Ricardo Manuel Tavares Cardoso

Voice, posture and autonomic nervous system: Relations and treatment

Universidade Fernando Pessoa

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Dissertation presented to *Universidade Fernando Pessoa* as a requirement to obtain the doctoral degree in *Desenvolvimento e Perturbações da Linguagem*, under the supervision of Professor Rute Meneses and Professor José Lumini de Oliveira.

ABSTRACT

Voice is the tool of excellence for verbal communication. For teachers, voice is their main instrument of work, since it allows them to transmit knowledge, thus being of great importance in the teaching-learning process. When used improperly, voice quality can suffer great damages and it can lead to serious health consequences.

The theoretical framework of this PhD thesis is comprised of three systematic review articles covering the associations between posture, voice and dysphonia (paper 1), the associations between autonomic nervous system function, voice and dysphonia (paper 2), and the effectiveness of physiotherapy and complementary therapies on voice disorders (paper 3).

The thesis also integrates three experimental articles. The first aimed to verify if there were differences in posture, muscle tension and voice between teachers with (*n*=13) and without (*n*=11) voice complaints (assessed by photogrammetry, muscle tension through palpation, algometry, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice - paper 4). The second analyzed if there were differences in autonomic nervous system function and voice between teachers with (*n*=13) and without (*n*=11) voice complaints (assessed by heart rate variability, The Questionnaire of Autonomic Dysfunction, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice - paper 5). Finally, a randomized controlled trial that was undertaken to verify the effects of myofascial release in teachers' posture, muscle tension and voice (*n*=12), compared to a control group (*n*=12), is presented (assessed by photogrammetry, muscle tension through palpation, algometry, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice - paper 6).

With this investigation it was found that in teachers and/or in other samples there is a close relationship between body posture, muscle tension, laryngeal musculature, voice production, voice complaints and dysphonia, as well as autonomic dysfunctions related to voice and dysphonia, where participants with dysphonia tend to present more symptoms of autonomic dysfunction concomitant with activation of the laryngeal musculature (papers 1, 2, 4, 5).

It has also been found that myofascial release in teachers, as well as massage, transcutaneous electrical nerve stimulation and acupuncture in other samples, appear to be effective treatments to reduce muscle tension, voice complaints and improve voice quality, supporting the inclusion of these therapies in the treatment of patients with voice disorders, promoting a transdisciplinary action that can optimize assessment and treatment in order to provide benefits to patients with voice problems (papers 3, 6).

Key words: Voice, voice complaints, voice disorders, dysphonia, posture, muscle tension, autonomic dysfunction, myofascial release, physiotherapy, complementary therapies.

RESUMO

A voz é a ferramenta de excelência para a comunicação verbal. Para os professores, a voz é o seu principal instrumento de trabalho, pois permite-lhes transmitir conhecimentos, assumindo primordial importância no processo de ensino-aprendizagem. Quando usada incorretamente, a qualidade da voz pode sofrer grandes danos e levar a sérias consequências à saúde.

O enquadramento teórico desta tese de doutoramento é composto por três artigos de revisão sistemática que abordam as associações entre postura, voz e disfonia (artigo 1), as associações entre função do sistema nervoso autónomo, voz e disfonia (artigo 2) e a efetividade da fisioterapia e das terapias complementares em distúrbios da voz (artigo 3).

A tese integra ainda três artigos experimentais. O primeiro teve como objetivo verificar se existiam diferenças na postura, tensão muscular e voz entre professores com (*n*=13) e sem (*n*=11) queixas vocais (avaliadas por fotogrametria, tensão muscular por palpação, algometria, avaliação aerodinâmica da voz, análise acústica e perceptivo-auditiva da voz - artigo 4). O segundo analisou se existiam diferenças na função do sistema nervoso autónomo e voz entre professores com (*n*=13) e sem (*n*=11) queixas vocais (avaliadas pela variabilidade da frequência cardíaca, Protocolo de Disfunção Autonómica, avaliação aerodinâmica da voz, análise acústica e perceptivo-auditiva da voz - artigo 5). Finalmente, um estudo randomizado controlado que foi realizado para verificar os efeitos da libertação miofascial na postura, tensão muscular e voz de professores (*n*=12), comparados a um grupo controlo (*n*=12), é apresentado (avaliados pela fotogrametria, tensão muscular por palpação, algometria, avaliação aerodinâmica da voz, análise acústica e perceptivo-auditiva da voz - artigo 6).

Com esta investigação, verificou-se que em professores e/ou noutras amostras existe uma estreita relação entre postura corporal, tensão muscular, musculatura laríngea, produção vocal, queixas vocais e disfonia, assim como que as disfunções autónomas se relacionam com a voz e com a disfonia, onde os participantes com disfonia tendem a apresentar mais sintomas de disfunção autónoma, concomitantes à ativação da musculatura laríngea (artigos 1, 2, 4, 5).

Verificou-se também que a libertação miofascial em professores, bem como a massagem, estimulação elétrica transcutânea do nervo e acupuntura noutras amostras, parecem ser tratamentos eficazes para reduzir a tensão muscular, as queixas vocais e melhorar a qualidade da voz, apoiando a inclusão dessas terapias no tratamento de pacientes com perturbações da voz, promovendo uma ação transdisciplinar que pode otimizar a avaliação e o tratamento, a fim de proporcionar benefícios aos pacientes com problemas de voz (artigos 3, 6).

Palavras-chave: Voz, queixas vocais, distúrbios da voz, disfonia, postura, tensão muscular, disfunção autonónoma, libertação miofascial, fisioterapia, terapias complementares.

RÉSUMÉ

La voix est l'outil d'excellence pour la communication verbale. Pour les enseignants, la voix est leur principal instrument de travail, car elle leur permet de transmettre des connaissances et revêt donc une grande importance dans le processus enseignement-apprentissage. En cas d'utilisation incorrecte, la qualité de la voix peut être gravement endommagée et entraîner de graves conséquences pour la santé.

Le cadre théorique de cette thèse de doctorat est composé de trois articles de revues systématiques couvrant les associations entre posture, voix et dysphonie (article 1), les associations entre le fonctionnement du système nerveux autonome, la voix et la dysphonie (article 2), et l'efficacité de la physiothérapie et des thérapies complémentaires dans les troubles de la voix (article 3).

La thèse intègre également trois articles expérimentaux. La première visait à vérifier s'il existait des différences de posture, de tension musculaire et de voix entre les enseignants avec (*n*=13) et sans (*n*=11) plaintes vocales (évaluées par photogrammétrie, tension musculaire par palpation, algométrie, évaluation aérodynamique de la voix, analyse acoustique et auditive-perceptuelle de la voix - article 4). La seconde analysait les différences de fonctionnement du système nerveux autonome et de la voix entre les enseignants avec (*n*=13) et sans (*n*=11) plaintes vocales (évaluées par la variabilité de la fréquence cardiaque, Le Questionnaire sur la Dysfonction Autonome, l'évaluation aérodynamique de la voix, l'analyse acoustique et auditive-perceptuelle de la voix - article 5). Enfin, un essai contrôlé randomisé mené pour vérifier les effets de la libération myofasciale sur la posture, la tension musculaire et la voix des enseignants (*n*=12) comparé à un groupe de contrôle (*n*=12), est présenté (évaluée par photogrammétrie, tension musculaire par palpation, algométrie, évaluation aérodynamique de la voix, analyse acoustique et auditive-perceptuelle de la voix - article 6).

Cette recherche a montré que chez les enseignants et/ou d'autres échantillons, il existe une relation étroite entre la posture corporelle, la tension musculaire, la musculature laryngée, la production vocale, les plaintes vocales et la dysphonie, ainsi que les dysfonctionnements autonomes sont liés à la voix et à la dysphonie. Les participants atteints de dysphonie ont tendance à présenter davantage de symptômes de dysfonctionnement autonome concomitant à l'activation de la musculature du larynx (articles 1, 2, 4, 5).

Il a également été constaté que la libération myofasciale chez les enseignants, ainsi que le massage, la stimulation nerveuse électrique transcutanée et l'acupuncture dans d'autres échantillons, semblaient être des traitements efficaces pour réduire la tension musculaire, les plaintes vocales et améliorer la qualité de la voix, favorisant ainsi l'inclusion de ces thérapies dans le traitement des patients souffrant de plaintes vocales, en promouvant une action transdisciplinaire permettant d'optimiser l'évaluation et le traitement afin de procurer des avantages aux patients présentant des problèmes de voix (articles 3, 6).

Mots clés: Voix, plaintes vocales, troubles de la voix, dysphonie, posture, tension musculaire, dysfonctionnement autonome, libération myofasciale, physiothérapie, thérapies complémentaires.

DEDICATION

To my wife who is the love of my life, Ana Santos Cardoso.

To my family, since ever, supported everything in my personal and professional life.

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CONTENTS

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LIST OF ABBREVIATIONS AND SYMBOLS

↑ – Improvement

= – No changes

ANS – Autonomic nervous system

AOT – Autonomic outlet types

CDI – Craniocervical Dysfunction Index

CEBM – The Centre for Evidence-based Medicine

CG – Control Group

CRICO – Cricothyroids

CSS – Cross-sectional study

dB – Decibel

DIAPH – Diaphragm

DP – Diastolic pressure

ECG – Electrocardiography

F – Female

F_0 – Fundamental frequency

F_0SD – Fundamental frequency standard deviation

F3 – Third formant

F4 – Fourth formant

F5 – Fifth formant

FVDs – Functional voice disorders

GNE – Glottal noise energy

GRBAS – Grade, Roughness, Breathiness, Asteny, Strain

GRBASH – Grade, Roughness, Breathiness, Astheny, Strain, Harshness

GRBASI – Grade, Roughness, Breathiness, Asteny, Strain, Instability

HAA – Horizontal alignment of acromion

HAASIS – Horizontal alignment of anterior superior iliac spine

HAH – Horizontal alignment of the head

HAP – Horizontal alignment of the pelvis

HAST3 – Horizontal asymmetry of the scapula in relation to T3

HF – High frequency

HNH – High-note hum

HNR – Harmonic-to-noise ratio

HR – Heart rate

HRV – Heart rate variability

HVEC – High vocal effort condition

Hz – Hertz

KI – Kyphosis index

Leq – Equivalent sound level

LF – Low frequency

LL – Lumbar length curvature

LMT – Laryngeal Manual Therapy

LNH – Low-note hum

M – Male

m.a. – Mean age

MCT – Manual Circumlaryngeal Therapy

MFR – Myofascial release

MP – Mean blood pressure

MPQ – Musculoskeletal Pain Questionnaire

MPT – Maximum phonation time

MTD – Muscle Tension Dysphonia

MVEC – Moderate vocal effort condition

NMSQ – Nordic Musculoskeletal Symptoms Questionnaire

NNE – Normalized noise energy

NOS – Newcastle–Ottawa scale

PEDro – Physiotherapy Evidence Database scale

PHARY – Pharyngolaryngeal muscles

PhD – Doctor of Philosophy

pNN50 – Percentage of adjacent NN intervals differing by more than 50 milliseconds

PNS – Parasympathetic nervous system

PRISMA – Preferred Reporting Items for Systematic Reviews and Meta-Analyses

PRV – Pulse rate variability

QAD – Questionnaire of Autonomic Dysfunction

RCT – Randomized controlled trial

RMSSD – Square root of the mean squared difference of successive RR intervals

SAPO – Postural evaluation software

SCAL – Scalenes

SDNN – Standard deviation of RR intervals

SLP – Sound pressure levels

SNR – Signal-to-noise ratio

SNS – Sympathetic nervous system

SP – Systolic pressure

SPL – Sound Pressure Level

SUB – Suboccipital muscles

SUP – Suprahyoids

TA – Trapezius

TENS – Transcutaneous electrical nerve stimulation

THY – Thyrohyoids

TL – Thoracic length curvature

TP – Total power

VAB – Vertical alignment of the body

VAHA – Vertical alignment of the head with the acromion

VAPP – Voice Activity and Participation Profile

VAS – Visual analogue scale

VCG – Voice complaints group

VCOP rms – Velocity of variation of the center of pressure

VHI – Voice handicap index

VHL – Voice Hygiene Lecture

VLF – Very Low Frequency

VM – Voice Massage™

VSSQ – Vocal Signs and Symptoms

w/ – With

WVCG – Without voice complaints group

WVEC – Weak vocal effort condition

INTRODUCTION

Voice is one of the most important components of communication between human beings, being essential for the interpersonal communication process (Ferreira & Costa, 2001), and any change in voice characteristics may affect the person's quality of life (Cielo et al., 2011; Spina et al., 2009).

Due to the multidimensional character of the voice, there are several proposals for the classification of voice disorders mentioned in the literature, leading to greater difficulty in establishing scientifically accepted criteria (Behlau, 2001, p. 139-147; Guimarães, 2007).

Dysphonia is characterized by any difficulty or change in voice production that prevents its natural emission, conditioning oral communication (Behlau & Pontes, 1995), normally promoting changes in vocal parameters that result in modifications in sound quality, timbre, pitch or intensity (Freitas, 2006; Ribeiro et al., 2011; Van Houtte, Van Lierde & Claeys, 2011), and may have important repercussions on the professional use of voice (Figueiredo et al., 2003).

In this thesis, the classification of dysphonia most frequently used in the literature will be adopted, according to the organic versus functional dichotomy (Behlau, 2001, p. 139-147; Guimarães, 2007). Organic dysphonia has a diffuse etiology (congenital, structural, inflammatory, endocrine, rheumatological, tumor, traumatic, neurological or unknown involvement), regardless of vocal use (Behlau, 2001, p. 139-147; Guimarães, 2007; Van Houtte, Van Lierde & Claeys, 2011). In functional dysphonia, voice quality is affected, however, the anatomophysiological integrity of the larynx is maintained, and its origin cannot be explained by an organic laryngeal lesion (Guimarães, 2007; Van Houtte, Van Lierde & Claeys, 2011). Functional dysphonia can arise due to the incorrect use of the voice, vocal inadequacies or psychogenic changes (Behlau, 2001, p. 139-147; Van Houtte, Van Lierde & Claeys, 2011).

Behlau et al. (2005, p. 139-147) define voice professional as "an individual who depends on a specific production and/or specific vocal quality for their survival". They are professionals who use voice as their instrument of work.

In order to categorize the voice professionals, Koufman and Isaacson (1991) subdivided voice professionals into four levels according to three factors: accuracy, overload and impact. The first level refers to the elite vocal performer (singers and professional actors), also known as voice athletes. In these cases, any voice change, even if it is small, may have serious professional consequences, since the performance of these professionals is dependent on the consistent use of exceptional vocal quality at all levels. In the second level are the professional voice user (teachers, lecturers, clergy), which are the focus of the present research (teachers). In these, the professional exercise depends on a great vocal resistance due to the prolonged use of voice-directed to large groups. They are professionally limited with a moderate vocal problem. The third level belongs to non-vocal professionals (businessmen, doctors, lawyers), whose professional activity is limited when the vocal problem is severe and may be slightly affected when moderate. The fourth and last level refers to non-vocal nonprofessionals (computer programmers, factory workers), who's professional activity does not depend on the use of voice.

Among the occupations at levels I and II, strenuous voice demands reach the functional capacity of vocal organs while creating adjustments. When that compensatory mechanism reaches its limit, dysphonic symptoms appear, such as voice quality fluctuations, vocal fatigue, and loss of voice power and volume, which create difficulties for a person's verbal and emotional communication abilities (Koufman, 1991). In addition to organic disorders, dysphonia may cause psychological disorders, difficulties in social and personal relationships, while negatively impacting the quality of life. It is a multi-factorial condition that should be analyzed within the context and environment where it occurs (Ortiz, Costa, Spina, & Crespo, 2004).

In stressful situations, the central nervous system accelerates the body's activities, resulting in a three-step organic activation: alarm, resistance and exhaustion (Giannini, Latorre & Ferreira, 2012; Park & Behlau, 2011), and the larynx is one of the organs affected by this conditions, due to the close relationship between voice and stress, especially on voice disorders of behavioral origin (Dietrich, Abbott, Gartner-Schmidt & Rosen, 2008). Related to that, subjects with voice complaints report symptoms that may be considered an indication of a dysfunction in the autonomic nervous system (ANS), and voice professionals, who have high and continuous demand, are considered the most susceptible individuals to develop a laryngeal compensation due to stress (Cielo, Ribeiro & Hoffmann, 2015). In a recent investigation about voice disorder and burnout syndrome in teachers, de Brito Mota et al. (2019) confirmed that teachers with the probable presence of voice disorders are more likely to exhibit a burnout syndrome, where voice disorders were also associated with certain work-related factors, including repetitive work, working under constant supervision and having to perform tasks requiring intense physical exertion.

Concerning teachers, their voice is one of the major determinants of their professional's didactic performance: vocal intensity, pauses, proper breathing are essential to maintain students' attention, in order to ensure the effective transmission of the contents, a task that makes each teacher adopt different strategies of vocal emission, creating a proper vocal identity. If there is a problem in the vocal apparatus, the teacher's voice will show the same change, causing a vocal quality that is dysphonic, hoarse and rough (Pinho, 2003), thus compromising speech and communication (Boone, 1996). This dysphonic condition is associated to excessive tension of the muscles not only of the pharynx, larynx, face and neck but often also in thorax and abdominal walls promoting disorders in the musculoskeletal system very often and disturbing the posture of the whole body and not only in the region of the speech apparatus (Angsuwarangsee & Morrison, 2002; Kooijman et al., 2005). In a recent study about teachers' working postures and their effects on their voice, Rantala, Sala and Kankare (2018) found that unergonomic postures while speaking affect the voice, increasing their sound pressure level and often voice breaks.

One of the best ways to assess posture is photogrammetry. Photogrammetry is a method that allows the recording of subtle postural changes difficult to assess by other forms of evaluation (Watson & Mac Donncha, 2000) and that demonstrates high reliability (Iunes et al., 2005; Sacco et al., 2007; Zonnenberg, Van Maanen, Elvers & Oostendorp, 1996). Concerning voice assessment, the outcome measures that are highly recommended by the literature are aerodynamic, acoustic and auditory-perceptual analysis of voice (Behlau, 2001, p. 139-147; Guimarães, 2007; Patel et al., 2018).

Fascia is a soft tissue component of the connective tissue system that permeates the human body. It is effectively a network recognized as part of a full-body tensional force transmission system (Schleip et al., 2012). Fascia has a key role to play in musculoskeletal dynamics: its ability to spontaneously adapt and adjust to strain or stretch establishes it as an active contributor to stability and mobility (Schleip et al., 2012). Myofascial release techniques act on the fascia through a sustained pressure combined with movement and aim to release the fascial constraints to restore maximum functionality to the organism (Simmonds, Miller & Gemmell, 2012). Theoretically, these techniques have an activation function of the ANS leading to vasodilation and muscle relaxation, with the main results being increased joint range of motion with decreased pain perception (Kautzner & Camm, 1997; Sztajzel, 2004). It produces, therefore, a local (mechanical) effect and a holistic (neurophysiological) effect, producing several changes in the organism as a result of the activation of the ANS (Simmonds, Miller & Gemmell, 2012).

Concerning other ways to treat voice disorders, in a recent investigation conducted by Aghadoost et al. (2019), it was found that vocal facilitating techniques and manual circumlaryngeal therapy are two effective techniques in voice therapy for teachers with muscle tension dysphonia. In another study, Conde et al. (2018) found that transcutaneous electrical nerve stimulation and laryngeal manual therapy may be used in voice treatment of women with behavioral dysphonia, because both treatments reduced musculoskeletal pain and partially improved voice quality. These two investigations are in line with the results of one systematic review of this thesis (paper 3).

In this context, the present thesis is divided into two parts: a first part that consists of 3 systematic reviews and a second part which contains 3 experimental studies. In the first part, the reviews were elaborated with the intention of knowing and organizing what had been produced for the scientific community up to that moment regarding assessment and treatment methods, in order to develop the empirical studies in a well-founded manner. These systematic reviews also aimed to make the theoretical framework of the topics explored, namely the associations between posture, voice and dysphonia (paper 1), associations between ANS function, voice and dysphonia (paper 2) and the effectiveness of physiotherapy and complementary therapies on voice disorders (paper 3). After the completion of these reviews, several samples were considered as possible targets, such as choir singers, healthy adults, teachers or seniors. However, with the difficulties that arose in obtaining samples with a high prevalence of voice disorders, we ended up choosing teachers for the experimental studies in the second part of the thesis, since they constitute the most cited samples in the literature on these subjects.

In the second part, that corresponds to the empirical component of the research, paper 4 aimed to verify if there were differences in posture, muscle tension and voice between teachers with and without voice complaints when assessed by photogrammetry, muscle tension through palpation, algometry, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice. Paper 5 analyzed if there were differences in ANS function and voice between teachers with and without voice complaints when assessed by heart rate variability, The

Questionnaire of Autonomic Dysfunction, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice. Finally, paper 6 consisted in a randomized controlled trial to verify the effects of myofascial release, compared to a control group, in posture, muscle tension and voice in teachers, according to photogrammetry, muscle tension through palpation, algometry, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice assessment.

MOTIVATIONS

From the theoretical framework the mechanism of voice production, its relation with posture and ANS, voice care and some strategies that help in the maintenance of vocal quality for voice professionals, who suffer a high incidence of dysphonia, revealing a greater need to acquire such knowledge as well as to undergo treatments, could be understood.

Thus, it became clear that basic care and behavioral strategies should be adopted by each teacher regarding the exposure and use of his/her voice in the work environment, since teachers with voice problems (dysphonia) and without vocal health habits do not act professionally in a healthy way.

As a physiotherapist and, lately, as a university professor, I am faced with the fact that teachers tend to neglect their voice, which is their instrument of work, and, many times, they do not know effective postural or vocal techniques for good communication with their students, and so they affect their voice and musculoskeletal health.

As a researcher, a PhD thesis organized by publications was adopted instead of a PhD by monograph, to more quickly share and contribute with results to the scientific community.

AIMS

Although voice and voice disorders are extensively studied, the exact underlying mechanisms associated to posture and ANS are still unclear.

Consequently, the general objective of the present investigation was to verify the associations between voice (disorders), posture and ANS, as well as to identify the best treatment strategies, in the context of physiotherapy and complementary therapies, to treat (voice) disorders related to these parameters.

To achieve this general objective, specific aims were designed and are the basis for each of the original theoretical and experimental articles/chapters of this thesis:

Paper I

To systematize the associations between posture, voice, and dysphonia in order to support future research directions. This step served to choose the necessary outcome measures for papers 4 and 6.

Paper II

To verify the relation between ANS dysfunctions, voice and dysphonia. This review served to select the necessary outcome measures for ANS parameters adopted for paper 5.

Paper III

To verify the effectiveness of physiotherapy and complementary therapies on voice disorders in order to support future research directions, possible clinical interventions and look for the best evidence-based treatments.

