of crosstalk is reported as one of the biggest limitations [11,13,14,17,18,23]. Crosstalk is the contamination of the signal of a specific muscle by the activation of the adjacent muscles, which may occur due to the proximity of the sensors between the muscles [36]. Claus et al., [32] believe that the combination of the surface electromyography and fine-wire electromyography allows more accurate assessments of the contraction pattern of muscle groups related to posture maintenance. Finsen et al., [12] and Finsen et al., [13] also noted that the results of their studies could be complemented if fine-wire electromyography were added.

Besides it, other forms of interference can be caused by displacement of the electrode, which occurs due to several factors, such as the participants' sweat. This detachment can cause distorted measures and, consequently, interfere negatively in the results of the study [5]. To minimize this problem, it is suggested that, in addition to EMG, non-invasive assessments such as vision technology or wearable inertial guidance sensors, be made for a more comprehensive analysis [19]. Other devices for postural assessment can also be associated with electromyographic analysis to perform a more reliable assessment [5,23]. Another study also observed that more detailed information on the muscular load of the shoulder region is produced when EMG recordings are supplemented by biomechanical calculations [12].

Table 1. Scientific studies on the use of electromyography to assess postural load in dental work

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Milerad et al., [11]	Quantify muscular load in shoulder, neck and arm during dentistry.	Upper trapezius, Infraspinatus Extensor carpi radialis	Different dental procedures made in upper and lower jaw	The sample rate was 1000 Hz; Data analysis software with a bandwidth of -1kHZ-10Hz; Data were normalized to MVC and expressed as RMS.	Relatively high mean load on the trapezius and carpi-radial extensor muscles of the dominant hand.	Shorting data collection time; Cross-talk; Need of standardize the Maximum Contraction test.
Finsen et al., [12]	Demonstrate that the supplementation of EMG analyzes with biomechanical calculations generates more detailed information about the muscular load of the shoulder region.	Trapezius	Two upper arm postures	The sample rate was 512 Hz; Data analysis software with high-pass filter of 10Hz; Data were normalized to maximum EMG amplitude and expressed as RMS.	Biomechanical calculations are a relevant supplement for EMG records.	Need for complementary methods of analysis
Finsen, [13]	Estimate mechanical loads by calculating of moments on cervical joints and muscular activity of the neck during occupational postures.	Splenius	Two levels of neck flexion	The sample rate was 512 Hz; Data analysis software with high-pass filter of 10Hz; Data were normalized to maximum EMG amplitude and expressed as RMS.	The study showed that EMG can underestimate the total tissue mechanical load.	Cross-talk
Dong et al., [14]	Compare the impacts of three different finger rest positions on muscle activity and pinch force during simulated procedures.	Flexor digitorum superficialis Flexor pollcis longus Extensor digitorum communis Extensor carpi radialis	Three different finger rest positions	Data collected at 100 Hz; Data were normalized to MVC and RMS.	Two fingers rest position reduced the pinch force and the activity of the evaluated muscles.	Cross-talk

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Rolander et al.,[15]	Examine if dentists that reported high physical load during dental work in a previous study also show signs of high muscular activity.	Upper trapezius	Dental work	The sample rate was 1024 Hz; Data analysis software with high-pass filter; Data were normalized as a percentage of the reference contraction value.	Accumulated rest% and increased average rectified value percent contribute to the high workload perceived by dentists	sEMG method used
Dong et al., [16]	Evaluate the effects of periodontal instrument handle features on hand muscle activity and pinch force in a simulated dental scaling task.	Flexor digitorum superficialis Flexor pollicis longus Extensor digitorum communis Extensor carpi radialis brevis	Ten different instrument handle designs	Data collected at 100 Hz; Data were normalized to MVC and expressed as RMS.	Pinch force and muscle activity during scaling task can be reduced using an instrument with a larger diameter and less weight.	Only used artificial tooth that may interfere in muscular workload
Simmer-Beck et al.,[17]	Evaluate the muscle activity using different dental mirrors handles during simulated dental hygiene procedures.	Extensor digitorum Flexor pollicis brevis Flexor digitorum superficialis	Phase I: diameter and weight Phase II: weight and padding	The fullwave was collected and an analysis software converted the data from analog to digital.	Modification in weight, diameter and padding of instrument cables affects muscle activity.	Cross-talk
Akesson et al., [18]	Quantify the general and specific workload experienced by dental hygienist during their work that may lead to the development of neck and upper limb musculoskeletal disorders	Descending part of the upper trapezius muscles Extensor forearm (m. carpi radialis longus and brevis)	Machinery tasks Manual scales Auxiliar tasks	The sample rate was 1024 Hz; Data analysis software with high-pass filter of 30Hz; Data were normalized to MVC.	High loads were observed in the m. extensor forearm and m. trapezius.	Cross-talk