Paper IV

To verify if there were differences in posture, muscle tension and voice between teachers with and without voice complaints regarding:

i. Acoustic analysis of voice
ii. Auditory-perceptual analysis of voice
iii. Aerodynamic assessment of voice
iv. Photogrammetry (posture)
v. Muscle tension assessment through palpation
vi. Algometry (muscle tension)

Paper V

To verify if there were differences in ANS function and voice between teachers with and without voice complaints concerning:

i. Acoustic analysis of voice
ii. Auditory-perceptual analysis of voice
iii. Aerodynamic assessment of voice
iv. The Questionnaire of Autonomic Dysfunction (ANS)
v. Heart rate variability (ANS)

Paper VI

To verify the effects of myofascial release in teachers' posture, muscular tension and voice quality concerning:

i. Acoustic analysis of voice
ii. Auditory-perceptual analysis of voice
iii. Aerodynamic assessment of voice
iv. Photogrammetry (posture)
v. Muscle tension assessment through palpation
vi. Algometry (muscle tension)

Table 1 presents a summary of the scientific activity undergone during the PhD.

Table 1 – *Summary of the Activities related to the PhD.*

Paper I	
Publication	Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019a). Associations between posture, voice, and dysphonia: A systematic review. *Journal of Voice*, 33(1), 124e1-12. doi: 10.1016/j.jvoice.2017.08.030
Presentation	Cardoso, R., Meneses, R. F., & Lumini-Oliveira, J. (2016). *Associations between posture, voice and dysphonia: A systematic review*. In *Dias de investigação 2016*. Porto: Universidade Fernando Pessoa. (Oral Communication)
Paper II	
Publication	Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019b, in press). Associations between autonomic nervous system function, voice, and dysphonia: A systematic review. *Journal of Voice*. doi: 10.1016/j.jvoice.2019.07.022
Presentation	Cardoso, R., Meneses, R. F., & Lumini-Oliveira, J. (2016). *Voice, posture and autonomic nervous system: Relations and treatment*. In *I Encontro de Metodologias de Investigação: Da teoria à prática*. Porto: Universidade Fernando Pessoa. (Oral Communication)
Paper III	
Publication	Cardoso, R., Meneses, R. F., & Lumini-Oliveira, J. (2017). The effectiveness of physiotherapy and complementary therapies on voice disorders: A systematic review of randomized controlled trials. *Frontiers in medicine 4*(45). doi: 10.3389/fmed.2017.00045
Presentation	Cardoso, R., Meneses, R. F., & Lumini-Oliveira, J. (2017). *A fisioterapia e terapias complementares nas perturbações da voz*. In *Dias da Investigação 2017*. Porto: Universidade Fernando Pessoa. (Oral Communication)
Paper IV	
Publication	Cardoso, R., Meneses, R. F., Lumini-Oliveira, J., Pestana, P., & Guimarães, B. (2020, in press). Associations between Teachers' Posture, Muscle Tension and Voice Complaints. *Journal of Voice*. doi:10.1016/j.jvoice.2020.02.011
Paper V	
Publication	Cardoso, R., Meneses, R. F., Lumini-Oliveira, J., & Pestana, P. (2020, in press). Associations Between Teachers' Autonomic Dysfunction and Voice Complaints. *Journal of Voice*. doi: 10.1016/j.jvoice.2020.03.013

PART I - THEORETICAL BACKGROUND

Chapter 1

Paper 1 - Associations between posture, voice and dysphonia: A systematic review

Abstract

Objective. The study aimed to systematize the associations between posture, voice and dysphonia in order to support future research directions and possible clinical interventions.

Study Design. Systematic review.

Methods. According to the PRISMA flowchart, a search on PubMed/Medline, SciELO, RCAAP, LILACS, Cochrane library, PEDro and Isi Web of Knowledge was performed from their inception through January of 2017, using the key words: posture AND (voice OR dysphonia). Inclusion criteria: full-text journal articles in French, English, Portuguese or Spanish, exploring the relationship between posture and voice or dysphonia, in adult's human beings. Exclusion criteria: coupled treatments for voice disorders, literature reviews and meta-analysis, case studies, opinion articles, and studies linking breathing with posture without assessing voice. Studies were analyzed using a modified version of the Newcastle–Ottawa scale (NOS).

Results. Twelve papers met the inclusion criteria with high methodological quality through NOS. The review shows that a correct posture is necessary for an efficient voice production, however, the relation between dysphonia and posture seems to be contradictory.

Conclusion. An effective posture allows a subject in the a static posture or while moving, to more easily shift the tension between muscles, allowing for a free movement of the larynx without blockages and with benefits to voice production.

Key words: Voice, voice disorders, dysphonia, posture, systematic review.

Introduction

The voice is one of the most important components of communication between human beings. Through it, humans are able to convey their intentions revealing itself crucial in the interpersonal communication process (Ferreira & Costa, 2000). Any change in voice characteristics may affect the person's quality of life (Cielo et al., 2008; Spina et al., 2009).

Dysphonia is characterized by any difficulty or change in voice production that prevents its natural emission, conditioning oral communication (Behlau & Pontes, 1995), normally promoting changes in vocal parameters that result in modifications in sound quality, timbre, pitch or intensity (Ribeiro et al., 2011). A gradual increase in the diagnosis of dysphonia was observed: from 1.3% to 1.7% of the population from 2008 to 2012, with an associated increase in the diagnosis of acute laryngitis, the largest diagnostic category. A strong correlation has been demonstrated, between the diagnosis of acute laryngitis and age, being more common in the younger populations and associated with malignancies in older ages (Benninger, Holy, Bryson & Milstein, 2017). This fact may change postural reflexes and awareness of postural use because this may increase muscular tension and promote the anteriorization of the head which may change overall posture. In the study of Golub et al. (2006), the prevalence of dysphonia in older people was 20%, with a large proportion having significantly impaired quality of life related to their dysphonia. Prevalence rates of the diagnosis of dysphonia are increasing and are associated with large healthcare costs (Benninger, Holy, Bryson & Milstein, 2017).

Craniocervical positional changes have been reported to influence voice production (Scotto, 1998). Therefore, posture has been understood as an important component of voice quality, especially from studies of functional dysphonia and more precisely with the introduction of the classification of the vocal abuse/misuse syndrome also referred as or Bogart-Bacall syndrome and muscle tension dysphonia (Van Houtte, Van Lierde & Claeys, 2011).

A good posture is considered an optimum alignment of the body, with minimal energy requirements from neuromuscular system without causing excessive strain on the various tissues (Dutton, 2008; Marques, Hallal & Gonçalves, 2010). The effect of a change in one joint can have consequences anywhere along the kinetic chain. These changes can manifest in gait, joint load, neural function, endurance, strength, balance, muscle coordination, respiratory function and ultimately the voice (Arboleda & Frederick, 2008; Dutton, 2008).

Among the specific activities in which posture is associated with, voice production must be considered. In particular, Hoit, Passman, Lasing & Hixon (1988) found that during speech production in a standing posture, the oblique abdominal muscles of the lateral region of the abdomen are actively contracted. The activity of abdomen and chest muscles seems to impair the postural control, since the active contraction of these muscles may induce the loss of postural balance or provide a less-effective postural strategy during voice production as a result of a modification of the body proprioceptive scheme in patients with voice disorders or even in healthy subjects (Bruno et al., 2009; Estenne, Zocchi, Ward & Macklem, 1990).

The postural imbalances in the neck and head structure promotes changes in the soft tissue of the pharynx and in the muscles that elevate the larynx, which impairs control and resonance of the voice (Arboleda & Frederick, 2008).

This systematic review aims to systematize the association between posture, voice and dysphonia in order to understand future research directions and possible clinical interventions.

Methods

The systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff & Altman, 2009).

A computerized search was undertaken, by two independent reviewers, on the databases PubMed/Medline, SciELO, RCAAP, LILACS, Cochrane library, PEDro and Isi Web of Knowledge in order to identify studies that evaluated the relation between posture, voice and dysphonia. The search was made according to the PRISMA flowchart and the following key words combination was used: posture AND (voice OR dysphonia). The databases were searched from their inception through January of 2017.

Studies were included if: (1) they were published as full-text journal articles in French, English, Portuguese or Spanish; (2) they explored the relationship between posture and voice or dysphonia; (3) they were in humans; (4) their samples comprised only of human adults (18 years and older).

Studies were excluded if: (1) they focused on coupled treatments for voice disorders; (2) they linked breath with posture without assessing voice; (3) they were literature reviews and meta-analysis; (4) case studies; or (5) opinion articles.

Data extraction

Two independent reviewers conducted the data extraction. The characteristics of the collected studies included the authors; year of publication; sample size, age and gender; study design; outcome measures; methods; and results/conclusions.

Methodological quality

The methodological quality of each study included in this review was assessed by two independent reviewers using a modified version of the Newcastle–Ottawa scale (NOS) for quality assessment of cross-sectional studies (Table 1) (Wells et al., 2011). In a "star rating system", each included study was judged in the following areas: sample representativeness; sample size; non-respondents; ascertainment of the exposure; comparability of results; outcome assessment and statistical methods. Studies' quality was rated on a scale from 0 (high risk of bias) to 10 (low risk of bias). A maximum score of ten points was given for the study that fulfilled all quality criteria (Wells et al., 2011). In this review, studies with five or more points were considered as high quality. This categorization was previously used in other systematic reviews (Aldabe, Milosavljevic & Bussey, 2012; Roffey et al., 2010). The reviewers solved any rating discrepancies through verbal discussion. A consensus was reached regarding all studies during the first meeting.

Table 1 – *Modified version of the Newcastle–Ottawa scale (NOS) for quality assessment of cross-sectional studies.*

Selection				Comparability	Outcome	
Representativeness of the sample	Sample size	Ascertainment of exposure	Non-respondents	The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.	Assessment of outcome	Was follow-up long enough for outcomes to occur
a)Truly representative of the average in the target population. * (all subjects or random sampling) b) Somewhat representative of the average in the target population. * (non-random sampling) c) Selected group of users. d) No description of the sampling strategy.	a) Justified and satisfactory.* b) Not justified.	a) Validated measurement tool. ** b) Non-validated measurement tool, but the tool is available or described. * c) No description of the measurement tool.	a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. * b) The response rate is unsatisfactory, or the comparability between respondents and nonrespondents is unsatisfactory. c) No description of the response rate or the characteristics of the responders and the non-responders.	a) The study controls for the most important factor. * b) The study control for any additional factor. *	a) Independent blind assessment.* b) Record linkage. ** c) Self report. d) No description.	a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). * b) The statistical test is not appropriate, not described or incomplete.

* a point assigned on the scale.

Results

Studies selection

The literature search identified 1334 records. After removing the duplicates, 1319 records were screened for content through title and abstract, by two independent reviewers. From these, 1302 were excluded. The full-text of 17 articles was then assessed, by the same reviewers, for eligibility and 5 articles were excluded. In total, 12 articles were included in the systematic review. The reasons for the exclusions are listed on the PRISMA flowchart (Figure 1).

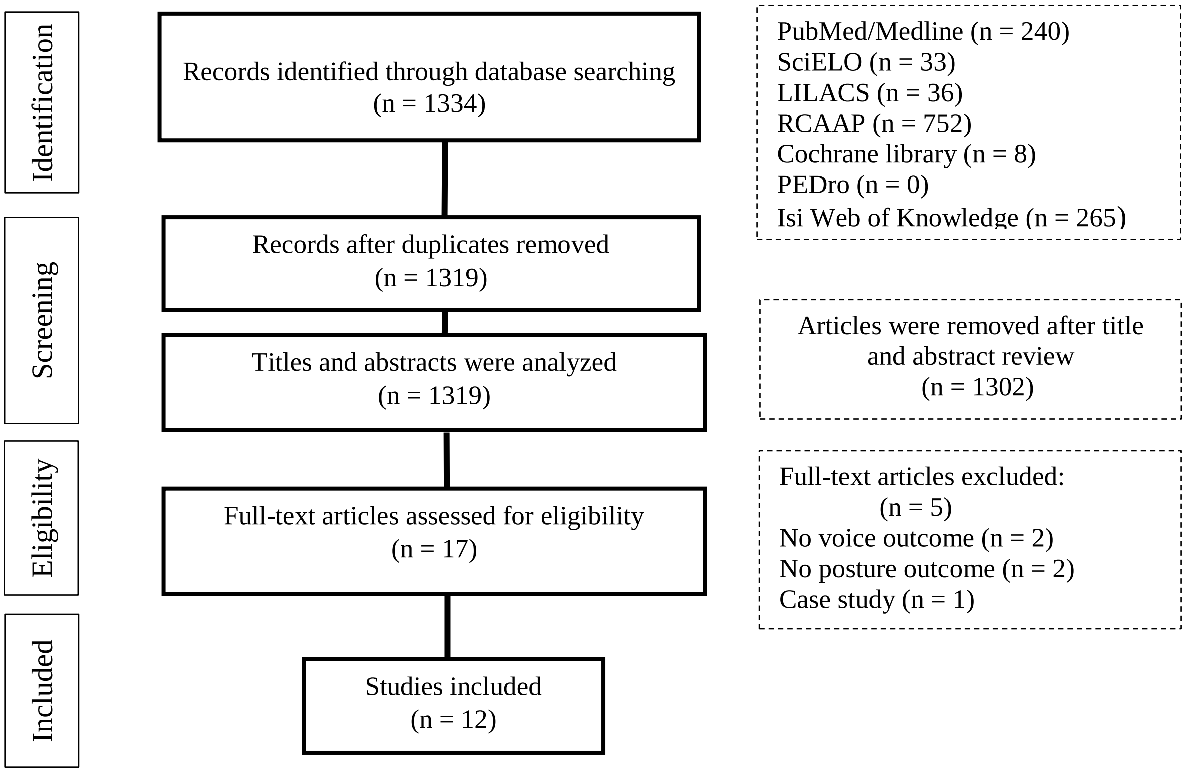

Figure 1 – *PRISMA flow diagram showing selection of article review.*

Studies description

The total number of subjects included in the 12 articles was 501, with a minimum sample size of 10 and maximum of 100. The studies included 163 male and 338 female participants. The age of the participants ranged from 18-93 years old. Most of the participants included in the 12 articles were heathy, being present in 10 articles (Bigaton et al., 2010; Carneiro, 2013; Franco et al., 2014; Gilman & Johns, 2016; Lagier et al., 2010; Mautner, 2015a; Mautner, 2015b; Menoncin et al., 2010; Miller et al., 2012; Miller et al., 2014). Were also included dysphonic subjects (Bigaton et al., 2010; Franco et al., 2014; Menoncin et al., 2010), teachers (Troni et al., 2006) and singers (Johnson & Skinner, 2009; Miller et al., 2014). The summary of the articles content is presented in Table 2.

All studies were cross-sectional studies. The studies were heterogeneous in relation to the outcome measures used, with a wide variety of instruments being applied. The outcome measures most frequently used for posture were photogrammetry (Bigaton et al., 2010; Carneiro, 2013; Franco et al., 2014) and magnetic resonance imaging (Johnson & Skinner, 2009; Miller et al., 2012; Miller et al., 2014). The outcome measure most frequently applied for voice assessment was a perceptual speech analysis (Carneiro, 2013; Franco et al., 2014; Mautner, 2015b; Menoncin et al., 2010, Troni et al., 2006) followed by acoustic analysis (Carneiro, 2013; Franco et al., 2014). In addition to these, other measurements were used for assessment, such as: electroglottography; cervical mobility tests; craniocervical dysfunction index; soft tissue palpation; nasoendoscopy; visual analog scale; audiovisual recordings; x-ray; and postural assessment.

Some studies had two groups: a group of healthy subjects was compared to a dysphonic group (Bigaton et al., 2010; Franco et al., 2014; Mautner, 2015b). The majority of studies had only one group.

The professional backgrounds of the examiners mentioned were Speech Therapy (Carneiro, 2013; Menoncin et al., 2010; Troni et al., 2006), Physiotherapy (Menoncin et al., 2010; Troni et al., 2006), Orthopedics (Troni et al., 2006) and Otolaryngology (Troni et al., 2006).

Table 2 – *Studies description.*

Author(s), year	Sample size	Study design	Outcome measures	Methods	Results/Conclusions
Troni et al, 2006	21 teachers (range: 22–62 years old) 0M and 21F	CSS	MPT; audiovisual recordings to speech and posture; perceptual-visual evaluation (spontaneous speech).	After vocal assessment, audiovisual recordings were performed to measure the speech articulation patterns and posture of teachers in two different situations: professional context (classroom) and outside the professional context (maintained dialogue with one of the researchers, who asked the teachers talk about their "life in teaching").	Female teachers showed differences in speech articulation patterns and posture when they were compared in a dynamic professional situation and in a non-professional context.
Johnson and Skinner, 2009	18 professional opera students (mean age F 20.86 ± 3.07 years; M 18.66 ± 1.36 years) 6 M and 12 F	CSS	Roentgen-cephalograms.	Two registrations for each participant were carried out via Roentgen-cephalograms using a Wehmer cephalostat with the participant in standing in the standardized upright posture and the head fixed by ear rods: 1- participant in the standardized upright posture at the end of quiet expiration 2 - participant in the standardized upright posture while singing the /a/ vowel and holding the /a/ pitch	Of the craniocervical postural variables in the singing registration, the angles measuring positional change of the atlas and C4 relative to the true horizontal were shown to be significantly related to an increased pharyngeal airway space at the C3 level ($p<0.01$).
Lagier et al., 2010	20 healthy subjects (range: 20–43 years old) 0 M and 20 F	CSS	Voice Data Collection: SPL; F_0; Closed quotient; Coefficient of variation of F_0; Duration of the words. Kinematic Data Collection and Postural Analysis: kinematic curves focused on the positions of the head, the trunk and the thighs in the sagittal plane (Movement	Participants had to communicate with a listener under 3 conditions requiring different levels of vocal effort: WVEC; MVEC; HVEC.	The close correlation of posture with vocal production shows that movement is not a mere consequence of vocal effort. Posture and voice are coordinated in communication behavior, and each body segment plays its specific role in the vocal effort behavior.

			amplitude; Movement duration).		
Bigaton et al., 2010	28 healthy and dysphonic women (31,25±8,14 years old) 0M and 28F	CSS	CDI and photogrammetry, determining the anterior angle formed between the seventh cervical vertebra and the tragus, which corresponds to the head position in the sagittal plane.	Two groups: experimental (N=16, patients with dysphonia) and control (N=12, clinically normal)	There was no difference between the evaluated groups regarding head position (p=0.2565). Dysphonic women presented more severe craniocervical dysfunction than the group control, which suggests that the dysphonia is more related to the functional alterations of the cervical region than to the postural ones of the same region.
Menocin et al, 2010	50 healthy and dysphonic subjects (range: 25–55 years old) 0M and 50F	CSS	Cervical mobility tests; soft tissue palpation; X-ray; Postural assessment; auditory-perceptual measurement (spontaneous speech; GRBAS).	Two groups: experimental (N=32, patients with dysphonia) and control (N=18, clinically normal).	Significant cervical abnormalities were found in both groups; it cannot be inferred that the changes are directly related to dysphonia.
Miller et al., 2012	10 healthy subjects (range 20–47 years old) 5M and 5F	CSS	Magnetic resonance imaging: Midsagittal magnetic resonance image; Craniocervical and angular variables; Craniocaudal variables; Anteroposterior variables.	Each individual was scanned three times: at rest during quiet breathing, while performing first a LNH, and then a HNH. Participants were asked to establish the lowest and highest notes they could comfortably sustain while humming over 20 seconds. Twenty-two craniocervical, angular, and linear dimensions defined on these images were compared.	Significant differences between low- and high-note conditions in six of the 22 measures and widespread pitch-related correlations between variables ($r \geq 0.63$, $p<0.05$) were found. Compared with low-note humming, high-note humming was accompanied by increased craniocervical angles opt/nsl and cvt/nsl ($p=0.008$ and 0.002, respectively); widening of the C3-menton distance ($p=0.003$), a rise of the larynx and hyoid in relation to the cranial base ($p=0.012$ and

			.		<0.001, respectively), and an increased sternum-hyoid distance (p<0.001).
Carneiro, 2013	100 healthy subjects (mean age: F - 24,72 years old; M - 23,46 years old) 50M and 50F	CSS	Acoustic analysis; perceptual speech; Photogrammetry angles: Condyle-acromion (ACA), menton-sternum (AME), and Frankfurt (AF).	Participants were photographed sited in lateral view in a straight spine alignment simultaneously to the recording process of the sustained vowel /a/ by the program sound forge 7.0 in four different cervical postures: P1) straight alignment; P2) forward head position; P3) backward head position; P4) cervical extension.	In the P2, P3 and P4 positions the voice became more acute, with more tension and worse quality when compared to the P1 position and also in P3 and P4 increased loudness was observed.
Franco et al., 2014	74 healthy and dysphonic subjects (range 20-50 years old) 35M and 39F	CSS	Sagittal plane photographs TL, KI and LL. The KI was calculated as a ratio of the thoracic width and the TL; Acoustic analysis; Perceptual speech; Nasoendoscopy. Normal and dysphonic speakers.	Two groups: experimental (N=33, participants with dysphonia) and control (N=41, clinically normal). A sagittal photograph was taken, with the participants in an upright standing position. Ten photographs were ''rerated'' three times, and the mean value obtained was then used. Laryngeal inspection was made by the ear, nose, and throat surgeon after a nasoendoscopic examination. The reference values of perceptive measures (grade component of the GRBAS scale) and acoustic measures (F_0, jitter, intensity, shimmer, and harmonic-to-noise ratio) were used to decide diagnosis.	Findings indicated significant differences in some sagittal spine posture measures between normal and dysphonic speakers. Postural measures can add useful information to voice assessment protocols and should be taken into account when considering particular treatment strategies.
Miller et al., 2014	10 healthy subjects (range 20-47 years old) 5M and 5F	CSS	Midsagittal magnetic resonance.	Six midsagittal magnetic resonance images (at rest, while breathing out, and while listening to, and humming low and high notes) were obtained. Eighty landmark points were chosen to define the shape of interest and an ASM was built using these (60) images.	As the humming pitch changes from low to high, the cervical spine moves from lordosis toward kyphosis, the airway becomes shorter, vocal structures (larynx, hyoid, epiglottis, and velum) rise together in relation to the cervical spine, the distance between the sternum and larynx increases, and the distance between the larynx and hyoid decreases.

Mautner, 2015a	85 healthy subjects (range 38-93 years old) 29M and 56F	CSS	Acoustic measures; electroglottographic measures.	Participants were instructed to sustain the vowel /a/ at a constant comfortable intensity level for approximately 3 seconds in three different pitch levels: normal, low, and high. To calculate a quadrilateral vowel space area (VSA), participants were asked to repeat the sentence ‘‘We saw two cars’’ containing the corner vowels /i/, /ɔ/, /u/, and /a/.	An open jaw posture was generally associated with positive changes in vocal behaviors, including higher F_0, improved phonatory stability, and voice clarity.
Mautner 2015b	40 normal-hearing listeners (range 18-47 years old) 20M and 20F	CSS	Auditory-perceptual measurement.	Participants performed two separate tasks: identifying vowels and comparing vowel clarity. Stimuli included vowels segmented from a sentence ("We saw two cars") produced using a normal and an open jaw posture by 40 individuals aged between 30s and 80s. Three types of stimuli were presented: variable length and intensity, fixed length and variable intensity, and fixed length and normalized intensity.	Open jaw posture resulted in higher rates of correct vowel identification, and vowels from contrast pairs were consistently judged as being "clearer" than vowels produced in normal jaw posture.
Gilman and Johns (2016)	45 healthy subjects (27,5 years old) 13M and 33F	CSS	VAS (0–40 least effort, 40–60 habitual effort, and 60–100 increased effort).	Participants sustained the vowel /a/ at a comfortable pitch and loudness for 5–10 seconds in each of six positions: sitting and standing in the manner habitual for each subject, two exaggerated positions of the head (head back and head forward), and two exaggerated positions in standing (standing with knees locked and with knees soft). Each position was repeated three times in randomized order, resulting in 18 trials for each subject. After each repetition of the sustained /a/, subjects were asked to rate their experience of vocal effort using a VAS.	The exaggerated forward and back head positions in both sitting and standing positions showed the greatest significance on the Tukey *post hoc* tests ($P < 0.000$). Posture may play a more important role in vocal fatigue than previously thought.

Abbreviations: CDI, Craniocervical Dysfunction Index; CSS, Cross-sectional study; F, Female; F_0, Fundamental frequency; GRBAS, Grade, Roughness, Breathiness, Asthenia, Strain; HNH, High-note hum; HVEC, High vocal effort condition; KI, Kyphosis index; LL, Lumbar length curvature; LNH, Low-note hum; M, Male; MPT, Maximum phonation time; MVEC, Moderate vocal effort condition; TL, Thoracic length curvature; VAS, Visual analogue scale; VCOP rms, Velocity of variation of the center of pressure; WVEC, Weak vocal effort condition.

Studies quality

The mean modified NOS score for the studies included in the review was 9,16 points (range: 8-10 points). Quality criteria for methodological assessment are shown in Table 3. According to the quality criteria set, all the studies included in this review were considered high quality.

The major bias of these cross-sectional studies was the risk of bias in the sample selection. No study mentioned blinding of the examiners.

Table 3 – *Methodological quality by a modified version of the Newcastle–Ottawa scale for the included studies.*

References	Selection				Comparability	Outcome		Total
	1	2	3	4	1	1	2	
Troni et al, 2006	B	B	A	B	A/B	B	A	8
Johnson and Skinner, 2009	B	B	A	B	A/B	B	A	8
Lagier et al., 2010	B	B	A	A	A/B	B	A	9
Bigaton et al., 2010	B	B	A	A	A/B	B	A	9
Menocin et al, 2010	B	A	A	A	A/B	B	A	10
Miller et al., 2012	C	B	A	A	A/B	B	A	8
Carneiro, 2013	B	A	A	A	A/B	B	A	10
Franco et al., 2014	B	A	A	A	A/B	B	A	10
Miller et al., 2014	C	B	A	A	A/B	B	A	8
Mautner, 2015[a]	B	A	A	A	A/B	B	A	10
Mautner 2015b	B	A	A	A	A/B	B	A	10
Gilman and Johns, 2016	B	A	A	A	A/B	B	A	10

Discussion

This systematic review provides an overview of the published evidence concerning the association between posture, voice and dysphonia. In an extensive search, only 12 cross-sectional studies met the inclusion criteria.

Dysphonia is characterized by the change of vocal parameters that result in modifications in sound quality, timbre, pitch or intensity (Johnson & Skinner, 2009; Ribeiro et al., 2011). Craniocervical changes have been reported in association with impairments in voice production (Scotto, 1998). Mitchinson & Yoffey (1948) observed that the change from humming a low note to a high note was accompanied by increased anteroposterior thickness of the prevertebral soft tissues. Some studies included in this review (Johnson & Skinner, 2009; Miller et al., 2012; Miller et al., 2014) also related craniocervical changes with voice production. Miller et al. (2014) found that as the humming pitch changes from low to high, the cervical spine moves from lordosis toward kyphosis, the airway becomes shorter, vocal structures (larynx, hyoid, epiglottis, and velum) rise together in relation to the cervical spine, the distance between the sternum and larynx increases, and the distance between the larynx and hyoid decreases. Johnson and Skinner (2009) identified postural changes in the craniocervical region associated with the demands of voice production in professional opera students where the angles measuring positional change of the atlas and C4 relative to the true horizontal were shown to be significantly related to an increased pharyngeal airway space at the C3 level. Miller et al. (2012), showed that the switch from humming a low note to a high note is accompanied by significant changes, affecting not only the vocal tract and related structures, but also extending to other regions of the head and neck. This investigation reported pitch-related changes involving the craniocervical angles in a nonphonetic context, a view supported by reports of pitch related involvement of the neck muscles during phonation (Pettersen & Westgaard, 2005; Yamawaki, 2003). An explanation for this finding might be the recognizing of the common nerve root origin of the nerves supplying postural neck and hyoid muscles (Standring et al, 2005).

The presence of synergy between cervical and strap muscles has important clinical implications because muscle tension dysphonia, for example, is characterized by excessive tension in extrinsic or (para)laryngeal musculature (Van Houtte, Van Lierde & Claeys, 2011) and the increased tension of the extrinsic muscles leads to elevation of the larynx in the neck, with the constant participation of the extrinsic muscles on phonation (Menoncin et al., 2010; Van Houtte, Van Lierde & Claeys, 2011). A study (do Brasil, Yamasaki, de Souza, 2005) showed a statistically significant difference between genders related to the vertical larynx position in the neck, because the women presented higher larynx position than men. This vertical larynx position has significant acoustic and physiological implications (do Brasil, Yamasaki, de Souza, 2005), as a higher larynx position is a characteristic often found in hyperfunctional dysphonia (Aronson, 1990; Iwarsson, 2001).

Some other studies reinforce the relation between body posture and larynx extrinsic muscles (Bigaton et al., 2010; Carneiro, 2013; Franco et al., 2014; Lagier et al., 2010; Mautner, 2015a), mostly assessed by photogrammetry (Bigaton et al., 2010; Carneiro, 2013; Franco et al., 2014). A case study, not included in this review, that used photogrammetry, found a relationship between posture and voice quality, where a computerized photogrammetry stated that the best way to produce the sound was in a straight posture (Carneiro & Teles, 2012). In another study, Carneiro (2013) verified that in a forward head, backward head and cervical extension positions, the voice becomes more acute, with more tension and worse quality when compared to a straight/neutral position. Additionally, Carneiro (2013) found that in a backward head position and cervical extension, an increased loudness can be observed.

Gilman and Johns (2016) found that posture can have a strong effect on vocal effort, even in the absence of vocal loading. The authors concluded that posture, even subtle shifts in position of the head or balance, can have a significant impact on the efficiency of laryngeal movement.

However, Franco et al. (2014) found significant differences in some sagittal spine posture measures between normal and dysphonic speakers because for thoracic length curvature and for the kyphosis index a significant effect of dysphonia was observed with mean thoracic length curvature and kyphosis index significantly higher for the dysphonic speakers than for the normal speakers. Authors concluded that postural measures can add useful information to voice assessment protocols and should be taken into account when considering particular treatment strategies. Another investigation that studied the relation of posture and dysphonia was that of Bigaton et al. (2010), where there were no differences between the evaluated groups regarding head position. However, dysphonic women presented more severe craniocervical dysfunction than the control group. In the study of Menoncin et al. (2010), the authors found that the cervical x-ray in the non-dysphonic group was normal, while the dysphonic participants showed a reduction of interdiscal spaces prevailed. In this study, most of the dysphonic participants showed a significant dysphonia in the auditory-perceptual assessment and a muscle shortening in the cervical region, however, the diagnosis by videolaryngostroboscopy showed no lesion on the vocal folds. The authors also refer that significant cervical abnormalities were found in both groups, and that it cannot be inferred that the changes are directly associated with dysphonia.

Another author included in this review that reported associations between posture and voice production was Mautner (2015a), who found that an open jaw posture was generally associated with positive changes in vocal behaviors, including higher F_0, improved phonatory stability, and voice clarity.

In another research, Troni et al. (2006) found that female teachers showed differences in speech articulation patterns and posture when they were compared in a dynamic professional situation and in a non-professional context. The authors found that teachers in the professional context adopted a more rigid and tense posture, increasing their vocal effort and slowed their voice. The data lead to the consideration that increasing the vertical range of mandibular movement, associated with postural changes and tension, especially in cervical area, can lead to the appearance or worsening of a voice disorder.

All subjects can be taught what an ideal posture is. However, anatomical considerations and different body types can result in different compensations which can lead and individual away from a perfect posture, which should be a result of a correct body alignment, where an imaginary line goes through the external acoustic meatus, the articular line of the shoulder, great trocanter, knee and ankle. A good posture should reflect the alignment of the different body segments in space with minimum energy requirements and tension on the musculoskeletal system and is considered by some authors to be something dynamic (Dutton, 2008; Marques, Hallal & Gonçalves, 2010).

A good posture is necessary because it can help to harmonize muscle tensions, which itself can cause postural changes. Also, muscle tension and dysphonia may influence each other. Muscle tension may cause dysphonia and, on the contrary, to be a result of dysphonia as subjects increasingly add muscle effort trying to make their voices work. The small intrinsic laryngeal muscles are responsible for the movement of the arytenoid cartilages and thus for vocal fold adduction, abduction, and tension. The larger extrinsic musculature (suprahyoid and infrahyoid muscles) maintain the larynx in a stable and natural position in which the intrinsic laryngeal musculature can contract freely and undisturbed. In patients with muscle tension dysphonia, an altered tension of the extrinsic musculature results in a changed position of the larynx in the neck (a mostly higher position) and a disturbed inclination of the cartilaginous structures of the larynx (hyoid, thyroid, cricoid, and arytenoid) that immediately affects the intrinsic musculature. Tension of the vocal folds is altered and the voice becomes disturbed (Rubin, Lieberman & Harris, 2000).

Although the methodological quality of the studies included in the review was high, 9,16 points (range: 8-10 points), this review has some limitations. Only one study evaluated muscle tension by palpation and no study measured this outcome through objective methods like electromyography or algometry. Without research that includes the assessment of muscle tension there can be no direct association of voice with a healthy postural use. Some studies had small samples, only four investigations had two groups and most of the included studies did not mention the professional background, the years of experience of the examiners in the physical evaluations nor did they mention the questionnaire evaluators. No study mentioned blinding of examiners. The studies did not note if assessments were always performed at the same hour of the day or in the same season.

Another limitation is that all included studies were cross-sectional observational clinical studies. These studies leave open the possibility of selection bias as no randomization was performed and therefore any associations drawn in cross-sectional studies do not imply causation. Although, we did not exclude longitudinal studies from our literature search, however, none were found, suggesting that studies with a more prolonged follow-up studies should be performed.

Despite these limitations, this review is, as far as the authors are aware, is the first to comprehensively and critically assess evidence of the associations between posture, voice and dysphonia, which may provide useful insight for further studies and clinical practice. This review can be considered as a first step in order to document these relations.

We suggest further research with more similar assessment methods in order to better compare the studies and systematize knowledge about the relationship between posture and voice and dysphonia. We also suggest longitudinal studies, investigations with larger samples and that relate gold standard measurements of voice, like aerodynamic, acoustic and auditory-perceptual assessments, with objective measurements of posture, like photogrammetry or imaging exams such as magnetic resonance imaging, as well as evaluation of muscle tension through electromyography or muscle palpation by validated scales. The posture assessment should be analyzed both in a fixed position and during a specific action or task. We suggest studies with two groups - healthy individuals and individuals with voice disorders -, using experienced blinded examiners. Samples with professionals that are frequently affected with voice disorders, like teachers and singers, are suggested as well as samples with more males.

Conclusion

The interaction between muscle tension, postural use, and vocal use has a very complex relation.

The knowledge of the relationship between body posture, laryngeal muscles, voice production and dysphonia is of paramount importance because a transdisciplinary action can optimize the evaluation and treatment in order to provide benefits to patients with voice problems. An effective posture allows a subject in the a static posture or while moving, to more easily shift the tension between muscles, allowing for a free movement of the larynx without blockages and with benefits to voice production. However, additional studies should be made to further demonstrate this both statically and while moving.

References

Aldabe, D., Milosavljevic, S., & Bussey, M. D. (2012). Is pregnancy related pelvic girdle pain associated with altered kinematic, kinetic and motor control of the pelvis? A systematic review. *European Spine Journal*, 21(9), 1777-1787. doi: 10.1007/s00586-012-2401-1

Arboleda, B.M.W. & Frederick, A.L. (2008). Considerations for maintenance of postural alignment for voice production. *Journal of Voice*, 22(1), 90-9. doi: 10.1016/j.jvoice.2006.08.001

Aronson, A.E. (1990). Therapy for voice disorders. In Aronson, A.E. *Clinical Voice Disorders*. 3rd ed. New York: Thieme/Stratton; 309-47.

Behlau M & Pontes P. (1995). Avaliação e tratamento das disfonias. *São Paulo: Lovise*, 143-66.

Benninger, M.S., Holy, C.E., Bryson, P.C. & Milstein, C.F. (2017). Prevalence and Occupation of Patients Presenting With Dysphonia in the United States. *Journal of Voice, 31*(5), 594-600. doi: 10.1016/j.jvoice.2017.01.011

Bigaton, D. R., Silvério, K. C. A., dos Santos Berni, K. C., Distefano, G., Forti, F., & de Jesus Guirro, R. R. (2010). Postura crânio-cervical em mulheres disfônicas Craniocervical posture in dysphonic women. *Revista da Sociedade Brasileira de Fonoaudiologia, 15*(3), 329-34. doi: 10.1590/S1516-80342010000300004

Bruno, E., De Padova, A., Napolitano, B., Marroni, P., Batelli, R., Ottaviani, F., & Alessandrini, M. (2009). Voice disorders and posturography: variables to define the success of rehabilitative treatment. *Journal of Voice*, *23*(1), 71-75.

Carneiro, P. R. (2013). *A influência de diferentes posturas da coluna cervical na análise do sinal de voz* (Doctoral dissertation). Universidade de São Paulo, Brazil.

Carneiro, P. R., & Teles, L. C. D. S. (2012). Influência de alterações posturais, acompanhadas por fotogrametria computadorizada, na produção da voz. *Fisioterapia em Movimento*, 25(1):13-20. doi:10.1590/S0103-51502012000100002

Cielo, C. A., Conterno, G., Carvalho, C. D. D. M., & Finger, L. S. (2008). Disfonias: relação s/ze tipos de voz. *Revista CEFAC*, *10*(4), 536-47. doi:10.1590/S1516-18462008000400014

Do Brasil, O. D. O. C., Yamasaki, R., & de Souza Leão, S. H. (2005). Proposta de medição da posição vertical da laringe em repouso. *Brazilian Journal of Otorhinolaryngology*, *71,* 313-317. doi: 10.1590/S0034-72992005000300008

Dutton, M. (2008). *Orthopaedic examination, evaluation, and intervention*. 2nd ed. New York, NY: McGraw-Hill.

Estenne, M., Zocchi, L., Ward, M., & Macklem, P. T. (1990). Chest wall motion and expiratory muscle use during phonation in normal humans. *Journal of Applied Physiology*, *68*(5), 2075-2082.

Ferreira, L., & Costa, H. (2000). Falando sobre o profissional da voz. São Paulo: Editora Roca Ltda.

Franco, D., Martins, F., Andrea, M., Fragoso, I., Carrão, L., & Teles, J. (2014). Is the sagittal postural alignment different in normal and dysphonic adult speakers?. *Journal of Voice*, *28*(4), 523-e1. doi: 10.1016/j.jvoice.2014.01.002

Gilman, M., & Johns, M. M. (2016). The effect of head position and/or stance on the self-perception of phonatory effort. *Journal of Voice*, *31*(1), 131-e1. doi: 10.1016/j.jvoice.2015.11.024

Golub, J. S., Chen, P. H., Otto, K. J., Hapner, E., & Johns, M. M. (2006). Prevalence of perceived dysphonia in a geriatric population. *Journal of the American Geriatrics Society*, *54*(11), 1736-1739.

Hoit, J. D., Plassman, B. L., Lansing, R. W., & Hixon, T. J. (1988). Abdominal muscle activity during speech production. *Journal of Applied Physiology*, *65*(6), 2656-2664.

Iwarsson, J. (2001). Effects of inhalatory abdominal wall movement on vertical laryngeal position during phonation. *Journal of Voice*, *15*(3), 384-394. doi: 10.1016/S0892-1997(01)00040-6

Johnson, G., & Skinner, M. (2009). The demands of professional opera singing on craniocervical posture. *European Spine Journal*, *18*(4), 562. doi: 10.1007/s00586-009-0884-1

Lagier, A., Vaugoyeau, M., Ghio, A., Legou, T., Giovanni, A., & Assaiante, C. (2010). Coordination between posture and phonation in vocal effort behavior. *Folia Phoniatrica et Logopaedica*, *62*(4), 195-202. doi: 10.1159/000314264

Marques, N. R., Hallal, C. Z., & Gonçalves, M. (2010). Características biomecânicas, ergonômicas e clínicas da postura sentada: uma revisão. *Fisioterapia e pesquisa*, *17*(3), 270-276.

Mautner, H. D. (2015a). An acoustic and electroglottographic study of the aging voice with and without an open jaw posture. *Journal of Voice*, *29*(4), 518-e1. doi: 10.1016/j.jvoice.2014.09.024

Mautner, H. D. (2015b). Effects of an open jaw posture on vowel perception in the aging voice. *Journal of Voice*, *30*(6), 772-e23. doi: 10.1016/j.jvoice.2015.11.011

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C. A., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia*, 14(4), 461-6. doi: 10.1590/S1809-48722010000400014

Miller, N. A., Gregory, J. S., Semple, S. I., Aspden, R. M., Stollery, P. J., & Gilbert, F. J. (2012). The effects of humming and pitch on craniofacial and craniocervical morphology measured using MRI. *Journal of Voice, 26*(1), 90-101. doi: 10.1016/j.jvoice.2010.10.017

Miller, N. A., Gregory, J. S., Aspden, R. M., Stollery, P. J., & Gilbert, F. J. (2014). Using active shape modeling based on MRI to study morphologic and pitch-related functional changes affecting vocal structures and the airway. *Journal of Voice, 28*(5), 554-564.doi: 10.1016/j.jvoice.2013.12.002

Mitchinson, A. G. H., & Yoffey, J. M. (1948). Changes in the vocal folds in humming low and high notes. A radiographic study. *Journal of anatomy, 82*(Pt 1-2), 88.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*,151(4): 264-269. doi: 10.1371/journal.pmed.1000097

Pettersen, V., & Westgaard, R. H. (2005). The activity patterns of neck muscles in professional classical singing. *Journal of Voice, 19*(2), 238-251. doi: 10.1016/j.jvoice.2004.02.006

Ribeiro, V. V., Leite, A. P. D., Alencar, B. L. F. D., Bail, D. I., & Bagarollo, M. F. (2013). Avaliação vocal de crianças disfônicas pré e pós intervenção fonoaudiológica em grupo: estudo de caso. *Revista CEFAC, 15*(2), 485-94. doi: 10.1590/S1516-18462012005000056

Roffey, D. M., Wai, E. K., Bishop, P., Kwon, B. K., & Dagenais, S. (2010). Causal assessment of awkward occupational postures and low back pain: results of a systematic review. *The Spine Journal*, 10(1), 89-99. doi: 10.1016/j.spinee.2009.09.003

Rubin, J. S., Lieberman, J., & Harris, T. M. (2000). Laryngeal manipulation. *Otolaryngologic Clinics of North America*, *33*(5), 1017-1034. doi: 10.1016/S0030-6665(05)70261-9

Scotto, N. D. C. (1998). Cervical spine abnormalities in professional singers. *Folia phoniatrica et logopaedica*, *50*(4), 212-218. doi: 10.1159/000021463

Spina, A. L., Maunsell, R., Sandalo, K., Gusmão, R., & Crespo, A. (2009). Correlação da qualidade de vida e voz com atividade profissional. *Revista Brasileira de Otorrinolaringologia*, 75(2): 275-9. doi: 10.1590/S0034-72992009000200019

Standring, S., Ellis, H., Healy, J., Johnson, D., Williams, A., Collins, P., & Wigley, C. (2005). Gray's anatomy: the anatomical basis of clinical practice. *American Journal of Neuroradiology*, *26*(10), 2703.

Troni, C. R., Arakaki, F. N., Lima, F. S., Mott, L., Rodrigues, K. A., & Ferreira, L. P. (2006). Professores em contexto profissional e não profissional: análise objetiva e subjetiva dos aspectos da articulação e da postura. *Distúrbios da Comunicação*, *18*(2).

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, 25(2), 202-207. doi: 10.1016/j.jvoice.2009.10.009

Wells, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M. & Tugwell, P. (2011) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in metaanalyses [WWW document]. URL http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp [accessed on 01 May 2017].

Yamawaki, Y. (2003). Forward movement of posterior pharyngeal wall on phonation. *American journal of otolaryngology*, *24*(6), 400-404.

Chapter 2

Paper 2 - Associations between autonomic nervous system function, voice and dysphonia: A systematic review

Abstract

Objective. The study aimed to verify the relation between autonomic nervous system (ANS) dysfunctions, voice and dysphonia.

Study Design. Systematic review.

Methods. According to the PRISMA flowchart, a search on PubMed/Medline, SciELO, RCAAP, LILACS, Cochrane library, PEDro and Isi Web of Knowledge was performed up to April of 2019, using the key words: autonomic nervous system AND (voice OR dysphonia). Inclusion criteria: full-text articles published in French, English, Portuguese or Spanish, exploring the relationship between ANS and voice or dysphonia, in human adults. Exclusion criteria: additional treatments for voice disorders, literature reviews and meta-analysis, case studies and opinion articles. All studies were analyzed using a modified version of the Newcastle–Ottawa scale (NOS).

Results. Nine papers met the inclusion criteria, all with high methodological quality. The review shows that ANS is related to voice and dysphonia. Individuals with dysphonia tend to show more symptoms of ANS dysfunction concurrent with laryngeal muscles activation and that heartbeat modulates the F_0 of human voice.

Conclusion. Changes in ANS function are associated with voice as well as with dysphonia.

Key words: Voice, voice disorders, dysphonia, autonomic nervous system, autonomic dysfunction, systematic review.