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Haddad et al., [19]	Compare the effect of a new ergonomic design dental chair and a common dental chair in trapezius muscular activity during simulated dental procedures.	Upper trapezius Middle trapezius	Two types of dental chair	The sample rate was 1024 Hz; Data analysis software with a bandwidth of 10-500Hz; Data were normalized to MVC.	The ergonomic dental chair generated a significant reduction in the activity of the evaluated muscles.	Need for complementary methods of analysis
O'Sullivan et al., [20]	Investigate if a new chair can reduce the effort of maintaining a neutral sitting posture.	Superficial lumbar multifidus Lumborum pars thoracis Thoracic erector spinae External oblique Internal oblique Rectus abdominis	Type of Chair	The sample rate was 1000 Hz; Data analysis software with a bandwidth of 0-500Hz; Data were normalized to MVC and expressed as RMS.	The BackApp chair allowed less muscle activation only for the Superficial lumbar multifidus, without interference with the other muscles.	Sample size
Pasternak-Júnior et al., [21]	Assess the muscular activity of endodontists during simulated root canals preparation using manual and rotatory techniques.	Flexor carpi radialis Extensor carpi radialis Brachioradialis Biceps brachii Triceps brachii Middle deltoid Upper trapezius	Two different techniques of canal system instrumentation (manual and rotatory)	The sample rate was 1000 Hz; Data analysis software with a bandwidth of 20-450Hz; Data were normalized to MVC.	The rotary technique showed greater uniformity of joint torques.	Not mentioned
Nevala et al., [22]	Evaluate the ergonomics and efficacy of five differently designed handles of instruments for dental scaling and root planing in a simulated dental setting.	Flexor pollicis brevis Extensor digitorum Flexor carpi radialis Trapezius pars descendens	5 different designed handles of instruments	The sample rate was 1000 Hz; Data analysis software with a bandwidth of 20-500Hz; Data were normalized to MVC.	The use of instruments with thick silicone handles causes less perception of musculoskeletal tension.	Sample size

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Takala, Toivonen [23]	Study the effects of different electrode locations and forearm postures on the association between the EMG signals and external hand load in a standard working setting.	Extensor digitorum communis Flexor digitorum superficialis Through forearm	Electrode location on the forearm Different simulated clinical activities	The sample rate was 10 Hz; Data analysis software with a bandwidth of 15-500Hz; Data were normalized to MVC.	EMG activity varied according to forearm posture, electrode location and type of task	Cross-talk
Blanc et al., [24]	Compare the variability of operator's musculoskeletal tension according to the concept of workstation	Upper trapezius Lumbar erector spinae	Different workstation concepts	The sample rate was 2048 Hz; Data were normalized to MVC and expressed as RMS.	The adjustment of the workstations can reduce the prevalence of MSDs.	Sample size; Learning parameter and adaptation time may increase strain in inexperienced practitioners in each concept.
McCombs et al., [25]	Compare the muscular load, time involved to complete the task and opinion of the dental hygienist about ease use of cord and cordless handpieces during simulated tooth polishing procedures.	Flexor digitorum superficialis Flexor pollicis longus Extensor digitorum communis Extensor carpi radialis brevis	Presence or absence of cord in handpieces	The sample rate was 1500 Hz; Data analysis software with high-pass filter of 10Hz; Data were normalized to VMC and expressed as Integrated EMG value.	The cordless handpiece did not influence muscle intensity, but it did decrease the overall muscle workload by reducing the polishing duration.	Convenience sample
Onety et al., [1]	Analyze the posture of endodontics during canal system preparation of molars.	Longissimus Anterior and middle deltoid Middle trapezius Biceps brachii Triceps brachii Brachioradialis	2 different techniques of canal system instrumentation (manual and rotatory)	The sample rate was 2 kHz; Data analysis software with a bandwidth of 0,2-2kHz; Data were normalized to MVC and expressed as RMS.	The endodontists studied showed posture disorders regardless of the technique used.	Not mentioned