Introduction

The literature on voice shows a relation between functional voice disorders (FVDs), posture and a myriad of psychological factors, with implications in terms of intervention (Cardoso, Lumini-Oliveira & Meneses, 2019; Cardoso, Meneses & Lumini-Oliveira, 2017; Van Houtte, Van Lierde & Claeys, 2011). One pathway implicated in the development and propagation of FVDs is a dysfunction of the autonomic nervous system (ANS) (Hisa et al., 1999). The ANS, also referred to as visceral, vegetative or automatic, presents two main divisions: sympathetic nervous system (SNS) and parasympathetic (PNS). The SNS and PNS work together to maintain body homeostasis (Gonçalves, 2014; Lefkowitz, Hoffman & Taylor, 1996; Wehrwein, Orer & Barman, 2016). The ANS seems to have a relation with voice because the vagus nerve is one of the most important cranial nerves for speech production. This nerve has three branches, each of which has a special importance for motor speech production (Erman, Kejner, Hogikyan & Feldman, 2009).

The pharyngeal branch supplies motor innervation for many muscles of the pharynx; bilateral damage of the pharyngeal branch promotes weakness or paralysis of almost all the muscles of the *velum* which can have a significant effect on resonance, producing a moderately or severely hypernasal speech, and pressure consonants may be weak and distorted because of nasal emission of air through the open velopharyngeal port (Erman, Kejner, Hogikyan & Feldman, 2009). The external superior laryngeal nerve branch innervates the cricothyroid muscle of the larynx, that contributes to stretch and tense the vocal folds during speech to control vocal pitch. Bilateral damage of this branch may result in an individual's decreased loudness and increased breathiness, and having notable difficulty to change vocal pitch (Erman, Kejner, Hogikyan & Feldman, 2009). The recurrent nerve branch provides motor innervation for all the abductor and adductor muscles of the vocal folds. Bilateral damage can lead to a fixation of the vocal folds in a position, which may be close enough to allow phonation, but can be breathy and hoarse; unilateral damage can promote breathy phonation and decreased vocal fold loudness, because the damaged vocal fold is halfway between being fully adducted or fully abducted (Erman, Kejner, Hogikyan & Feldman, 2009).

The vagus nerve receives sensory input from the larynx, pharynx, external auditory canal, lateral aspect of the tympanic membrane, and the meninges of the posterior fossa and also supplies parasympathetic innervation to smooth muscle and glands of the pharynx, larynx, and thoracic and abdominal viscera (Erman, Kejner, Hogikyan & Feldman, 2009; Parent, 1996).

This nerve, with the glossopharyngeal nerve, mediate the complex interplay between the many functions of the upper aerodigestive tract. Defects may occur anywhere from the brainstem to the peripheral nerve and can result in significant impairment in speech, swallowing, and breathing. Patients with dysfunction of the vagus nerve may present with dysphagia, hoarseness, or dyspnea (Erman, Kejner, Hogikyan & Feldman, 2009).

In stressful situations, the SNS speeds up many of the body activities, preparing the body for what is called a flight or to fight response. The organic activation of stress occurs in three phases: alarm phase, resistance phase and the exhaustion phase (Dietrich, Abbott, Gartner-Schmidt & Rosen, 2008; Seifert & Kollbrunner, 2005; Wolf & Finestone, 1986).

The relationship between voice and stress is well known. In fact, some vocal disorders present a recognized emotional etiology, as is the case of psychogenic dysphonias (Rammage, Nichol & Morrison, 1987; Van Houtte, Van Lierde & Claeys, 2011).

Some studies indicate that the muscles of the larynx are sensitive to stress, which can cause anxiety, irritability, impatience, frustration and depression (Dietrich, Abbott, Gartner-Schmidt & Rosen, 2008; Seifert & Kollbrunner, 2005). Moreover, muscle tension dysphonia is a possible manifestation of stress and anxiety, often associated with an overactivity of the ANS (Demmink-Geertman & Dejonckere, 2008; Koufman & Blalock, 1991). Regarding the possible connections between the ANS and vocal cues, Demmink-Geertman and Dejonckere (2008) confirmed that muscle tension dysphonia mainly occurs in a context of disturbed balance of the ANS and patients undergoing functional voice therapy clearly differ in their evolution from control subjects. However, the authors remain unable to directly answer the question of whether autonomic dysfunction should be considered causal, correlational, or consequential of voice dysfunctions. Other studies showed a tendency toward a slightly higher mean fundamental frequency (F_0) in the afternoon (Artkoski, Tommila & Laukkanen, 2002) and have reported that changes in F_0 follow a clear circadian pattern which can be influenced by sleep rhythm (Bouhuys, Schutte, Beersma & Nieboer, 1990).

Individuals with vocal problems refer to symptoms that may be signs of dysfunction in the ANS. To verify this relationship, assessment of ANS dysfunctions can be assessed through heart rate variability (HRV) (Zuttin et al., 2008) or by a questionnaire composed of the main symptoms of ANS dysfunction, called The Questionnaire of Autonomic Dysfunction (QAD) (Demmink-Geertman & Dejonckere, 2008).

The use of the QAD can provide relevant information that favors the care of the dysphonic patient, since it opens the possibility for a therapeutic approach based on autonomic signs and symptoms that have direct relation with voice, as well as constant reassessments to verify the evolution with therapy (Demmink-Geertman & Dejonckere, 2008).

This systematic review aims to verify the relation between ANS function, voice and dysphonia. This analysis is intended to contribute to the systematization of knowledge of this subject in order to promote clinical practice according to scientific evidence.

Methods

The systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher, Liberati, Tetzlaff & Altman, 2009).

A computerized search was performed, by two independent reviewers, on the databases PubMed/Medline, SciELO, RCAAP, LILACS, Cochrane library, PEDro and Isi Web of Knowledge in order to identify studies that evaluated the relation between ANS, voice and dysphonia. The search was made according to the PRISMA flowchart and the following key words combination was used: "autonomic nervous system AND (voice OR dysphonia)". The databases were searched through April of 2019.

Studies were included if: (1) they were published as full-text journal articles in French, English, Portuguese or Spanish; (2) they explored the relationship between ANS and voice or dysphonia; (3) their samples comprised only of human adults.

Studies were excluded if: (1) they focused on additional treatments for voice disorders; (2) they were literature reviews and meta-analysis; (3) case studies; or (4) opinion articles.

Data extraction

Two independent reviewers conducted the data extraction. The characteristics of the collected studies included the authors; year of publication; sample size, age and gender; study design; outcome measures; methods; and results/conclusions.

Methodological quality

The methodological quality of each study included in this review was assessed by two independent reviewers using a modified version of the Newcastle–Ottawa scale (NOS) for quality assessment of cross-sectional studies (Table 1) (Wells et al., 2011). In a "star rating system", each included study was judged in the following areas: sample representativeness; sample size; non-respondents; ascertainment of the exposure; comparability of results; outcome assessment and statistical methods. Studies' quality was rated on a scale from 0 (high risk of bias) to 10 (low risk of bias). A maximum score of ten points was given for the study that fulfilled all quality criteria (Wells et al., 2011). In this review, studies with five or more points were considered as high quality. This categorization was previously used in other systematic reviews (Aldabe, Milosavljevic & Bussey, 2012; Roffey et al., 2010). The reviewers solved any rating discrepancies through verbal discussion. A consensus was reached regarding all studies during the first meeting.

Table 1 – *Modified version of the Newcastle–Ottawa scale (NOS) for quality assessment of cross-sectional studies.*

Selection				Comparability	Outcome	
Representativeness of the sample	Sample size	Ascertainment of exposure	Non-respondents	The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.	Assessment of outcome	Was follow-up long enough for outcomes to occur
a)Truly representative of the average in the target population. * (all subjects or random sampling) b) Somewhat representative of the average in the target population. * (non-random sampling) c) Selected group of users. d) No description of the sampling strategy.	a) Justified and satisfactory.* b) Not justified.	a) Validated measurement tool. ** b) Non-validated measurement tool, but the tool is available or described. * c) No description of the measurement tool.	a) Comparability between respondents and non-respondents characteristics is established, and the response rate is satisfactory. * b) The response rate is unsatisfactory, or the comparability between respondents and nonrespondents is unsatisfactory. c) No description of the response rate or the characteristics of the responders and the non-responders.	a) The study controls for the most important factor. * b) The study control for any additional factor. *	a) Independent blind assessment.* b) Record linkage. ** c) Self report. d) No description.	a) The statistical test used to analyze the data is clearly described and appropriate, and the measurement of the association is presented, including confidence intervals and the probability level (p value). * b) The statistical test is not appropriate, not described or incomplete.

* a point assigned on the scale.

Results

Studies selection

The literature search identified 1513 records. After removing the duplicates, 1497 records were screened for content through title and abstract, by two independent reviewers. From these, 1485 were excluded. The full-text of 12 articles was then assessed, by the reviewers, for eligibility and 3 articles were excluded. In total, 9 articles were included in the systematic review. The reasons for the exclusions are listed on the PRISMA flowchart (Figure 1).

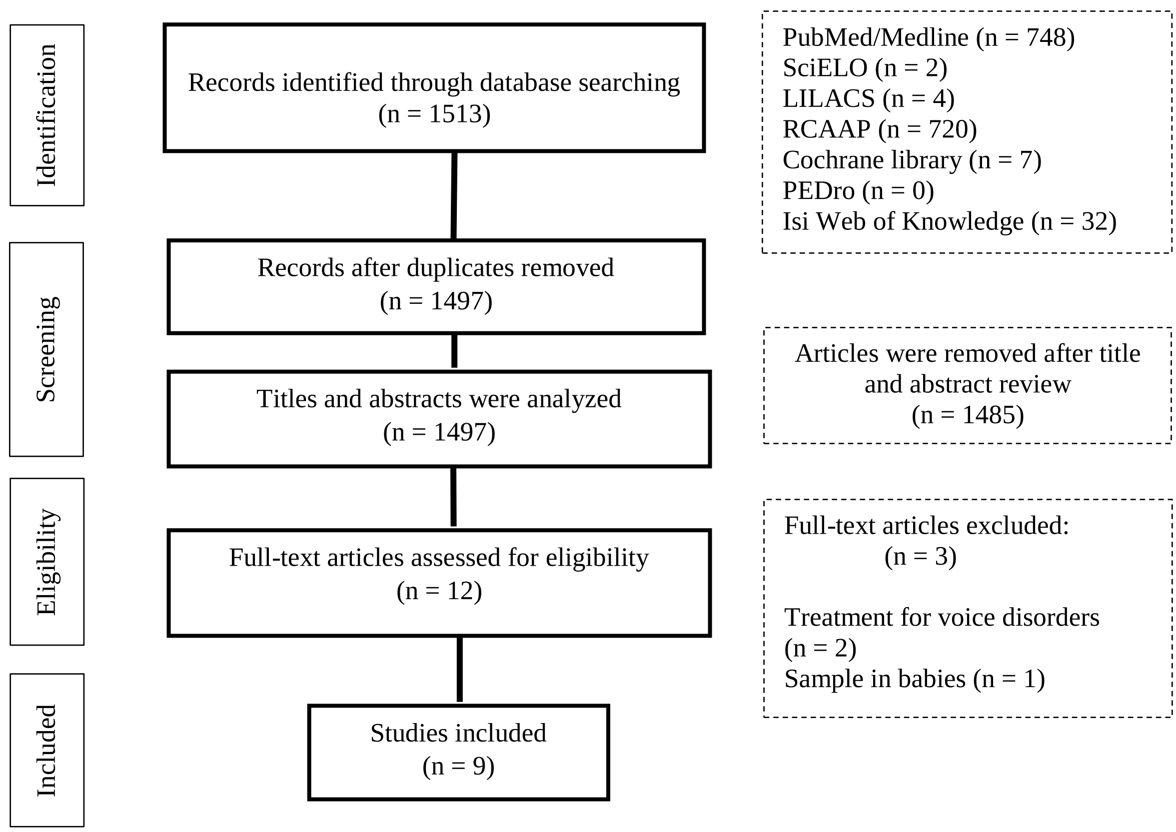

Figure 1 – *PRISMA flow diagram showing selection of article review.*

Studies description

The total number of subjects included in the 9 articles was 634, with a minimum sample size of 8 and a maximum of 167. The studies included 177 male and 457 female participants. Teachers were the only professional class cited in the studies, with a total of 230 teachers participating. The summary of the articles' content is presented in Table 2.

All studies were cross-sectional studies. The studies were heterogeneous in relation to the outcome measures used, with a wide variety of assessment instruments used. The outcome measures most frequently used for ANS function were the QAD (Cielo, Ribeiro & Hoffmann, 2015; Demmink-Geertman & Dejonckere, 2002; Paes, Zambon & Behlau, 2014; Park & Behlau, 2011) and HRV (Alvear, Barón-López, Alguacil & Dawid-Milner, 2013; Helou et al., 2013; Schneider et al., 2006). The outcome measure most frequently used for voice was F_0 (Alvear, Barón-López, Alguacil & Dawid-Milner, 2013; Orlikoff & Baken, 1989; Park et al., 2011; Schneider et al., 2006).

However, associated with ANS outcome measures, blood pressure (Alvear, Barón-López, Alguacil & Dawid-Milner, 2013; Helou et al., 2013) was also frequently used. In addition to these, other measurements were used for assessment, such as: skin conductance response; vocal signs and symptoms protocol; digital temperature slope; autonomic outlet types; profile of mood states; Grade Roughness Breathiness Asthenia Strain (GRBAS) scale; pulse transition time; electromyography; occupational and vocal complaints; cardiac cycles by electrocardiography; pulse rate variability and state-trait anxiety inventory.

Some studies had two groups (Demmink-Geertman & Dejonckere, 2002; Paes, Zambon & Behlau, 2014; Park & Behlau, 2011; Schneider et al., 2006): a group of healthy subjects was compared to a dysphonic group. The other studies had only one group (Alvear, Barón-López, Alguacil & Dawid-Milner, 2013; Cielo, Ribeiro & Hoffmann, 2015; Helou et al., 2013; Orlikoff & Baken, 1989; Park et al., 2011).

Table 2 – *Studies description.*

Author(s), year	Sample characteristics	Study design	Outcome measures	Methods	Results/Conclusions
Orlikoff and Baken, 1989	12 healthy subjects (range 21–47 years old) 6M and 6F	CSS	Acoustic analysis (F_0, SPL, Jitter); Cardiac cycles (ECG)	Each subject, seated in a sound-attenuated room, was told to produce the vowel /a/ for "as long as possible" at a "comfortable pitch" while keeping both SPL monitoring lights off. The frequency displayed on the F_0 voltmeter was taken as that subjects' "comfortable" F_0. Data collection began approximately 1 s after phonatory onset. The ECG signals were continually monitored on an oscilloscope to assure acceptable signal quality.	Heartbeat modulates the F_0 of human voice.
Demmink-Geertman and Dejonckere, 2002	167 subjects (healthy and with nonorganic voice disorder) (range 18–77 years old) 36M and 131F	CSS	QAD	Two groups: control group (84 subjects) and nonorganic voice disorder group (83 subjects) answered to the QAD.	Female patients in all age categories with a nonorganic habitual dysphonia report significantly more autonomic symptoms and complaints than healthy controls. This association could not be confirmed for the male subgroup.
Schneider et al., 2005	33 teachers with either normal voice constitution or constitutional hypofunction (range: 17–41 years old) 0M and 33F	CSS	AOT; HR; pulse transition time; acoustic analysis (F_0); State-trait Anxiety Inventory; skin conductance response; digital temperature slope.	Participants were divided in two groups (normal voice constitution or constitutional hypofunction), were assessed by voice range profile measurements, underwent a standardized baseline test to register selected autonomic test parameters and were classified into AOT. Later the subjects were examined during 1 hour of teaching (field study).	No detectable influence of individual autonomic reactivity, anxiety proneness, and situational anxiety regarding changes of F_0 during vocal load. A constitutionally weak voice seems to be a risk factor for developing a professional voice disorder.

Park et al., 2011	75 college students (range: 19–24 years old) 53M and 22F	CSS	Profile of Mood States; acoustic analysis (F_0; Jitter, Shimmer NNE, HNR, SNR, amp. Tremor); PRV; LF; HF; TP and the ratio of LF to HF power	Subjects were seated in a comfortable chair in a quiet room and then asked to relax for 15 min. After the relaxation period, a photoplethysmography transducer was strapped to the subject's left second finger and connected to the PPG amplifier. After that and before acoustic recording, the subjects relaxed for 10 min by reading a magazine or newspaper and then were seated in a quiet room. Participants produced a sustained vowel sound (/a/) for 3 s to calculate acoustic parameters.	The results of this study suggest that mood states in resting young subjects can be estimated from PRV and acoustic parameters.
Park and Behlau, 2011	128 subjects (healthy and dysphonic) (range 14–74 years old) 40M and 88F	CSS	QAD	The QAD was administered to two groups: with behavioral dysphonia (61 subjects) and without vocal complaints (67 subjects).	Individuals with behavioral dysphonia presented higher occurrence of neurovegetative signs and symptoms, particularly those with direct relationship with voice, indicating greater lability of the autonomic nervous system in these subjects.
Helou et al., 2013	8 healthy subjects No age specified 0M and 8F	CSS	Surface electromyography; bipolar hook-wire electromyography; HR; SP; DP.	A cold pressor task was used to trigger a whole-body ANS response in the participants. Outcome measures were used to characterize participants' response to cold pressure exposure compared to at-rest baseline.	Human laryngeal muscles exhibited an elevated level of activation concurrent with ANS activation.
Alvear, Barón-López, Alguacil and Dawid-Milner, 2013	14 healthy subjects (mean age 22 ± 1.3 years) 7M and 7F	CSS	HR; SP; DP; MP; acoustic analysis (F_0); GRBAS scale.	Subjects performed a 5 minute control trial which consisted of monitoring cardiovascular variables in resting conditions. To obtain voice samples, subjects were asked to sustain the Spanish / æ / for 5 seconds at comfortable pitch and loudness. In sum, a total of 70 voice samples and 210 cardiovascular variables were obtained during the 14 initial control trials. These F_0 and cardiovascular values were established as baseline measures for every subject. After that, three classical autonomic tasks were performed, i.e. isometric hand grip, cutaneous cold test, and mental arithmetic task.	All cardiovascular variables were significantly associated to laryngeal vocal function in both resting and stressful conditions.

Paes, Zambon and Behlau, 2014	83 teachers (healthy and dysphonic) (mean age: 37,6 years) 23M and 60F	CSS	QAD	Two groups: with or without voice complaints, defined according to the number of symptoms marked in the protocol VSSQ.	The group with voice complaints showed a higher number of neurovegetative symptoms, particularly on issues related to the voice, than the group without complaints.
Cielo, Ribeiro and Hoffmann, 2015	114 teachers (range: 20–66 years old) 12M and 102F	CSS	QAD; Occupational and vocal complaints	Participants performed a QAD. They also reported occupational and vocal complaints.	Women and individuals with vocal complaints showed more signs and symptoms of autonomic dysfunction.

Abbreviations: amp. Tremor, amplitude tremor; ANS, Autonomic nervous system; AOT, Autonomic outlet types; CSS, Cross-sectional study; DP, Diastolic pressure; ECG, Electrocardiography; F_0, Fundamental frequency; GRBAS, Grade, Roughness, Breathiness, Asthenia, Strain; HF, High frequency; HNR, Harmonic-to-noise ratio; LF, Low frequency; MP, Mean blood pressure; NNE, Normalized noise energy; PRV, Pulse rate variability; QAD, Questionnaire of Autonomic Dysfunction; SNR, Signal-to-noise ratio; SP, Systolic pressure; SPL, Sound pressure levels; TP, Total power; VSSQ, Vocal Signs and Symptoms.

Studies quality

The mean modified NOS score for the studies included in the review was 9,22 points (range: 7-10 points). Quality criteria for methodological assessment are shown in Table 3**.**

According to the quality criteria set, all the studies included in this review were considered high quality.

Table 3 – *Methodological quality by a modified version of the Newcastle–Ottawa scale for the included studies.*

References	Selection				Comparability	Outcome		Total
	1	2	3	4	1	1	2	
Orlikoff and Baken, 1989	C	B	A	A	A/B	B	A	8
Demmink-Geertman and Dejonckere, 2002	B	A	A	A	A/B	B	A	10
Schneider et al., 2005	A	A	A	A	A/B	B	A	10
Park and Behlau, 2011	B	A	A	A	A/B	B	A	10
Park et al., 2011	B	A	A	A	A/B	B	A	10
Alvear, Barón-López, Alguacil and Dawid-Milner, 2013	C	B	A	A	A/B	B	A	8
Helou et al., 2013	C	B	A	A	A/B	B	A	7
Paes, Zambon and Behlau, 2014	B	A	A	A	A/B	B	A	10
Cielo, Ribeiro and Hoffmann, 2015	A	A	A	A	A/B	B	A	10

The major bias of these cross-sectional studies was the risk of bias in the sample selection. Some studies used convenience samples from schools. No study mentioned blinding of the examiners.

Discussion

This systematic review provides an overview of the published evidence concerning the association between ANS function, voice and dysphonia. In an extensive search, only 9 cross-sectional studies met the inclusion criteria. The ANS plays an important role in mediating cardiovascular changes caused by stress. Acute hemodynamic changes are associated with high levels of sympathetic discharge and a floating parasympathetic activity (Smith, Veale, Pépin & Lévy, 1998). The organic activation of stress occurs in three phases: alarm phase, resistance phase and exhaustion phase (Wolf & Finestone, 1986).

In the first stage, there is intense hormonal discharge that mobilizes the whole organism, known as the "General Adaptation Syndrome", and physical symptoms such as tachycardia, sweating, headache, pallor, high blood pressure, fatigue and tinnitus can occur. After this stage, the body may return to its homeostasis or seek a way to cope with such a situation, and there may be localized mobilization, called "Local Adaptation Syndrome". This syndrome causes the centralization of the internal reaction of stress in the most vulnerable organ of the body at that moment, generating psychosocial symptoms as: irritability, social isolation, inability to disconnect and feelings of fear. If the situation is continuous, it can lead to the appearance of specific symptoms of disorder related to the organ in question, to the point of exhaustion. Studies show that one of the organs affected by this syndrome is the larynx, due to the close relationship between voice and stress, especially in vocal disorders of behavioral origin (Dietrich, Abbott, Gartner-Schmidt & Rosen, 2008; Seifert & Kollbrunner, 2005).