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Ford et al., [26]	Examine the inter-relationship of the exertion levels of upper extremity muscles during dental procedures.	Sternocleidomastoid Upper trapezius Latissimus dorsi Infraspinatus Supraspinatus Anterior, lateral and posterior deltoid Triceps brachi Biceps brachii Pectoralis major	Thirty-four activities, combining four predictor variables: posture, precision, line of sight and type of grip.	The sample rate was 1000 Hz; Data analysis software with a bandwidth of 0-500Hz; Data were normalized to MVC.	Seated postures can contribute to the development of MSDs due to high efforts of the upper trapezius.	Sample size
De Bruyne et al., [5]	Verify the influence of different types of dental stools on the muscular activity and lumbar posture of dentists during work.	Latissimus dorsi; Iliocostalis lumborum thoracic part Multifidius; Gluteus maximus Rectus femoris Internal abdominal oblique External abdominal oblique	Different types of dental stools	The sample rate was 1000 Hz; Data analysis software with band-pass filter; Data were normalized to MVC and expressed as RMS.	To maintain a neutral posture, Ghopec is considered the most suitable stool.	Shorting data collection time
Pejčić et al., [27]	Analyze muscle activities and back inclination of dentists when performing standard dental examination during dental work.	Erector spinae Trapezius descendens Sternocleidomastoideus Splenius capitis	Working positions (standing and sitting)	The sample rate was 1000 Hz; Data analysis software with notch filter of 50Hz; Data were normalized to VMC and expressed as RMS.	Combination of sitting and standing postures can reduce the risk for increased fatigue and possible injuries.	Not mentioned
Petrović et al., [28]	Assess ergonomic risk level in dentistry	Erector spinae Trapezius descendens Sternocleidomastoideus Splenius capitis	Working positions (standing and sitting)	The sample rate was 1000 Hz; Data analysis software with notch filter of 50Hz; Data were normalized to VMC and expressed as RMS.	Combination of sitting and standing postures can reduce ergonomic risk	Not mentioned

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Tran et al., [29]	Compare the degree of muscular activation in dental students while using a regular dental stool and an ergonomic one.	Longissimus thoracis Iliocostalis lumborum.	Two types of dental stool	The sample rate was 1000 Hz; Data analysis software with a bandwidth of 20-450Hz; Data Were expressed as RMS.	The use of dental stool with mid-sternum chest support reduces the muscular activity of the studied region.	Shorting data collection time
La Delfa et al., [30]	Evaluate the muscular demands placed on the shoulder and neck of dental hygienists and the posture differences when working at different clock positions during a simulated scaling task.	Cervical erector spinae Pectoralis major Anterior deltoid Posterior deltoid Lower tapezius Upper trapezius	Different clock positions	The sample rate was 2048 Hz; Data analysis software with a bandwidth of 20-450Hz; Data were normalized to MVC.	The 8 o'clock position demands more physically from the neck and shoulder and take more time.	Not mentioned
Suedbeck et al., [31]	Compare the effects of 4 periodontal instrument handle designs on forearm muscle activity during a simulated periodontal scaling task.	Flexor digitorum superficialis; Flexor pollicis longus; Extensor digitorum communis; Extensor carpi radialis brevis.	Four periodontal instrument handle designs	The sample rate was 1000 Hz; Data were normalized to MVC.	The instrument with the greatest weight and diameter generated more elevated muscle activity compared to the other instruments.	Minimal time participants used each instrument; The various textures of the instrument cables may have interfered with muscle workload; Shorting data collection time
Claus et al., [32]	Evaluate if people with low back pain caused by prolonged sitting have different patterns of trunk muscle activation in determined postures.	Lumbar multifidus Iliocostalis; Longissimus thoracis; Transversus abdominis.	Different postures presence or absence of low back pain	The sample rate was 2000 Hz; Data analysis software with high-pass filter of 50Hz; Data were normalized as a percentage of the peaky value for each muscle and expressed as RMS.	The group with low back pain showed greater muscle activity, modulation of this activity and EMG amplitude in the lordosis position.	Shorting data collection time

Author	Proposition	Evaluated Muscles	Independent Variable	Signal Processing	Results	Limitations
Garcia-Vídal et al., 2019	Evaluate the effect of two types of ergonomic tools (dental stool and magnification) on the muscular activity during a restorative procedure.	Upper trapezius; Middle deltoid; Anterior deltoid.	Ergonomic tools (dental stool and magnification lenses)	The sample rate was 1000 Hz; Data analysis software with high-pass filter of 64Hz; Data were normalized to VMC and expressed as RMS.	The combination of the two ergonomic supports reduced the activity of the evaluated muscles.	EMG data collected only on the dominant side of the body
Wong et al., [33]	Compare the effect of three common sitting postures on pain, lumbar RoM, proprioception and trunk muscle activity.	Obliquus internus/Transversus abdominis; Obliquus externus; Lumbar erector spinae.	Three common sitting postures	The sample rate was 1500 Hz; Data analysis software with notch filter of 50Hz; Data were normalized to VMC and expressed as RMS.	Sitting for 20 minutes of duration have no adverse effects on the biomechanics of the spine, regardless of the posture adopted.	Sample size; Cross-talk

The studied body regions are presented in Fig. 1

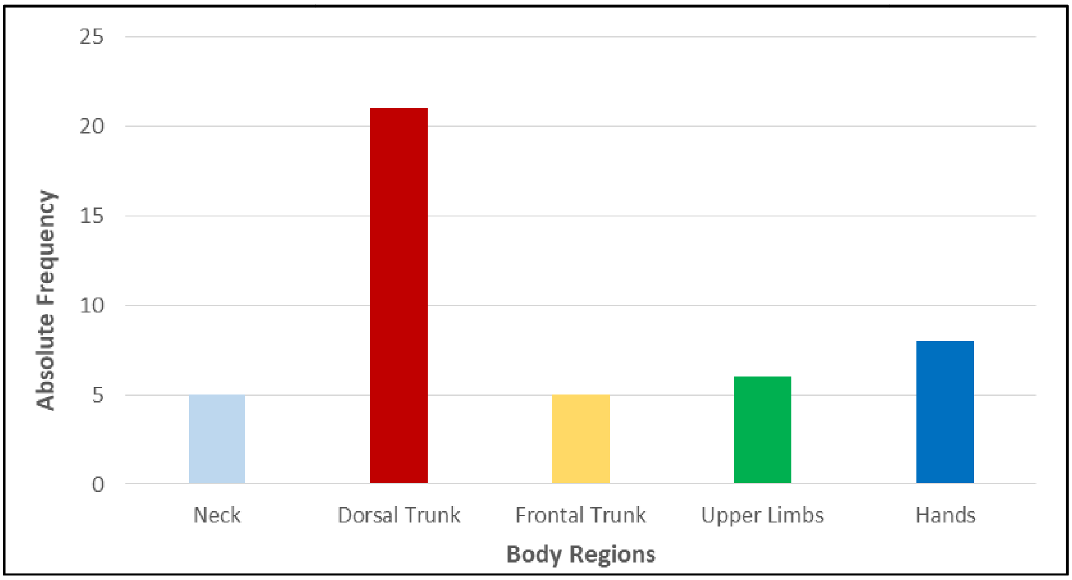

Fig. 1. Studied body regions

The evaluation of the muscle activity during the performance of specific dental activities, such as dental scaling, was also pointed out in the literature as a limitation. Although manual scaling has been considered a high-risk activity for developing musculoskeletal disorders in the upper limbs and neck, it only represents one of the many tasks performed in dental routine [18,30]. Petrović et al., [28] recommends that analyzes involving other activities be carried out with the intention of determining which specialty requires greater muscle activity, as well as the difference in contraction patterns between professionals of different ages. It is also recommended that analyzes be conducted during the actual clinical work routine, which would involve performing various dental activities for longer periods of time over an entire workday [16,19].

It was also possible to verify that most studies used a small sample size, a short period of time to collect the EMG signal and analysis of muscle activity only of the dominant side of work [5,10,11,19,20,22,24,26,29,31,32,33,35]. According to Rolander et al., [15] it might be associated with the fact of electromyographic analyzes are very expensive and time-consuming. In addition, when the sample consists of trained dental surgeons, they have their own appointments with their patients in the clinical routine [11]. The necessity of perform simulated procedures in laboratories with the objective of standardization can also be one of the factors that interferes with the time collect and sample size [5].

4. CONCLUSION

The aim of this study was to perform a literature review of the use of electromyography to assess postural load in dental work. Therefore, the authors considered the evaluated regions, the limitations and the objectives of each study. Thus, it was observed that electromyography is beneficial to assess the influence of different devices used in dental work; however, as it has limitations, researchers must be aware of them to seek alternatives to circumvent them.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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