The ANS outcome measure most used in the studies reviewed was the QAD, been present in 4 of the studies. In these 4 studies, a relation between voice and ANS was found. In the investigation of Cielo, Ribeiro and Hoffmann (2015), they found that women and individuals with vocal complaints showed more signs and symptoms of autonomic dysfunction. However, there was no correlation between the signs and symptoms of autonomic dysfunction and age, years of teaching, daily use of voice nor with the schools in which the teachers worked. Another study (Demmink-Geertman & Dejonckere, 2002) that had similar results found that female patients in all age categories with a nonorganic habitual dysphonia reported significantly more autonomic symptoms and complaints than healthy controls. This hypothesis cannot be confirmed for the male subgroup, however a level of significance could be reached due to the large size of the groups. Similar results were also found in the study of Park and Behlau (2011), where individuals with behavioral dysphonia presented higher occurrence of neurovegetative signs and symptoms, particularly those with direct relationship with voice, indicating greater lability of the ANS in these subjects. Similar results were found in the study by Paes, Zambon and Behlau (2014) where the sample was only composed of teachers. The authors concluded that the group with voice complaints showed a higher number of neurovegetative symptoms, particularly on issues related to the voice, than the group without complaints.

However, this outcome measure has limitations because patients who know they have a disorder may be predisposed to consider that they have a large number of the complaints and symptoms addressed by the questionnaire, whereas the controls may be predisposed not to report the complaints being inventoried, as they know they have no disorder.

The type of neurovegetative symptoms measured through this scale was used in 2 studies (Demmink-Geertman & Dejonckere, 2008, 2010) which included treatment. The authors found that the number of neurovegetative symptoms and complaints connected with voice function was strongly reduced in patients after therapy.

However, there were studies that demonstrated a relationship between ANS and voice using objective measures, as that of Alvear, Barón-López, Alguacil and Dawid-Milner (2013), in which healthy subjects' cardiovascular variables were significantly associated to laryngeal vocal function in both resting and stressful conditions, especially heartbeat variations that have a significant influence on phonatory frequency.

It was also demonstrated that human laryngeal muscles exhibit an elevated level of activation concurrent with ANS activation in the study by Helou et al. (2013).

Another study (Orlikoff & Baken, 1989) showed that heartbeat modulates the F_0 of human voice. The authors concluded that changes in F_0 were caused by pressure-related changes in the stiffness of the vocal fold vascular bed and by heartbeat cyclic alterations of the geometry of the thyroarytenoid muscle.

The results of the study of Park et al. (2011) suggest that autonomic and acoustic parameters are indicative of mood states in resting young subjects. Additionally, the results revealed significant gender differences. Sympathovagal balance-related parameters, such as low frequency/ high frequency, were dominant indicators of fatigue in men and women, whereas low frequency and high frequency were indicative of depression and anger in women. The authors concluded that it is plausible that an immediate change of mood induces increases in sympathetic activity and decreases in parasympathetic activity, whereas long-standing sympathetic activity due to long-term preservation of moods may exhaust conserved energy and finally result in decreases in both sympathetic and parasympathetic activities. Therefore, decreased low frequency, high frequency and total power related to depression and anger in women may result from decreased sympathetic and parasympathetic activities due to long-term preservation of depression and anger. In terms of acoustic parameters, the authors found that shimmer and standard deviation of the F_0, which were related to roughness and instability in voice quality, were indicative of tension and depression in men and women.

In other investigation, Schneider et al. (2005) performed a study in 33 subjects with either normal voice constitution or constitutional hypofunction, and concluded: that there was no detectable influence of individual autonomic reactivity, anxiety proneness, or situational anxiety on changes of F_0 during vocal load; and that the increase of F_0 after only 30 minutes of teaching in the group with constitutional vocal hypofunction has to be regarded as vocal fatigue independent of autonomic stress reaction and anxiety. Thus, a constitutionally weak voice seems to be a risk factor for developing a professional voice disorder.

The methodological quality of the included cross-sectional studies was high, since the mean of a modified version of the NOS score for the studies included in the review was 9,22 points (range: 7-10 points).

This review has, nonetheless, some limitations. Few objective assessments of ANS function, such as HRV, as well as few objective voice evaluations were found. There were no studies with individuals associated with high levels of stress, such as health professionals or stockbrokers. In addition to teachers, other professionals with a high frequency of voice use were not included, such as singers and telemarketeers. In addition, although the increase aging of the general population, participants aged over 77 years were not mentioned. Only 3 studies included participants over 65 years of age, but without being specifically focused on the elderly. It should also be noted that only one study had more male participants than female participants, and there were several differences between the two groups. Another limitation is that all included studies were cross-sectional observational clinical studies. These studies leave open the possibility of selection bias, as no randomization was performed. Therefore, associations drawn in cross-sectional studies do not imply causation. Importantly, we did not exclude longitudinal studies from our literature search. Additionally, the included studies did not mention the professional background nor the years of experience of the examiners in the physical evaluations nor did they mention the questionnaire examiners. No study mentioned blinding of examiners. The studies do not demonstrate if they were always performed at the same hour of the day or in the same season.

Despite these limitations, this review is, as far as the authors are aware, the first to comprehensively and critically assess evidence of the associations between ANS dysfunction, voice and dysphonia, which may provide useful insight for further studies. This review can be considered as a first step in order to document this relations.

We suggest further studies with objective measures of the ANS, such as HRV or skin conductance response. According Ribeiro, Brum and Ferrario (1992), one of the most accessible and reliable outcome measures of the ANS effects on the cardiovascular system is HRV. We also suggest investigations with larger samples, ideally with a similar number of female and male participants and that relate these objective measurements with other voice evaluations, as F_0 or auditory-perceptual measurement. We suggest the development of studies with objective measures of ANS and voice in participants over 65 years of age, healthy individuals and individuals with voice disorders, as well as in individuals who experience high levels of stress and a high frequency of voice use, using experienced blind examiners.

Conclusion

The knowledge of the relationship between ANS, laryngeal muscles, voice production and dysphonia is of paramount importance in order to develop a transdisciplinary action to provide benefits to patients with voice problems. With this review it was verified that the ANS function is related to voice as well as to dysphonia, since the individuals with dysphonia tend to show more ANS dysfunction. It was also verified that the human laryngeal muscles exhibit an elevated level of activation concurrent with ANS activation, that autonomic and acoustic parameters can be indicative of mood states in resting young subjects and that heartbeat is associated with the modulation of the F_0 of human voice. The laryngeal musculature must have adequate tone and synchronized movement to approximate the vocal folds in the midline for sound production. Moreover, muscular control of vocal fold tension and length modulates vocal pitch where a neurological impairment may affect normal sound production.

References

Aldabe, D., Milosavljevic, S., & Bussey, M. D. (2012). Is pregnancy related pelvic girdle pain associated with altered kinematic, kinetic and motor control of the pelvis? A systematic review. *European Spine Journal*, 21(9), 1777-1787. doi: 10.1007/s00586-012-2401-1

Alvear, R. M. B. D., Barón-López, F. J., Alguacil, M. D., & Dawid-Milner, M. S. (2013). Interactions between voice fundamental frequency and cardiovascular parameters. Preliminary results and physiological mechanisms. *Logopedics Phoniatrics Vocology*, 38(2), 52-58. doi:10.3109/14015439.2012.696140

Artkoski, M., Tommila, J., & Laukkanen, A. M. (2002). Changes in voice during a day in normal voices without vocal loading. *Logopedics Phoniatrics Vocology*, 27(3), 118-123. doi: 10.1080/140154302760834840

Bouhuys, A. L., Schutte, H. K., Beersma, D. G., & Nieboer, G. L. (1990). Relations between depressed mood and vocal parameters before, during and after sleep deprivation: a circadian rhythm study. *Journal of affective disorders*, 19(4), 249-258. doi: 10.1016/0165-0327(90)90102-E

Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019a). Associations between posture, voice, and dysphonia: A systematic review. *Journal of Voice*, 33(1), 124e1-12. doi: 10.1016/j.jvoice.2017.08.030

Cardoso, R., Meneses, R. F., & Lumini-Oliveira, J. (2017). The effectiveness of physiotherapy and complementary therapies on voice disorders: A systematic review of randomized controlled trials. *Frontiers in medicine 4*(45). doi: 10.3389/fmed.2017.00045

Cielo, C. A., Ribeiro, V. V., & Hoffmann, C. F. (2015). Sinais e sintomas de disfunção autônoma em professores e sua relação com as queixas vocais e as variáveis ocupacionais. *Distúrbios da Comunicação*, 27(3).

Demmink-Geertman, L., & Dejonckere, P. H. (2002). Nonorganic habitual dysphonia and autonomic dysfunction. *Journal of Voice*, 16(4), 549-559. doi: 10.1016/S0892-1997(02)00130-3

Demmink-Geertman, L., & Dejonckere, P. H. (2008). Neurovegetative symptoms and complaints before and after voice therapy for nonorganic habitual dysphonia. *Journal of Voice*, *22*(3), 315-325. doi: 10.1016/j.jvoice.2006.10.011

Demmink-Geertman, L., & Dejonckere, P. H. (2010). Differential effects of voice therapies on neurovegetative symptoms and complaints. *Journal of Voice*, *24*(5), 585-591. doi: 10.1016/j.jvoice.2008.12.013

Dietrich, M., Abbott, K. V., Gartner-Schmidt, J., & Rosen, C. A. (2008). The frequency of perceived stress, anxiety, and depression in patients with common pathologies affecting voice. *Journal of Voice*, 22(4), 472-488. doi: 10.1016/j.jvoice.2006.08.007

Erman, A. B., Kejner, A. E., Hogikyan, N. D., & Feldman, E. L. (2009). Disorders of cranial nerves IX and X. In Seminars in neurology, *Thieme Medical Publishers,* 29(01): 085-092.

Gonçalves, J. (2014). A influência do sistema nervoso autónomo na resposta inflamatória da sepsis. *Arquivos de Medicina*, *28*(1), 08-17.

Helou, L. B., Wang, W., Ashmore, R. C., Rosen, C. A., & Abbott, K. V. (2013). Intrinsic laryngeal muscle activity in response to autonomic nervous system activation. *The Laryngoscope*, 123(11), 2756-2765. doi: 10.1002/lary.24109

Hisa, Y., Bamba, H., Koike, S., Shogaki, K., Tadaki, N., & Uno, T. (1999). Neurotransmitters and neuromodulators involved in laryngeal innervation. *Annals of Otology, Rhinology & Laryngology*, 108(7_suppl), 3-14. Doi: 10.1177/00034894991080S702

Koufman, J. A., & Blalock, P. D. (1991). Functional voice disorders. *Otolaryngologic Clinics of North America*, 24(5), 1059.

Lefkowitz R.J., Hoffman B.B., & Taylor P. (1996). Neurotransmission: The autonomic and somatic motor nervous systems. *Goodman & Gilman´s. The Pharmacologyical Basis of Therapeutics*. 9th ed. Section II, Chap 6. New York: Mc Graw Hill. p.105-40.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*,151(4): 264-269. doi: 10.1371/journal.pmed.1000097

Orlikoff, R. F., & Baken, R. J. (1989). The effect of the heartbeat on vocal fundamental frequency perturbation. *Journal of Speech, Language, and Hearing Research*, 32(3), 576-582.

Paes, C. F., Zambon, F. C., & Behlau, M. (2014). Signs and symptoms of the autonomic dysfunction in teachers. *Revista CEFAC*, 16(3), 957-966. doi: 10.1590/1982-021620141613

Parent A. (1996). *Carpenter's Human Neuroanatomy*. Baltimore, MD: Williams & Wilkins, 9: 442-451.

Park, K., & Behlau, M. (2011). Sinais e sintomas da disfunção autônoma em indivíduos disfônicos. *Jornal da Sociedade Brasileira de Fonoaudiologia*, 23(2), 164-9. doi: 10.1590/S2179-64912011000200014

Park, C. K., Lee, S., Park, H. J., Baik, Y. S., Park, Y. B., & Park, Y. J. (2011). Autonomic function, voice, and mood states. *Clinical Autonomic Research*, 21(2), 103-110. doi: 10.1007/s10286-010-0095-1

Rammage, L. A., Nichol, H., & Morrison, M. D. (1987). The psychopathology of voice disorders. *Human Communication Canada*, 11(4), 21-25

Ribeiro, M. P., Brum, J. M., & Ferrario, C. M. (1992). Análise espectral da freqüência cardíaca: conceitos básicos e aplicação clínica. *Arquivos Brasileiros de Cardiologia*, 59(2), 141-9.

Roffey, D. M., Wai, E. K., Bishop, P., Kwon, B. K., & Dagenais, S. (2010). Causal assessment of awkward occupational postures and low back pain: results of a systematic review. *The Spine Journal*, 10(1), 89-99. doi: 10.1016/j.spinee.2009.09.003

Schneider, B., Enne, R., Cecon, M., Diendorfer-Radner, G., Wittels, P., Bigenzahn, W., & Johannes, B. (2006). Effects of vocal constitution and autonomic stress-related reactivity on vocal endurance in female student teachers. *Journal of Voice,* 20(2), 242-250. doi: 10.1016/j.jvoice.2005.03.002

Seifert, E., & Kollbrunner, J. (2005). Stress and distress in non-organic voice disorders. *Swiss medical weekly*, 135(27/28), 387.

Smith, R. P., Veale, D., Pépin, J. L., & Lévy, P. A. (1998). Obstructive sleep apnoea and the autonomic nervous system. *Sleep medicine reviews*, 2(2), 69-92.

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, 25(2), 202-207. doi: 10.1016/j.jvoice.2009.10.009

Wehrwein, E. A., Orer, H. S., & Barman, S. M. (2016). Overview of the anatomy, physiology, and pharmacology of the autonomic nervous system. *Comprehensive Physiology*, 6, 1239-1278. doi: 10.1002/cphy.c150037

Wells, G., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M. & Tugwell, P. (2011) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in metaanalyses [WWW document]. URL http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp [accessed on 01 May 2017].

Wolf, S., & Finestone, A. J. (1986). *Occupational stress: health and performance at work*. Littleton (MA): PSG Publishing Company.

Zuttin, R., Moreno, M., César, M., Martins, L., Catai, A. & Silva, E. (2008). Evaluation of autonomic heart rate modulation among sedentary young men, in sitting and supine postures. *Brazilian Journal of Physical Therapy/Revista Brasileira de Fisioterapia*, *12*(1). doi: 10.1590/S1413-35552008000100003

Chapter 3

Paper 3 - The effectiveness of physiotherapy and complementary therapies on voice disorders: a systematic review of randomized controlled trials

Abstract

The treatment of voice disorders includes physiotherapy and complementary therapies. However, research to support these treatments is scarce. Objective: to verify the effectiveness of physiotherapy and complementary therapies on voice disorders. Research on electronic databases PubMed/Medline, SciELO and LILACS was performed using the combination: voice AND (treatment OR intervention) according to PRISMA guidelines. Only randomized controlled trials (RCTs) were included in the review. Studies were analyzed using the Physiotherapy Evidence Database (PEDro) scale and the Center for Evidence-Based Medicine's Levels of Evidence scale. Eight papers met the inclusion criteria. From the RCTs included in this review, 6 assessed massage, 1 transcutaneous electrical nerve stimulation (TENS), 1 refer to spinal manipulative therapy and 1 to acupuncture. The literature regarding the effectiveness of physiotherapy and complementary therapies was good in both quality and results, indicating that massage, TENS and acupuncture seem to be effective treatments to reduce voice complaints and improve voice quality, supporting the inclusion of complementary therapies but mostly physiotherapy interventions in the treatment of patients with voice disorders

Key words: Voice, voice disorders, physiotherapy, complementary therapies, manual therapy, acupuncture, osteopathy, systematic review.

Introduction

Postural changes and muscle tension have been reported in association with voice production (Johnson & Skinner, 2009; Scotto, 1998). Increased muscle tension around the shoulders, neck and thorax may compromise the quality of the singing voice (Cialdini & Behlau, 2005; Pettersen & Westgaard, 2004; Mello, Silva, Ferreira & Herr, 2009). This relation can be explained by the action of laryngeal mechanoreceptors, which trigger reflex adaptations in the vocal cords when stimulated by minute changes in body position (Mello, Silva, Ferreira & Herr, 2009). In this way, an appropriate muscle tone and a good posture are required for producing a good quality voice (Cialdini & Behlau, 2005; Pettersen & Westgaard, 2004). There are many interventions to treat voice disorders (Behlau, Madazio & Oliveira, 2015; Van Houtte, Claeys, Wuyts & Van Lierde, 2011), however, physiotherapy and complementary therapies, which improve posture and muscle tone in relation to voice have been insufficiently explored.

Postural exercises and breathing had been shown to have a positive effect on the cervical muscles and body posture, which suggests that it may improve voice quality (Corrêa & Bérzin, 2007) as demonstrated by the improvement of voice parameters in classical singing students by a physiotherapy program (Staes et al., 2011). Moreover, manual therapy and exercise have been shown to improve outcomes in patients with muscle tension dysphonia (Tomlinson & Archer, 2015). Physiotherapy, which consisted of a systematic approach of manual therapy, education, and therapeutic exercises, had similar results to voice therapy, improving Voice Handicap Index (VHI) scores (Craig et al., 2015). Transcutaneous electrical nerve stimulation (TENS) has been shown to promote pain relief in trapezius and sternocleidomastoid muscles, decreased the root media readings in trapezius, sternocleidomastoid and suprahyoid muscles during the production of the /e/ vowel and reduce the level of dysphonia and hoarseness during spontaneous speech in dysphonic participants (Guirro et al., 2008). A manual therapy, usually associated with complementary therapies like osteopathy and chiropractic but also used by physiotherapists, which that has been shown to increase range of motion, reduce muscle tension and pain which suggest that may improve voice quality (Lehman, Vernon & Mcgill, 2001; Maigne & Vautravers, 2003) was spinal manipulation. Another treatment which facilitated an anti-inflammatory process in phonotraumatic vocal pathologies was acupuncture (Yiu et al., 2016).

To date, and as far as the authors are aware, the literature lacks a systematic review of clinical trials', showing the evidence of the effectiveness of physiotherapy and complementary therapies on voice disorders. Thus, the purpose of this systematic review is to summarize and synthesize the clinical evidence on the effectiveness of physiotherapy and complementary therapies on voice disorders.

Methods

The systematic review was conducted according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, whose main goal is to improve presentation patterns of systematic revisions and meta-analysis (Moher, Liberati, Tetzlaff &Altman, 2009).

A computerized research was undertaken, by two independent reviewers, on the databases PubMed/Medline, SciELO and LILACS in order to identify randomized controlled trials (RCTs) that evaluate the effectiveness of physiotherapy and complementary therapies on voice disorders.

The research was made according to the PRISMA flowchart and the following key words combination was used: “voice AND (treatment OR intervention)”. The databases were searched from their inception through May of 2016.

The studies were included if: (1) they reported interventions of physiotherapy or complementary therapies; (2) were published as full-text journal articles in English, Portuguese, French or Spanish; (3) evaluate voice; (4) included humans; (5) had ten or more participants; (6) included adult participants only (18 years and older); (7) were RCTs.

The exclusion criteria were: (1) literature reviews and meta-analysis; (2) case studies; (3) opinion articles; (4) assessed prevention of voice disorders; (5) used pharmacological treatments (in the same group); (6) absence of speech sample; (7) tracheostomized participants; (8) participants diagnosed with any of the following: a voice disorder associated with local nervous system involvement (e.g., spasmodic dysphonia, vocal fold paralysis), neurological disorders (e.g., Parkinson or Alzheimer disease, amyotrophic lateral sclerosis), organic disease or trauma (e.g., keratosis, contact ulcers, papilloma’s), pediatric conditions (e.g., congenital anomalies), carcinoma or other tumors or gastroesophageal reflux disease (Ruotsalainen, Sellman, Lehto & Verbeek, 2008).

Data extraction

Two reviewers conducted the data extraction. The characteristics of the collected studies included the authors, year of publication, sample size, study design, speech sample, outcome measures, duration and type of treatment, results/conclusions, and effectiveness of treatment.

Methodological quality

The methodological quality of each RCT included in this review was assessed by two independent reviewers using the Physiotherapy Evidence Database (PEDro) scoring scale (Maher et al., 2003). The PEDro scale comprises of a checklist of 11 criteria, of which only 10 criteria are scored (Table 1). For each criterion the study met, 1 point was awarded. The clear and unambiguous meeting of a criterion leads to 1 point being awarded. Consequently, a total of 10 points are available. The scale applies only to experimental studies (Maher et al., 2003). For this review, investigations with PEDro scores of 6-10 were considered high quality, of 4-5 were considered moderate quality, and of 0-3 were considered low quality (Beardsley & Škarabot, 2015). The PEDro scale does not evaluate clinical usefulness. The reviewers solved any rating discrepancies through verbal discussion. A consensus was reached regarding all studies during the first meeting.

Table 1 – *PEDro scale for measuring the study quality of randomized controlled trials.*

Physiotherapy Evidence Database (PEDro) scoring scale (Maher et al., 2003).		
1	Eligibility criteria were specified.	Yes/No
2	Subjects were randomly allocated to groups.	1
3	Allocation was concealed.	1
4	The groups were similar at baseline regarding the most important prognostic indicators.	1
5	There was blinding of all subjects.	1
6	There was blinding of all therapists who administered the therapy.	1
7	There was blinding of all assessors who measured at least one key outcome.	1
8	Measures of at least one key outcome were obtained from more than 85% of the subjects initially allocated to groups.	1
9	All subjects for whom outcome measures were available received the treatment or control condition as allocated or, where this was not the case, data for at least one key outcome was analysed by “intention to treat”.	1
10	The results of between-group statistical comparisons are reported for at least one key outcome.	1
11	The study provides both point measures and measures of variability for at least one key outcome.	1
Total points	10	

The Centre for Evidence-based Medicine (CEBM) Levels of Evidence scale assesses quality based on study design, which categorize the studies in a scale ranging from 1 to 5 with further subdivision for each. Systemic reviews with homogeneity of RCTs are ranked in the highest levels while expert opinions rank the least (Table 2) (Phillips et al., 2009). In both scales, RCTs receives higher rankings, particularly with long-term follow-up and narrow confidence intervals.

Table 2 – *Centre of evidence-based medicine: Levels of evidence.*

Level	Definition
1a	Systematic reviews of randomized controlled trials
1b	Individual randomized controlled trial
1c	All-or-none studies
2a	Systematic reviews of cohort studies
2b	Individual cohort studies or low-quality randomized controlled trials
2c	Outcomes research
3a	Systematic reviews of case-control studies
3b	Individual case-control studies
4	Case series, poorly designed cohort or case-control studies
5	Animal and bench research, expert opinion

Results

Studies selection

The literature search identified 15433 records. After duplicates removed, 15301 records were screened for content through title and abstract, by two independent reviewers. From these, 15279 were excluded. The full-text of 22 articles was then assessed, by the same reviewers, for eligibility and 14 articles were excluded. In total, 8 articles were included in the systematic review. The reasons for the exclusions are listed on the PRISMA flowchart (Figure 1).

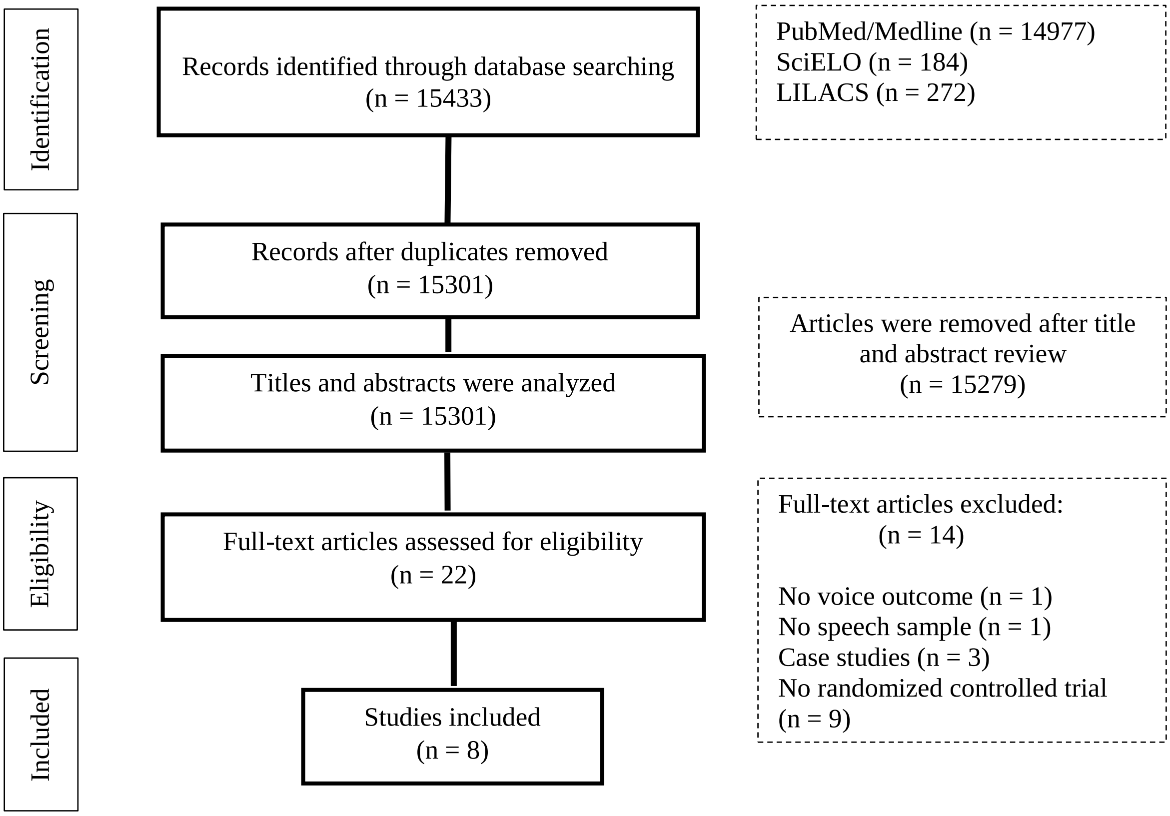

Figure 1 – *PRISMA flow diagram showing selection of article review.*

Studies were divided in 4 categories: massage (6 studies), TENS (1 study), spinal manipulative therapy (1 study), and acupuncture (1 study).

Studies description

The total number of subjects included in the 8 articles was 286, with a minimum sample size of 12 (Fachinatto et al., 2015) and a maximum sample of 84 (Yiu et al., 2015). The participants' age ranged from 17 to 59 years. The female gender was prevalent: 225 women were included. The summary of the articles' content is presented in Table 3.

Table 3 – *Studies description.*

Reference	Sample size	Study Design	Speech Sample	Outcome measures	Duration and Type of Treatment	Results/Conclusions	Efectiveness of treatment
Ternström, Andersson, and Bergman, 2000	N=31 amateur choir singers 9M and 22F	RCT: Parallel-group	Reading a 3-min passage of prose text	Acoustic analysis (SPL; F_0). Were measured for the pre- and post-treatment recordings.	Two groups: 16 in the massage group (30 min), 15 in the control group rested, lying down in silence for the same amount of time.	Subjects lowered their F_0 by 1.1 semitones and their SPL by 1.0 dB, with very high statistical significance. The drop in F_0 was somewhat larger for the males than for the females. The control subjects showed no effect at all.	↑ F_0 ↑ SPL
Leppänen, Laukkanen, Ilomäki and Vilkman, 2009	N=60 teachers 26 to 57 yrs m.a.: 40.6 yrs 0M and 60F	RCT: Parallel-group	Sustained vowel /a/ for 5s; reading sample for 1 min at both habitual loudness and loudly.	VAS (for a questionnaire about voice quality, ease or difficulty of phonation, and tiredness of the throat); perceptual-auditory analysis; acoustic analyses (F_0; Jitter; Shimmer; Leq; α-Ratio). Measurements were at the beginning and end of the autumn school term, before and after a working day.	All subjects received a 3-hour VHL. After that they were divided in two groups: VM (5 times in 1 hour sessions; The first 3 sessions were given at intervals of 1 week, while the last 2 sessions were given at intervals of 1 month) and a VHL that received the previous 3-hour VHL.	The mean F_0 (in reading samples) was higher and more difficulty of phonation was reported in the VHL group. Perceived pitch in loud reading increased in the VHL group and decreased in the VM group. In the VM group, the perceived firmness of loud reading decreased ($p = 0.026$). The results suggest that VM may help in sustaining vocal well-being during a school term.	↑ Perceived pitch ↑ Perceived firmness of loud reading
D'haeseleer, Claeys and Lierde, 2013	N=16 vocal performers 19 to 25 yrs m.a.:21.4 yrs 5M and 16F	RCT: Parallel-group	Sustained vowel /a/	MPT; Acoustic analysis (F_0; Jitter; Shimmer; Noise-to-harmonic ratio); Voice range profile; DSI; Self-Evaluations of Vocal Quality Questionnaire. Immediately before and after the therapy or vocal rest, an identical objective voice assessment protocol was performed.	Single treatment approach. The experimental group received MCT for 20 minutes, whereas the control group was instructed to have complete vocal rest for 20 minutes.	In the experimental group a significant difference in DSI was found between the measurement before and after MCT. No differences in DSI were found in the control group between the two measurements. In MCT group, improvements in MPT time and jitter were not significant.	↑ DSI = MPT = Jitter

Anhaia et al., 2014	N=42 professors 26 to 59 yrs m.a.: 38 yrs 6M and 36F	RCT: Parallel-group	Sustained vowel /e/ and an automatic speech sequence (count from 1 to 20) in regular voice.	VAPP; VAS for cervical muscle tension evaluation; Perceptual-auditory analysis (GRBASI); acoustic analysis (GNE; shimmer; jitter).	Two groups: perilaryngeal manual massage (G1) or vocal training (G2); 8 sessions (30 min), once a week.	Both groups had an improvement in vocal symptoms. No difference in VAPP between groups. The perilaryngeal manual massage provides a slight improvement in professors' global dysphonia level and reduces cervical tension, which is significantly reflected in self-perceived pain.	G1: ↑VAPP ↑VAS ↑ Perceptual-auditory analysis; ↑ GNE G2: ↑VAPP =VAS = Perceptual-auditory analysis ↑ GNE ↑ Shimmer
Kennard, Lieberman, Saaid and Rolfe, 2015	N=12 singers m.a.:24 yrs 7M and 5F	RCT: Crossover	Reading ''Arthur the Rat.''	Acoustic analysis (F_0 and glottal closing quotient). Singers were measured acoustically immediately before and immediately after each intervention using a laryngograph. After a washout of 6 weeks participants were switched between groups.	Single treatment approach. Two osteopathic treatments: specific laryngeal manipulation (30min) and postural manual therapy (30min).	Positive effects of laryngeal manipulation and postural manual therapy in singers. Specific laryngeal manipulation and postural manual therapy showed a significant improvement of F_0 ($p = 0.018$, $p = 0.0143$, respectively). No differences in glottal closing time.	↑ F_0 = Glottal closing time
Fachinatto et al., 2015	N=21 singers 17 to 51 yrs m.a.:26.3 yrs 29M and 0F	RCT: Crossover	Sing 1-minute segment of a Gregorian version of the ''Hail Mary'' prayer.	Perceptual-auditory analysis; acoustic analysis (F_0; F3; F4; F5) Recordings of the singing voice of each participant were taken immediately before and after the procedures. After a washout of 14 days participants were switched between groups.	Single treatment approach. Two groups: chiropractic spinal manipulative therapy (10 min) and nontherapeutic TENS procedure (10 min).	No differences in the quality of the singing voice of asymptomatic male singers were observed on perceptual audio evaluation or acoustic analysis after a single spinal manipulative intervention of the thoracic and cervical spine.	= Perceptual audio = Acoustic analysis

Silvério et al., 2015	N=20 w/ dysphonia 18 to 45 yrs m.a.:21.4 yrs 0M and 20F	RCT: Parallel-group	Sustained vowel /a/ isolated and after deep inspiration in pitch and usual loudness Spontaneous speech, in speed, articulation, usual pitch and loudness, answering the questions, ‘‘What do you think of your voice?’’ and ‘‘Tell me about your work’’	Vocal and laryngeal symptoms (questionnaire); NMSQ; VAS (pain); Perceptual-auditory analysis.	The volunteers were subdivided into: TENS Group (10 volunteers); LMT Group (10 volunteers). Both groups received 12 sessions of treatment, twice a week (6 weeks), lasting 20 minutes each	After TENS, there was significant improvement in the ‘‘high pitched voice’’ and ‘‘effort to speak’’ symptoms; there was significantly lower frequency of pain in the posterior neck and shoulder; TENS significantly reduced the intensity of pain in the posterior neck, shoulder, and upper back. The auditory perceptual analysis showed improvement only in the strain parameter after TENS. After LMT, there was improvement of the ‘‘sore throat,’’ significantly lower incidence of pain in the anterior neck, and the pain intensity in the posterior neck decreased. Conclusion. TENS appeared to be a treatment method intended to be used as a complement to voice therapy.	After TENS: ↑‘‘high pitched voice’’ ↑‘‘effort to speak’’ ↑VAS ↑ Perceptual-auditory analysis After LMT: ↑‘‘sore throat” ↑VAS
Yiu et al., 2015	N=84 w/ dysphonia 20 to 56 yrs 18M and 66F	RCT: Parallel-group	Sustained vowel /a/ (Voice range profile); sustained /i/ with their tongue protruded at a comfortable pitch level for at least 5 seconds	Voice range profile (maximum F0 and intensity); Size of vocal fold lesion using laryngoscopy evaluation; VAPP. Pre-treatment baseline measures were taken about an hour before the first acupuncture treatment. Second set of measures were taken 2 hours after the last acupuncture session (6th week; post-treatment), then followed by three	3 groups: the genuine acupuncture group received needles puncturing nine voice-related acupoints for 30 minutes, two times a week for 6 weeks; the sham acupuncture group received blunted needles stimulating the skin surface of the nine acupoints for the same frequency and	Significant improvement in vocal function, as indicated by the maximum fundamental frequency produced and perceived quality of life, were found in both the genuine and sham acupuncture groups, but not in the no-treatment group. Structural (morphological) improvements were, however, only noticed in the genuine acupuncture group, which demonstrated a significant reduction in the size of the vocal fold lesions.	After genuine acupuncture: ↑ Voice range profile ↑Maximum F0 ↑ VAPP ↑ Size of vocal fold lesion After sham acupuncture: ↑ Voice range profile ↑Maximum F0 ↑ VAPP

	(laryngoscopy)	assessments, conducted 14 days, 30 days and 90 days after treatment. Participants in the no-treatment group were assessed on the day of enrollment, and at the 6th, 8th, 10th, and 19th week of their participation	duration; the no-treatment group did not receive any intervention but attended the assessment sessions.		= Size of vocal fold lesion After no-treatment group: = Voice range profile = Maximum F_0 = VAPP = Size of vocal fold lesion

Abbreviations: ↑, Improvement; =, No changes; CG, Control Group; DSI, Dysphonia Severity Index; F_0, Fundamental Frequency; F3, Third formant; F4, Fourth formant; F5, Fifth formant; GNE, glottal noise energy; GRBASI, Grade, Roughness, Breathiness, Asteny, Strain, Instability; Leq, Equivalent sound level; LMT, Laryngeal Manual Therapy; MCT, Manual Circumlaryngeal Therapy; m.a., mean age; MPT, Maximum phonation time; MTD, Muscle Tension Dysphonia; MPQ, Musculoskeletal Pain Questionnaire; NMSQ, Nordic Musculoskeletal Symptoms Questionnaire; RCT, Randomized controlled trial; SNR, Signal-to-noise ratio; SPL, Sound Pressure Level; TENS, Transcutaneous Electrical Nerve Stimulation; VAS, Visual Analogue Scale; VAPP, Voice Activity and Participation Profile; VHL, Voice Hygiene Lecture; VM, Voice Massage™; w/, With; YRS, years.

The studies presented some homogeneity regarding speech samples, since sustained vowel was present in 5 articles (Anhaia et al., 2014; D'haeseleer, Claeys & Lierde, 2013; Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Silvério et al., 2015; Yiu et al., 2015), followed by reading (Kennard, Lieberman, Saaid & Rolfe, 2015; Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Ternström, Andersson & Bergman, 2000), spontaneous speech (Silvério et al., 2015), automatic speech sequence (Anhaia et al., 2014) and singing (Fachinatto et al., 2015).

Taking into account the voice assessment parameters, the investigations were similar because of the 8 RCTs, 6 used acoustic analysis (Anhaia et al., 2014; D'haeseleer, Claeys & Lierde, 2013; Fachinatto et al., 2015; Kennard, Lieberman, Saaid & Rolfe, 2015; Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Ternström, Andersson & Bergman, 2000) and 4 included perceptive-auditory analysis (Anhaia et al., 2014; Fachinatto et al., 2015; Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Silvério et al., 2015). However, regarding other outcome measures, the studies were heterogeneous varying from Voice Range Profile, maximum phonation time (MPT), size of vocal fold lesion, muscle palpation, Visual Analogue Scale (VAS), and scales like Voice Activity and Participation Profile (VAPP) and Nordic Musculoskeletal Symptoms Questionnaire.

Most of the studies had two groups, where a single experimental group was compared to a control group (D'haeseleer, Claeys & Lierde, 2013; Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Ternström, Andersson & Bergman, 2000), or to two different interventions (Anhaia et al., 2014; Kennard, Lieberman, Saaid & Rolfe, 2015; Silvério et al., 2015) or where an experimental group was assessed versus a placebo group (Fachinatto et al., 2015). However, one investigation (Yiu et al., 2015) had three groups (intervention group, sham intervention group and no treatment group). In terms of study design, 6 studies were RCTs (Parallel-group) (Anhaia et al., 2014; D'haeseleer, Claeys & Lierde, 2013; Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Silvério et al., 2015; Ternström, Andersson & Bergman, 2000; Yiu et al., 2015) and 2 were RCTs (Crossover) (Fachinatto et al., 2015; Kennard, Lieberman, Saaid & Rolfe, 2015).

Most interventions had a duration of 30 minutes (Anhaia et al., 2014; Kennard, Lieberman, Saaid & Rolfe, 2015; Ternström, Andersson & Bergman, 2000; Yiu et al., 2015). However, some were 10 (Fachinatto et al., 2015), 20 (D'haeseleer, Claeys & Lierde, 2013; Silvério et al., 2015) or 60 minutes (Leppänen, Laukkanen, Ilomäki &Vilkman, 2009) long. The length of the studies varied from a single treatment approach (D'haeseleer, Claeys & Lierde, 2013;

Fachinatto et al., 2015; Kennard, Lieberman, Saaid & Rolfe, 2015; Ternström, Andersson & Bergman, 2000) to six weeks (Silvério et al., 2015; Yiu et al., 2015), eight weeks (Anhaia et al., 2014) or three months of intervention (Leppänen, Laukkanen, Ilomäki &Vilkman, 2009).

The studies presented some heterogeneity regarding the professional background of the therapists who administered the therapy and in the years of experience. The professional background of the intervener in the articles that do not mention the years of experience range from therapist (Silvério et al., 2015), physiotherapist (Anhaia et al., 2014; Fachinatto et al., 2015), chiropractor (Fachinatto et al., 2015), osteopath (Kennard, Lieberman, Saaid & Rolfe, 2015) to a naprapathy therapist (Ternström, Andersson & Bergman, 2000). When the experience is mentioned, it varies from acupuncturists (Yiu et al., 2015) with two years of experience, to experienced voice therapists (D'haeseleer, Claeys & Lierde, 2013) or voice massage therapists with ten years of experience (Leppänen, Laukkanen, Ilomäki &Vilkman, 2009).

All studies showed positive results in their interventions, with exception of the **s**pinal manipulative therapy (Fachinatto et al., 2015).

Studies quality and levels of evidence

The mean PEDro score for the studies included in the review was 8,25 points (range: 7-10 points) (Table 4**).**

Table 4. *Methodological quality (PEDro scale) and levels of evidence (CEBM) of included studies.*

Study author	Present criteria on PEDro scale	Total score on PEDro scale	Level of Evidence (CEBM)
Ternström, Andersson, and Bergman, 2000	2,3,4,5,8,9,10,11	8/10	2b
Leppänen, Laukkanen, Ilomäki andVilkman, 2009	2,3,4,5,7,8,9,10,11	9/10	1b
D'haeseleer, Claeys and Lierde, 2013	2,3,4,5,8,9,10,11	8/10	2b
Anhaia et al., 2014	2,3,4,8,9,10,11	7/10	2b
Kennard, et al., 2014	2,3,4,8,9,10,11	7/10	2b
Fachinatto et al, 2015	2,3,4,5,6,7,8,10,11	10/10	2b
Silvério et al , 2015	2,3,4,7,8,9,10,11	8/10	2b
Yiu et al., 2015	2,3,4,5,7,8,9,10,11	9/10	1b

According to the quality criteria set, the average quality of the studies included in this review is high.

There was not a high degree of variation in quality between studies, however only one study (Fachinatto et al., 2015) was able to satisfy the blinding criteria for the therapists (PEDro scale question 6), four studies (Anhaia et al., 2014; D'haeseleer, Claeys & Lierde, 2013; Kennard, Lieberman, Saaid & Rolfe, 2015; Ternström, Andersson & Bergman, 2000) were not able to satisfy the blinding criteria for the assessors (PEDro scale question 7) and three RCTs (Anhaia et al., 2014; Kennard, Lieberman, Saaid & Rolfe, 2015; Silvério et al., 2015) were not able to satisfy the blinding criteria for the subjects (PEDro scale question 5). The remaining criteria were always scored positively. Given the difficulty to comply with the blinding criteria given the nature of the intervention performed, it is unsurprising that there were difficulties to apply it. Only one trial was able to meet all the criteria (Fachinatto et al., 2015).

Having regard to evidence levels, only two studies rated as 1b (Leppänen, Laukkanen, Ilomäki &Vilkman, 2009; Yiu et al., 2015) and six studies as 2b (Anhaia et al., 2014; D'haeseleer, Claeys & Lierde, 2013; Fachinatto et al., 2015; Kennard, Lieberman, Saaid & Rolfe, 2015; Silvério et al., 2015; Ternström, Andersson & Bergman, 2000) in the CEBM ratings. The most common reason for a 2b rank was that the study had a small sample size.

Massage

Massage appears to improve vocal quality, muscle tension and pain through VAS and VAPP. The average quality of the studies included in this section of the review was slightly lower than the average quality of the studies in the overall review (mean PEDro score = 7,83; range: 7-9). In terms of levels of evidence, one study was rated as 1b and the others were rated as 2b. To date, six RCTs have explored the effects of massage on voice. All of them showed good results.

In the investigation of Ternström, Andersson and Bergman (2000), 31 amateur choir singers performed a 30 minutes massage. They found that massage improved fundamental frequency (F_0) and Sound Pressure Level. D'haeseleer, Claeys and Lierde (2013) conducted a study in 16 vocal performers where the experimental group received a single treatment approach of Manual Circumlaryngeal Therapy (MCT) for 20 minutes, whereas the control group was instructed to have complete vocal rest for 20 minutes. In the experimental group a significant difference in Dysphonia Severity Index was found before and after MCT. No differences in Dysphonia Severity Index were found in the control group between the two measurements. In the MCT group, improvements in MPT and jitter were not significant. In another study (Anhaia et al., 2014), 42 professors were divided in two groups: perilaryngeal manual massage or vocal training. Participants performed 8 sessions (30 minutes), once a week. The authors found that both groups had an improvement in vocal symptoms. No difference was verified in VAPP between groups. The perilaryngeal manual massage provided a slight improvement in professors' global dysphonia level and reduced cervical tension, which was significantly reflected in the self-perceived pain score. Silvério et al. (2015) demonstrated that Laryngeal Manual Therapy (LMT) promoted an improvement of the ''sore throat,'' significantly lowering the incidence of pain in the anterior neck, and posterior neck. Twenty dysphonic participants received 12 sessions of treatment, twice a week (6 weeks), lasting 20 minutes each. Kennard, et al. 2014 conducted a crossover RCT where 12 asymptomatic singers received specific laryngeal manipulation (30min) or postural manual therapy (30min). Both groups showed a significant improvement of F_0 ($p = 0.018$, $p = 0.0143$, respectively). No differences were found in glottal closing time. The study of Leppänen, Laukkanen, Ilomäki and Vilkman (2009) was rated as a high-quality one, ranked at level 1b on the CEBM scale and earned 9 of 10 points on the PEDro scale. The 1b rating reflects a study that was well designed, with a sufficient number of participants and adequate long-term follow-up. The PEDro score indicates that the study design was strong. All sixty teachers received a 3-hour Voice Hygiene Lecture (VHL). After that they were divided in two groups: Voice Massage™ (VM) group (5 times in 1 hour sessions; the first 3 sessions were given at intervals of 1 week, while the last 2 sessions were given at intervals of 1 month) and a VHL group that received the previous 3-hour VHL. Measurements were at the beginning and end of the autumn school term, before and after a working day. The mean F_0 (in reading samples) was higher and more difficulty of phonation was reported in the VHL group. Perceived pitch in loud reading increased in the VHL group and decreased in the VM group. In the VM group, the perceived firmness of loud reading decreased ($p = 0.026$). The results suggest that VM may help in sustaining vocal well-being during a school term.

Transcutaneous electrical nerve stimulation

Only one RCT (Silvério et al., 2015) was included in this section. The quality of the study was high (PEDro score = 8) and was rated as 2b in terms of levels of evidence. Authors concluded that TENS can reduce the intensity and frequency of pain in shoulders, upper back and neck. They also found that TENS group had symptoms that significantly improved from ‘‘thin voice’’ and ‘‘effort to speak’’. From the analysis of the vowel /a/, they verified that 60% of the participants in TENS group significantly improved the ‘‘tension’’ parameter in voice, which did not occur with the women of the LMT group. In the analysis of spontaneous speech, no significant differences were found in all of the parameters analyzed. In this study 20 dysphonic participants received a 12 sessions of treatment, twice a week (6 weeks), lasting 20 minutes each. The TENS application consisted the bilateral placement of electrodes (5.0 x 5.0 cm) on the upper trapezius region and in the submandibular region, with a low (10 hertz (Hz)), symmetrical biphasic square pulse, phase 200 ms, at a motor threshold intensity. According the authors, TENS applied in this way, can promote muscle relaxation because stimulates both nociceptive fibers type A-delta and C and motor efferent fibers, producing not just an analgesic effect, but also decreasing the symptoms in the vocal tract.

Spinal manipulative therapy

Spinal manipulative therapy showed no differences in the quality of the singing voice of asymptomatic male singers, when compared to nontherapeutic TENS procedure. The quality of the study (Fachinatto et al., 2015) was the highest in this review (PEDro score = 10) and was rated as 2b in terms of levels of evidence. Comparing to control group, authors found no differences on perceptual audio evaluation or acoustic analysis of the male singers, after a single spinal manipulative intervention of the thoracic and cervical spine. According to researchers, the parameters used for nontherapeutic TENS application influenced participants psychologically and provided a certain degree of muscle relaxation, consequently improving voice quality.

Acupuncture

Yiu et al. (2015) conducted a high quality study that was rated at level 1b on the CEBM scale and earned 9 of 10 points on the PEDro scale. In this RCT, 84 participants with dysphonia were divided in three groups: genuine acupuncture group that received needles in nine voice-related acupoints (two Hegu and two Lieque points at the wrists, one Lianquan and two Renying points in the neck, and two Zhaohai points at the ankles). Disposable stainless steel needles (0.25 mm diameter, 25 mm long with a 25 mm extended handle) were used, with a depth about 13 mm for Zhaohai, Hegu, and Lianquan and 5–8 mm for Lieque and Renyin acupoints. Stimulation was applied by twirling the needles once every 5 minutes for 30 minutes; the sham acupuncture group received blunted needles stimulating the skin surface of the nine acupoints for the same frequency and duration as the genuine acupuncture group; and the no-treatment group. A significant improvement in vocal function, as indicated by the maximum fundamental frequency produced was verified in both the genuine and sham acupuncture groups, but not in the no-treatment group. About perceived quality of life, genuine acupuncture groups showed significant results comparing to sham acupuncture group ($p = 0{,}003$) and no-treatment group ($p = 0{,}01$). No significant difference was found between the no-treatment and sham acupuncture group ($p = 0{,}83$). Only the genuine acupuncture group demonstrated a significant reduction in the size of the vocal fold lesions.

Discussion

Voice disorders are a common problem that occurs more frequently in teachers than in other professionals that use the voice frequently (Kooijman et al., 2006; Sala et al., 2001; Sliwinska-

Kowalska et al., 2006). The results of the present review support this notion since teachers were the most prevalent professionals. The predominance of female participants in this study (225 out of 286 participants) is a consistent feature in the international literature, as the female gender is predominant in the teaching profession and has a higher prevalence of vocal problems, due to the demand of the profession (Behlau, Zambon, Guerrieri & Roy, 2012; Bovo, Galceran, Petruccelli & Hatzopoulos, 2007; Munier & Kinsella, 2008).

Individuals with functional or organofunctional dysphonia may have an increase of muscle tension in cervical and perilaryngeal muscles (Bigaton et al., 2010; Menoncin et al., 2010), muscle pain at rest or during function (Angsuwarangsee & Morrison, 2002; Menoncin et al., 2010), reduced range of motion in cervical spine (Angsuwarangsee & Morrison, 2002; Menoncin et al., 2010), hyperactivity of extrinsic laryngeal muscles (Angsuwarangsee & Morrison, 2002) and postural changes (Menoncin et al., 2010).

A proven effective method to induce normotension of cervical and laryngeal muscles is manual therapy, such as laryngeal massage and massage on the neck or shoulder girdle, as well as passive stretch. Manual therapy have been used by professionals from several different fields, such as speech-language therapists (Anhaia et al., 2014; Ternström, Andersson & Bergman, 2000), osteopaths (Kennard, Lieberman, Saaid & Rolfe, 2015) and physiotherapists (Craig et al., 2015; Staes et al., 2011; Tomlinson & Archer, 2015). This variety reflects different descriptors or denominations that are used in research and clinically. The main goal of this technique is to relax the muscles that are excessively tense, which ends up inhibiting the balance of phonatory function. This may enlarge the diameter of the resonance cavity, particularly at the pharynx, which is an important goal of classical singing (Guzman et al., 2013). The high position of the larynx may influence the vocal function, changing length control and the rigidity of vocal folds, which contributes to the decrease of the vocal quality (Cialdini & Behlau, 2005; Pettersen & Westgaard, 2004).

Manual therapy, in the form of massage was the intervention most frequently used in the studies reviewed, being present in 6 of the 8 articles. This treatment was effective in all studies. It should be noted that massage was helpful in sustaining vocal well-being during a school term (Leppänen, Laukkanen, Ilomäki &Vilkman, 2009).

Another technique of manual therapy is spinal manipulative therapy. The authors (Fachinatto et al., 2015) that conducted this investigation found no differences in the voice quality. Once excessive cervical muscle tension was not a criterion for subject selection, it is possible that most participants did not have excessive muscle tension and, therefore, spinal manipulation wasn´t effective on the singing voice. Moreover, spinal manipulation cannot be a standardized intervention as it was used, as depends on the origin of the dysfunction. So, in cases of postural misalignment, where the head and neck are not properly aligned, spinal manipulation may improve posture, especially the positioning of the head relative to the thorax and reduce cervical and thoracic muscle tension, thus reducing tension during sound emission and increasing pharyngeal cavity volume (Johnson & Skinner, 2009; Lehman, Vernon & Mcgill, 2001; Pettersen & Westgaard, 2004; Maigne & Vautravers, 2003; Mello, Silva, Ferreira & Herr, 2009). Reducing muscle tension and improving posture to have better voice quality are corroborated in the studies of Craig et al. (2015), Tomlinson and Archer (2015), and Staes et al. (2011), where they successfully applied physiotherapy programs to improve posture, pain, and voice quality. These programs consist of spinal manipulation (Staes et al., 2011), joint mobilizations (Craig et al., 2015), myofascial release (Craig et al., 2015), contract-relax techniques (Craig et al., 2015; Tomlinson & Archer, 2015), cervical stretches (Tomlinson & Archer, 2015), therapeutic exercises of neck (Craig et al., 2015; Staes et al., 2011) and lumbar spine (Craig et al., 2015; Staes et al., 2011), pelvic floor exercises (Staes et al., 2011), ergonomics (Craig et al., 2015; Tomlinson & Archer, 2015) and breathing exercises (Staes et al., 2011).

In this review, one RCT (Silvério et al., 2015) about another usual physiotherapy treatment, TENS was included showing good results. An investigation with similar results was conducted by Guirro et al. (2008), where 10 participants with dysphonia performed 10 TENS sessions (200µs and 10Hz; 4 electrodes applied in the trapezius and sternocleidomastoid muscles bilaterally), with pain relief through VAS. The TENS decreased the Root Media readings of right and left trapezius, left sternocleidomastoid and suprahyoid muscles during the production of the /e/ vowel and for right and left trapezius as well as right and left sternocleidomastoid during spontaneous speech. The voice analysis, showed a decrease in the level of laryngeal injuries; with no difference during the production of the /e/ vowel in the perceptive-auditory analysis and with a decrease in the level of dysphonia and hoarseness during spontaneous speech.

The other treatment included in this review was acupuncture, a method of complementary medicine (Vas et al., 2004). The RCT included (Yiu et al., 2015) demonstrated that acupuncture was more effective than a control group receiving no treatment or a sham treatment. In other investigation, Yiu et al. (2016) showed that acupuncture of voice-related acupoints facilitated an anti-inflammatory process in phonotraumatic vocal pathologies of seventeen dysphonic individuals.

The experience and training of the therapists who gave the treatments were mentioned in very few studies. No adverse events were reported in the trials included in this review.

The methodological quality of the included RCTs was high. However only one study was able to satisfy the blinding criteria for the therapists, four studies were not able to satisfy the blinding criteria for the assessors and three RCTs were not able to satisfy the blinding criteria for the subjects.

Regarding the evidence levels, only two studies rated as 1b and six studies as 2b in the CEBM ratings, demonstrating an overall good quality for the studies.

The results of the studies were encouraging. There is evidence that massage, TENS and acupuncture may be useful as either a unique therapies or as an adjunct therapies to other established treatments for voice disorders.

This review may be subject to several critics. Some studies had small samples and did not evaluate physical parameters like posture or muscle tension. Most of them had short follow-ups, with exception of one study (Yiu et al., 2015) that performed repeated assessments 14, 30 and 90 days after baseline. Most of the studies had a short duration, since many of them had a single treatment approach and some of them don't refer the experience of the therapists who administered the therapy.

Despite these limitations, this review is, as far as the authors are aware, the first to comprehensively and critically assess evidence of the effectiveness of physiotherapy and complementary therapies on voice disorders, which may provide useful insight for further studies. This review can be considered as a first step in order to document physiotherapy and complementary therapies approaches in dysphonic participants, singers and teachers, with the aim to improve postural alignment and optimize muscle activity.

To attain the highest-quality evidences, good quality RCT designs should be utilized in the future researches. Participants should be randomized, the design should be double blinded, and the clinician performing the treatment should use it regularly in clinical practice. As well, if possible, treatments should be compared with a control (no-treatment) group, placebo group and with other established treatments. We also suggest further RCTs with healthy participants (especially teachers and singers) and with individuals with voice or cervical complaints, larger samples and long-term follow-ups, in order to verify long-term effects. Posture evaluations, electromyography and muscle palpation are needed to improve assessment protocols as well as the combination of physiotherapy or complementary therapies with voice therapy programs. These guidelines will result in higher-quality studies that can help us determine the true effectiveness of these therapies as a treatment for voice disorders.

Conclusions

The literature regarding the effectiveness of physiotherapy and complementary therapies was good in both quality and results. The evidence from the studies included in the review suggest that manual therapy through laryngeal massage and massage of the neck or shoulder girdle is an effective treatment to reduce dysphonia complaints and muscle tension and to improve voice quality. It is important to emphasize that the TENS and acupuncture also presented good results. The knowledge of the relationship between body posture, laryngeal muscles, voice production and dysphonia is of paramount importance because a transdisciplinary action can optimize evaluation and treatment in order to provide clinically significant benefits to patients with voice problems.

References

Anhaia, T.C., Klahr, P.D.S., Ourique, A.A.B., Gadenz, C.D., Fernandes, R.A., Spagnol, P.E. & Cassol, M. (2014). Effects of two interventions in teachers with voice complaints. *Audiology-Communication Research*, 9(2), 186-193. doi: 10.1590/S2317-64312014000200014

Angsuwarangsee, T. & Morrison M. (2002). Extrinsic laryngeal muscular tension in patients with voice disorders. *Journal of Voice*, 16(3), 333-343. doi: 10.1016/S0892-1997(02)00105-4

Beardsley, C., & Škarabot, J. (2015). Effects of self-myofascial release: A systematic review. *Journal of bodywork and movement therapies*, 19(4), 747-758. doi: 10.1016/j.jbmt.2015.08.007

Behlau, M., Madazio, G. & Oliveira, G. (2015). Functional dysphonia: strategies to improve patient outcomes. *Patient Related Outcome Measures*, 6, 243. doi: 10.2147/PROM.S68631

Behlau, M., Zambon, F., Guerrieri, A.C. & Roy, N. (2012). Epidemiology of voice disorders in teachers and nonteachers in Brazil: prevalence and adverse effects. *Journal of voice,* 26(5), 665-e9. doi: 10.1016/j.jvoice.2011.09.010

Bigaton, D. R., Silvério, K. C. A., dos Santos Berni, K. C., Distefano, G., Forti, F., & de Jesus Guirro, R. R. (2010). Postura crânio-cervical em mulheres disfônicas Craniocervical posture in dysphonic women. *Revista da Sociedade Brasileira de Fonoaudiologia*, *15*(3), 329-34. doi: 10.1590/S1516-80342010000300004

Bovo, R., Galceran, M., Petruccelli, J., & Hatzopoulos, S. (2007). Vocal problems among teachers: evaluation of a preventive voice program. *Journal of voice*, *21*(6), 705-722. doi: 10.1016/j.jvoice.2006.07.002

Cialdini, R. D. C. V., & Behlau, M. S. (2005). Ação da postura corporal estática e da força dos músculos respiratórios e sua correlação com a produção e qualidade vocal em professores. *The Brazilian Journal of Physical Therapy,* 6(3), 168-174.

Corrêa, E. C., & Bérzin, F. (2007). Efficacy of physical therapy on cervical muscle activity and on body posture in school-age mouth breathing children. *International journal of pediatric otorhinolaryngology*, *71*(10), 1527-1535. doi: 10.1016/j.ijporl.2007.05.031

Craig, J., Tomlinson, C., Stevens, K., Kotagal, K., Fornadley, J., Jacobson, B., & Francis, D. O. (2015). Combining voice therapy and physical therapy: a novel approach to treating muscle tension dysphonia. *Journal of communication disorders*, *58*, 169-178. doi: 10.1016/j.jcomdis.2015.05.001

D'haeseleer, E., Claeys, S., & Van Lierde, K. (2013). The effectiveness of manual circumlaryngeal therapy in future elite vocal performers: a pilot study. *The Laryngoscope*, *123*(8), 1937-1941. doi: 10.1002/lary.24050

Fachinatto, A. P. A., de Campos Duprat, A., & Silva, M. A., Bracher, E. S. B., de Carvalho Benedicto, C., Luz, V. B. C., & Fonseca, B. S. G. (2015). Effect of spinal manipulative therapy on the singing voice. *Journal of Voice*, *29*(5), 645-e33. doi: 10.1016/j.jvoice.2014.10.005

Guirro, R. R. D. J., Bigaton, D. R., Silvério, K. C. A., Berni, K. C. D. S., Distéfano, G., Santos, F. L. D., & Forti, F. (2008). Transcutaneous electrical nerve stimulation in dysphonic women. *Pró-Fono Revista de Atualização Científica*, *20*(3), 189-194. doi: 10.1590/S0104-56872008000300009

Guzman, M., Laukkanen, A. M., Krupa, P., Horáček, J., Švec, J. G., & Geneid, A. (2013). Vocal tract and glottal function during and after vocal exercising with resonance tube and straw. *Journal of Voice*, *27*(4), 523-e19. doi: 10.1016/j.jvoice.2013.02.007

Johnson, G., & Skinner, M. (2009). The demands of professional opera singing on craniocervical posture. *European Spine Journal*, *18*(4), 562. doi: 10.1007/s00586-009-0884-1

Kennard, E. J., Lieberman, J., Saaid, A., & Rolfe, K. J. (2015). A preliminary comparison of laryngeal manipulation and postural treatment on voice quality in a prospective randomized crossover study. *Journal of Voice*, *29*(6), 751-754. doi: 10.1016/j.jvoice.2014.09.026

Kooijman, P. G., De Jong, F. I. C. R. S., Thomas, G., Huinck, W., Donders, R., Graamans, K., & Schutte, H. K. (2006). Risk factors for voice problems in teachers. *Folia Phoniatrica et Logopaedica*, *58*(3), 159-174. doi: 10.1159/000091730

Lehman, G. J., Vernon, H., & McGill, S. M. (2001). Effects of a mechanical pain stimulus on erector spinae activity before and after a spinal manipulation in patients with back pain: a preliminary investigation. *Journal of Manipulative and Physiological Therapeutics*, *24*(6), 402-406. doi: 10.1067/mmt.2001.116421

Leppänen, K., Laukkanen, A. M., Ilomäki, I., & Vilkman, E. (2009). A comparison of the effects of voice massage™ and voice hygiene lecture on self-reported vocal well-being and acoustic and perceptual speech parameters in female teachers. *Folia Phoniatrica et Logopaedica*, *61*(4), 227-238. doi: 10.1159/000228000

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical therapy*, *83*(8), 713-721.

Maigne, J. Y., & Vautravers, P. (2003). Mechanism of action of spinal manipulative therapy. *Joint bone spine*, *70*(5), 336-341. doi: 10.1016/S1297-319X(03)00074-5

Mello, E. L., Silva, M. A. D. A., Ferreira, L. P., & Herr, M. (2009). Voz do cantor lírico e coordenação motora: uma intervenção baseada em Piret e Béziers. *Revista da Sociedade Brasileira de Fonoaudiologia,* 352-361. doi: 10.1590/S1516-80342009000300011

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C. A., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia*, 14(4), 461-6. doi: 10.1590/S1809-48722010000400014

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*,151(4): 264-269. doi: 10.1371/journal.pmed.1000097

Munier, C., & Kinsella, R. (2008). The prevalence and impact of voice problems in primary school teachers. *Occupational Medicine*, *58*(1), 74-76. doi: 10.1093/occmed/kqm104

Pettersen, V., & Westgaard, R. H. (2004). Muscle activity in professional classical singing: a study on muscles in the shoulder, neck and trunk. *Logopedics Phoniatrics Vocology*, *29*(2), 56-65. doi: 10.1080/14015430410031661

Phillips, B., Ball, C., Sackett, D., Badenoch, D., Strauss, S., Haynes, B., et al. (2009). Oxford Centre for Evidence-based Medicine Levels of Evidence. available from URL: http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/ (accessed 15/12/2016).

Ruotsalainen, J., Sellman, J., Lehto, L., & Verbeek, J. (2008). Systematic review of the treatment of functional dysphonia and prevention of voice disorders. *Otolaryngology—Head and Neck Surgery*, *138*(5), 557-565. doi: 10.1016/j.otohns.2008.01.014

Sala, E., Laine, A., Simberg, S., Pentti, J., & Suonpää, J. (2001). The prevalence of voice disorders among day care center teachers compared with nurses: a questionnaire and clinical study. *Journal of Voice, 15*(3), 413-423. doi: 10.1016/S0892-1997(01)00042-X

Scotto, N. D. C. (1998). Cervical spine abnormalities in professional singers. *Folia phoniatrica et logopaedica*, *50*(4), 212-218. doi: 10.1159/000021463

Silverio, K. C. A., Brasolotto, A. G., Siqueira, L. T. D., Carneiro, C. G., Fukushiro, A. P., & de Jesus Guirro, R. R. (2015). Effect of application of transcutaneous electrical nerve stimulation and laryngeal manual therapy in dysphonic women: clinical trial. *Journal of Voice, 29*(2), 200-208. doi: 10.1016/j.jvoice.2014.06.003

Sliwinska-Kowalska, M., Niebudek-Bogusz, E., Fiszer, M., Los-Spychalska, T., Kotylo, P., Sznurowska-Przygocka, B., & Modrzewska, M. (2006). The prevalence and risk factors for occupational voice disorders in teachers. *Folia Phoniatrica et Logopaedica*, *58*(2), 85-101. doi: 10.1159/000089610

Staes, F. F., Jansen, L., Vilette, A., Coveliers, Y., Daniels, K., & Decoster, W. (2011). Physical therapy as a means to optimize posture and voice parameters in student classical singers: a case report. *Journal of Voice*, *25*(3), 91-101. doi: 10.1016/j.jvoice.2009.10.012

Ternström, S., Andersson, M., & Bergman, U. (2000). An effect of body massage on voice loudness and phonation frequency in reading. *Logopedics Phoniatrics Vocology*, *25*(4), 146-150. doi: 10.1080/140154300750067520

Tomlinson, C. A., & Archer, K. R. (2015). Manual therapy and exercise to improve outcomes in patients with muscle tension dysphonia: a case series. *Physical therapy*, *95*(1), 117-128. doi: 10.2522/ptj.20130547

Van Houtte, E., Claeys, S., Wuyts, F., & Van Lierde, K. (2011). The impact of voice disorders among teachers: vocal complaints, treatment-seeking behavior, knowledge of vocal care, and voice-related absenteeism. *Journal of voice*, *25*(5), 570-575. doi: 10.1016/j.jvoice.2010.04.008

Vas, J., Méndez, C., Perea-Milla, E., Vega, E., Panadero, M. D., León, J. M., & Jurado, R. (2004). Acupuncture as a complementary therapy to the pharmacological treatment of osteoarthritis of the knee: randomised controlled trial. *Bmj*, *329*(7476), 1216. doi: 10.1136/bmj.38238.601447.3A

Yiu, E. M., Chan, K. M., Kwong, E., Li, N. Y., Ma, E. P., Fred, W. T., & Tsang, R. (2016). Is acupuncture efficacious for treating phonotraumatic vocal pathologies? A randomized control trial. *Journal of Voice*, *30*(5), 611-620. doi: 10.1016/j.jvoice.2015.07.004

Yiu, E. M., Chan, K. M., Li, N. Y., Tsang, R., Abbott, K. V., Kwong, E., Estella, P. M. & Lin, Z. (2016). Wound-healing effect of acupuncture for treating phonotraumatic vocal pathologies: A cytokine study. *The Laryngoscope*, *126*(1), E18-E22. doi: 10.1002/lary.2548

PART II - EMPIRICAL STUDIES

Chapter 4

Paper 4 - Associations between teachers' posture, muscle tension and voice complaints

Abstract

Objective. The interaction between muscle tension, posture, and vocal use is very complex as clinical research suggests that abnormal laryngeal posture can be associated with muscle adaptive changes, although specific evidence concerning body posture and voice disorders has been lacking. Thus, the aim of this study was to verify if there were differences in posture, muscle tension and voice between teachers with and without voice complaints.

Study Design. Cross-sectional study.

Methods. Twenty-four teachers, 6 males and 18 females, were submitted to photogrammetry, muscle tension assessed through palpation and algometry assessment. Aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice were done. Participants were divided into without voice complaints group (WVCG; *n*=11) and voice complaints group (VCG; *n*=13) based on Sociodemographic and Clinical Questionnaire completion.

Results. For auditory-perceptual analysis, VCG showed a significant higher values on GRBASH subscales Grade (p=0,001) and Roughness (p=0,011). The VCG showed statistically significant higher values on muscle tension of suprahyoids (p=0,001), thyrohyoids (p=0,009) and cricothyroids muscles (p=0,040) and statistically significant lower values on algometry of the cricothyroid (p=0,023 left & p=0,026 right), suprahyoids (p=0,017 left & p=0,018 right), thyrohyoids (p=0,006 left & p=0,007 right) and pharyngolaryngeal (p=0,016 left & p=0,021 right) muscles of both sides. Concerning the aerodynamic assessment of voice and acoustic analysis of voice, no statistically significant differences between the groups were found.

Conclusions. Findings indicated statistically significant differences in muscle tension in laryngeal intrinsic muscles and auditory-perceptual analysis between teachers with and without voice complaints.

Key Words: Voice disorders, voice complaints, posture, muscle tension, teachers.

Introduction

The voice is a very important mechanism of communication between human beings (Ferreira & Costa, 2001) and any difficulty or alteration in vocal production that prevents the natural emission of the voice, conditioning oral communication, is called dysphonia (Behlau & Pontes, 1995; Spina et al., 2009).

Although professional voice use is common in one third of the working population (Vilkman, 2000), certain professions require the use of voice for long periods of time, often for hours at a time, without breaks and in adverse conditions (Putnoki, 2010). The production of voice is a function that entails an enormous energy expenditure and can lead to vocal fatigue after excessive use. The characteristic symptoms of vocal fatigue are poor intensity voice, with restricted modulation and air emission (Behlau & Pontes, 2001).

According to Ferreira et al. (2010), professionals whose voice is their work instrument, such as singers, telemarketers, receivers, actors and teachers are more likely to develop vocal pathology. However, teachers are, in fact, professionals with a high risk of developing dysphonia due to vocal wear as a result from professional use (Guimarães, 2007).

Clinical experience indicates that many patients with dysphonia have problems related to muscles or supporting structures of the larynx and some researchers have suggested that bad posture and hypertonicity associated with adverse psychological states (Morrison, 1997; Van Houtte, Van Lierde & Clayes, 2011) are the trigger factors. These postural imbalances in the neck and head structure leads to muscle weakness and adaptive lengthening, limitation of motion, degenerative changes and promotes changes in the soft tissue of the pharynx and in the muscles that elevate the larynx, which impairs control and resonance of the voice (Arboleda & Frederick, 2008).

A previously published systematic review (Cardoso, Lumini-Oliveira & Meneses, 2019) found that the interaction between muscle tension, posture, and vocal use is very complex and an effective posture allows a subject, in a static posture or while moving, to more easily shift the tension between muscles, allowing for a free movement of the larynx without blockages and with benefits to voice production.

Furthermore, objective assessment for muscle tension with algometry and photogrammetry to measure asymmetries and postural deviations are recommended (Cardoso, Lumini-Oliveira & Meneses, 2019).

Photogrammetry is a method that allows the recording of subtle postural changes difficult to assess by other forms of evaluation (Watson & Mac Donncha, 2000) and that demonstrates high reliability (Iunes et al., 2005; Sacco et al., 2007; Zonnenberg, Van Maanen, Elvers & Oostendorp, 1996).

The purpose of this study was to verify if there were differences in posture, muscle tension and voice between teachers with and without voice complaints.

Materials and methods[1]

Ethics statement

Initially the project protocol was submitted to the approval of the Ethics Committee of the UFP's University Hospital. During the first face-to-face contact with each participant, signed informed consent was obtained following the World Medical Association Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects), ensuring the anonymity and confidentiality of the data and that it would not be used for purposes other than this research. Participants were also informed that, if they wished, they could cease their participation in the study at any time without any consequences for themselves.

Sample selection

After obtaining the necessary authorizations to carry out the study in the UFP's University Hospital, the directors of the school groups of São Pedro da Cova and Rio Tinto were contacted by telephone to inform them about the nature, objectives, procedures and period of the study.

Subsequently, an email was sent to those directors with a cover letter and information about the study and to all teachers to recruit volunteers. Teachers who were on leave or had retired were excluded. After each teacher confirmed his/her participation via email, the day of the

[1] For ethical reasons, and by indication of the advisor, a copy of the assessment protocol and related authorizations is presented only to the jury, in a separate document.

assessment in the Physical Medicine and Rehabilitation Service of the UFP's University Hospital was scheduled.

After the data collection period, a new email was sent to thank the interest of the teachers and their participation in the study. The final results of the study were also disclosed to teachers this way. The collected data was archived separately and, following the Ethics Committee instruction will be deleted when no longer serves for any research purpose.

Subjects

The convenience sample consisted of 24 teachers of both genders, between 27 and 60 years of age who signed an informed consent form. To standardize the sample regarding the vocal load, only participants who were teaching full-time were included (Anhaia et al., 2014).

The exclusion criteria were: to have hearing loss (Anhaia et al., 2014); to have undergone voice therapy or lessons for voice enhancement in the last six months (Anhaia et al., 2014); to have neurological diseases; to have been under pharmacological treatment for the last purpose; to have history of oncological pathology; to have dermatological lesions; to be tracheostomized or laryngectomized; to have extensive scar of any origin (surgery, radiotherapy, trauma) in the anterior region of the cervical and soft tissues surrounding the larynx (Angsuwarangsee & Morrison, 2002).

Participants were divided into two groups: without voice complaints (WVCG) and voice with complaints (VCG), based on the completion of a Sociodemographic and Clinical Questionnaire.

Experimental procedure

Participants completed a Sociodemographic and Clinical Questionnaire, to characterize the sample and identify possible exclusion criteria. The Sociodemographic and Clinical Questionnaire included: personal data (10 items), vocal habits (7 items), personal habits (5 items) and clinical background (2 items). The data collection was done in a room of the Physical Medicine and Rehabilitation Service of the UFP's University Hospital, in a calm environment, illuminated with soft white light and at a temperature between 20ºC and 23ºC. All the assessments were done within three months and took place in the afternoon, between 15:00 and 19:00 hours, to standardize their schedules.

After completing the Sociodemographic and Clinical Questionnaire, the subjects were divided into two groups designated by WVCG (n = 11) and VCG (n = 13). Initially, each individual was evaluated for their anthropometric composition, using a stadiometer (Seca® Medical Scales and Measuring Systems®, UK) to record their height and a scale (Seca® Medical Scales and Measuring Systems®, UK) to measure their weight.

The following evaluation parameters were collected by an experienced physiotherapist investigator, using a blinded approach and trained for the purpose. The average time to assess each participant was 60 minutes.

Voice assessment

The voice assessments were performed in an acoustically isolated room in the hospital, respecting the maximum threshold of 45dB ambient noise that was measured by the application of an Android smartphone, Sound Meter 3.5.0 (Na et al., 2014; Remacle & Eckel, 2010, p.12).

The participants produced the sustained vowel /a/. They were asked to stand with their backs straight, and with their head forming perpendicular to the line of the shoulders. This allowed better control under the respiratory system, better postural control, approximation to the habitual use of the voice and defined aerodynamic characteristics ideal for voice production (Behlau, 2001, p.139-147; Carneiro & Teles, 2012; Teixeira & Behlau, 2015).

The microphone was held by the participant´s hand, positioned at an angle of 90º and 20 cm away from the mouth (Behlau, 2001, p.139-147; Camargo & Madureira, 2009; Choi, Lee, Sprecher & Jiang, 2012; Uloza et al., 2011).

The vowel / a / was recorded in the habitual pitch and loudness. The vowel was sustained as long as participants were able – the task was then repeated three times (Carneiro & Teles, 2012; Watts et al., 2015). The recording of sustained vowels is very useful since it allows the sound to be analyzed without alterations derived from the articulation of the words, thus remaining in its most stable and clear form.

The vowel / a / was chosen because when acoustic analysis of vowels is performed, it tends to be the most affected among all vowels (Guimarães, 2007) and, as described by Behlau (2001), is the best vowel for verifying variations in frequency and intensity.

The maximum phonation time, an aerodynamic variable that indicates the voice's efficiency, was also assessed. This evaluation consisted in measuring, in seconds, the maximum phonation time of the vowel /a/ during exhalation. The assessment was repeated three times and the average was considered (Marszałek et al., 2012; Zielińska-Bliźniewska et al., 2013).

The acquisition and analysis of the acoustic signal was done with the opensource software PRAAT version 6.0.35 with a single channel, 16 bits resolution and a sampling rate of 44,100 Hz (Choi, Lee, Sprecher & Jiang, 2012; Smits et al., 2005; Teixeira & Behlau, 2015). The recording was done with the dynamic microphone Shure SM58, through the digital interface Behringer FCA 1616 connected to the HP Pavilion beatsaudio computer (Vogel & Morgan, 2009).

The studied variables for acoustic analysis were: fundamental frequency (F_0), standard deviation fundamental frequency (F_0SD), Jitter, Shimmer and Harmonic-to-Noise Ratio (HNR) (Carneiro & Teles, 2012; Cho, Yin, Park, & Park, 2011; Halawa, Freire, Muñoz & Pérez, 2014; Teixeira & Behlau, 2015; Zielińska-Bliźniewska et al., 2013). These variables were chosen because they provide information on vocal signal modifications that reflect physiological changes in the vocal folds (Carneiro & Teles, 2012). The F_0 was chosen because it is "the natural result of vocal fold length" and its aerodynamic characteristics in the interaction with subglottic pressure (Behlau, 2001, p. 139-147). The Jitter indicates "the variability of F_0 in the short term by measuring the differences between neighboring glottic cycles" (Behlau, 2001, p. 139-147). The Shimmer indicates "the variability of the amplitude of the sound wave in the short term" (Behlau, 2001, p. 139-147). As for HNR, it is an indicator capable of expressing the "vocal fold signal contrast with the irregular signal of the folds and vocal tract, offering an index that relates the harmonic component versus the noise component of the acoustic wave" (Behlau, 2001, p. 139-147). The auditory-perceptual analysis of the voice was performed by three experienced voice therapists (over five years of experience) who listened to the voice recordings in a blind and random manner (Fachinatto et al., 2015; Teixeira & Behlau, 2015). The three clinicians were asked to listen carefully to all the voice samples successively. Each voice sample was played, and the clinicians were asked to complete perceptual evaluation of the subjects' vocal quality on the Grade, Roughness, Breathiness, Astheny, Strain, Harshness (GRBASH) subscales using a four-point scale: 0 = normal, 1 = mild deviance, 2 = moderate deviance, and 3 = severe deviance. Afterwards the mean values of each subscale of GRBASH was calculated based on the three clinicians' perceptual evaluation (Cho, Yin, Park, & Park, 2011; Santos, 2013; Zielińska-Bliźniewska et al., 2013). In order to adapt the GRBAS, Nemr and Lehn (2010) included the term harshness -H to the original scale, giving rise to the GRBASH scale, with the aim of adapting the perceptive assessment of voice to the voices concomitant to a partial laryngectomy, with harshness being a perceptual parameter evident in these cases. The GRBASH scale maintains the remaining parameters originally proposed by the GRBAS scale.

Photogrammetry

The photogrammetry was assessed by following the recommendations of the postural evaluation software (SAPO). A plumb line (Rubi®) attached to the ceiling was used, with two strips of neuromuscular bands (Sportex®) spaced 50 cm from each other, glued on the wire for later calibration of the image. The participant was positioned in such a way that the plumb line would lie in the same plane perpendicular to the axis of the digital camera (CANON -S40, with a resolution of 4.1 megapixels, 3.0 x zoom) (Carneiro & Teles, 2012; Marques, 2003; Santos, 2014) that was placed on a support camera tripod (Cullmann primax 350) leveled to 1 meter from the ground, and the participant was at a distance of 3 meters, so as to allow their correct visualization from head to toe (Carneiro & Teles, 2012; Marques, 2003; Santos, 2014).

In a first phase, the points were marked, using the surface anatomy and palpation, according to the SAPO protocol. The following points were referenced with orange colored stickers (Santos, 2014):

Anterior view: Tragus of the right ear (2) and tragus of the left ear (3); right acromion (5) and left acromion (6); right antero-superior iliac spine (12) and left iliac spine (13); greater trochanter of the right (14) and left (15) femur; joint line of right (16) and left knee (19); medial point of the right (17) and left (20) kneecap; tuberosity of the right (18) and left (21) tibia; right (22) and left (25) lateral malleolus and right (23) and left (26) medial malleolus.

Side view: Ear tragus (2); acromion (5); spinous process C7 (8); anterosuperior iliac spine (21); posterior superior iliac spine (22); greater trochanter of the femur (23); medial articular line of the knee (24); lateral malleolus (30); and the point between the head of the 2nd and 3rd metatarsals (31).

Subsequently, the participants were instructed to stand in orthostatic position on the green card (Staples). Four photographs were taken for each participant: anterior view, right lateral view, left lateral view and posterior view, after the anatomical points marking (Carneiro & Teles, 2012; Marques, 2003; Santos, 2014). In an attempt to minimize the error, the photographs were carried out by the same investigator (Santos, 2014).

Muscle tension assessment through palpation

For muscle tension assessment through palpation, the Lieberman method, which consists of a graduation system of four muscle groups surrounding the larynx (Lieberman, 1998), was used. Graduation varies from 0 to 3, with 0 indicating normal tonus, 1 for mild muscle tension, 2 for moderate tension and 3 for severe muscular tension (Angsuwarangsee & Morrison, 2002). The palpated muscle groups were the suprahyoids, thyrohyoids, cricothyroid and pharyngolaryngeal muscles. The assessment was performed with the participants lying in the supine position on a massage table (Posturarte® Olympic).

Algometry

In algometry, the pressure pain threshold was evaluated using an algometer (Wagner Fdix®, USA) at the same points of the muscle tension through palpation and in the same position. Trapezius, diaphragm, suboccipital muscles (Wytrążek et al, 2015) and scalenes were also assessed in algometry, in supine position (Tixa, 2006). The average of 3 measurements was collected. Participants were instructed to say "yes" when the pressure became uncomfortable in each assessment, averaging three measurements (Wytrążek et al., 2015).

Statistical analyses

The data was analyzed with IBM SPSS Statistics 25. The Shapiro-Wilks test was used for assessment of normality and the Levene´s test for the homogeneity of variance. As both normality and variance homogeneity of variances were secured, therefore parametric tests were used. The independent samples Student´s t-test was applied to evaluate the differences, between the WVCG and the VCG, on the acoustic analysis, photogrammetry and algometry. Pearson's chi-squared test was applied for nominative variables (auditory-perceptual and muscle tension through palpation). The Intraclass Correlation Coefficients was applied to evaluate the inter-rater reliability between the three raters of auditory-perceptual analysis of voice through GRBASH scale and the intra-rater reliability in photogrammetry. A p value equal or lower than 0.05 was considered significant.

Results

The biometric characteristics of the sample variables are summarized in Table 1, for both groups. No difference was found between both study groups considering age, weight, height, and body mass index.

Table 1 – *Comparison between the groups in terms of biometric characteristics.*

Variables	Without voice complaints group	Voice complaints group	*p* between groups
n	11	13	
Gender (F)	8	10	
Age (years)	37,09 ± 2,13	43,53 ± 2,73	0,077
Weight (kg)	66,81 ± 2,79	69,46 ± 4,33	0,614
Height (cm)	167,18 ± 1,99	163,46 ± 2,30	0,236
Body mass index (kg/m^2)	23,81 ± 0,66	25,87 ± 1,32	0,181

There were no statistically significant differences between the two groups in any of the acoustic measures (Table 2). However, when maximum phonation time (MPT) was compared, it was found that the WVCG presented higher values (16,93 ± 3,97s) than the VCG (13,92 ± 4,28s).

In the auditory-perceptual analysis statistically significant differences between the groups in GRBASH subscales Grade (p=0,001) and Roughness (p=0,011) were found (Table 2). Reliability analysis was carried out on the three raters of auditory-perceptual analysis of voice through the GRBASH scale. The Intraclass Correlation Coefficients was superior than 0,92 in all GRBASH subscales.

Table 2 – *Differences between the groups in aerodynamic, acoustic and auditory-perceptual analysis of voice.*

		Without voice complaints group		Voice complaints group		*p*
	Variables	n	Mean ±SD	n	Mean ±SD	
Aerodynamic assessment	MPT (s)	11	16,93 ± 3,97	13	13,92 ± 4,28	0,088
Acoustic assessment	F_0 (Hz)	11	180,67 ± 51,74	13	177,96 ± 36,17	0,882
	F_0SD (Hz)	11	1,62 ± 0,33	13	1,41 ± 0,44	0,200
	Jitter (%)	11	0,33 ± 0,07	13	0,42 ± 0,21	0,168
	Shimmer (%)	11	2,89 ± 0,84	13	3,60 ± 1,89	0,121
	HNR (dB)	11	22,26 ± 1,66	13	21,48 ± 2,55	0,377
Auditory-perceptual assessment	Grade	11	0,09 ± 0,28	13	1,15 ± 0,53	0,001*
	Roughness	11	0,45 ± 0,49	13	1,38 ± 0,62	0,011*
	Breathiness	11	0,09 ± 0,28	13	0,31 ± 0,46	0,193
	Astheny	11	0,09 ± 0,28	13	0,31 ± 0,46	0,193
	Strain	11	0,09 ± 0,28	13	0,38 ± 0,48	0,098
	Harshness	11	0,09 ± 0,28	13	0,31 ± 0,46	0,193

* Significant values ($p \leq 0.05$)
Abbreviations: F_0, fundamental frequency; F_0SD, fundamental frequency standard deviation; HNR, Harmonic-to-Noise Ratio; MPT, maximum phonation time; SD, standard deviation.

Regarding the photogrammetry, there were no statistically significant differences between the groups (Table 3). The Intraclass Correlation Coefficients was superior than 0,86 in all photogrammetry variables.

Table 3 – *Differences between the groups in the photogrammetry.*

	Without voice complaints group		Voice complaints group		*p*
Variables (º)	n	Mean ±SD	n	Mean ±SD	
HAH	11	1,78 ± 1,37	13	1,17 ± 2,76	0,49
HAA	11	1,55 ± 1,29	13	0,87 ± 2,35	0,38
HAASIS	11	1,42 ± 1,13	13	0,81 ± 2,30	0,43
VAHA	11	2,68 ± 2,15	13	3,23 ± 3,74	0,65
HAP	11	-3,21 ± 5,50	13	-3,78 ± 4,26	0,77
VAB	11	1,20 ± 1,03	13	0,45 ± 2,01	0,25
Left VAHA	11	2,85 ± 2,16	13	3,48 ± 3,66	0,61
Left HAP	11	-3,51 ± 5,54	13	-4,31 ± 4,00	0,69
Left VAB	11	1,19 ± 1,07	13	0,36 ± 1,90	0,20
HAST3	11	-1,34 ± 4,18	13	-1,83 ± 3,89	0,77

Abbreviations: HAA, horizontal alignment of acromion; HAASIS, horizontal alignment of anterior superior iliac spine; HAH, horizontal alignment of the head; HAP, horizontal alignment of the pelvis; HAST3, Horizontal asymmetry of the scapula in relation to T3; VAB, vertical alignment of the body; VAHA, vertical alignment of the head with the acromion.

Concerning the algometry assessment, statistically significant differences between the groups were found in right (p=0,018) and left (p=0,017) suprahyoids muscles, in right (p=0,007) and left (p=0,006) thyrohyoid muscles, in right (p=0,026) and left (p=0,023) cricothyroid muscles, as well as in right (p=0,021) and left (p=0,016) pharyngolaryngeal muscles. In the other muscles assessed by algometry no statistically significant differences between the groups were found. However, right and left suboccipital muscles as well right trapezius showed results very close to (p= 0,05), where with a larger sample, could have significant differences (Table 4).

Table 4 – *Differences between the groups in the algometry.*

	Without voice complaints group		Voice complaints group		*p*
Muscles (Kgf/m^2)	n	Mean ±SD	n	Mean ±SD	
Right SUB	11	2,75 ± 0,65	13	2,06 ± 0,99	0,055
Left SUB	11	2,63 ± 0,54	13	2,00 ± 0,90	0,051
Right TA	11	2,96 ± 0,80	13	2,27 ± 0,85	0,057
Left TA	11	2,93 ± 0,83	13	2,36 ± 0,78	0,102
Right DIAPH point	11	2,87 ± 0,85	13	2,40 ± 0,87	0,203
Left DIAPH point	11	2,86 ± 0,86	13	2,40 ± 0,88	0,218
Right SCAL	11	2,84 ± 0,76	13	2,25 ± 0,87	0,090
Left SCAL	11	2,85 ± 0,75	13	2,25 ± 0,85	0,084
Right SUP	11	2,49 ± 0,55	13	1,83 ± 0,71	0,018*
Left SUP	11	2,49 ± 0,55	13	1,83 ± 0,69	0,017*
Right THY	11	2,34 ± 0,54	13	1,62 ± 0,64	0,007*
Left THY	11	2,34 ± 0,53	13	1,61 ± 0,64	0,006*
Right CRICO	11	2,47 ± 0,57	13	1,83 ± 0,71	0,026*
Left CRICO	11	2,47 ± 0,57	13	1,84 ± 0,70	0,023*
Right PHARY	11	2,48 ± 0,55	13	1,86 ± 0,68	0,021*
Left PHARY	11	2,49 ± 0,54	13	1,84 ± 0,67	0,016*

* Significant values (p≤0.05)
Abbreviations: CRICO, cricothyroids; DIAPH, diaphragm; PHARY, pharyngolaryngeal muscles; SCAL, scalenes; SD, standard deviation; SUP, suprahyoids; SUB, suboccipital muscles; TA, trapezius; THY, thyrohyoids.

When muscle tension through palpation was assessed (Lieberman method), statistically significant differences between the groups were found in suprahyoids (p=0,001), thyrohyoids (p=0,009) and cricothyroids muscles (p=0,040) (Table 5).

Table 5 – *Differences between the groups in muscle tension assessed through palpation according to Lieberman method.*

Muscles	Without voice complaints group		Voice complaints group		*p*
	n	Mean ±SD	n	Mean ±SD	
Suprahyoids	11	0,45 ± 0,52	13	1,54 ± 0,52	0,001*
Thyrohyoids	11	0,54 ± 0,69	13	1,69 ± 0,63	0,009*
Cricothyroids	11	0,27 ± 0,47	13	0,92 ± 0,64	0,040*
Pharyngolaryngeal	11	0,36 ± 0,50	13	0,77 ± 0,60	0,222

* Significant values ($p \leq 0.05$)
Abbreviations: SD, standard deviation.

Discussion

The sample was composed mostly by participants of the female gender, a group that presents a higher incidence of voice disorders and was present in a greater number in studies related to teachers and presence of vocal alterations (Brasolotto & Fabiano, 2000; Troni et al., 2006; Vedovato & Monteiro, 2008). It should be stressed that there were no statistically significant differences between the groups in terms of the biometric characteristics mentioned.

In the auditory-perceptual analysis of the voice, it was verified that the VCG presented statistically significant higher values in GRBASH subscales Grade and Roughness. Muscle tension dysphonia is characterized by a hoarse voice with an admixture of roughness, with a certain strain, created with tension, which is illustrated by the results obtained in the analyzed group using GRBASH scale. In this way, Grade and Roughness presented statistically significant higher values. Although it was not significant, strain showed higher values in the group with dysphonia than in the group without dysphonia as well as higher values compared other 3 subscales. Corroborating this investigation, the studies of Ferreira et al. (2003), Viola et al. (2000) and Troni et al. (2006), found that these values of were higher in individuals with dysphonia. However, there is a possibility that the differences observed was due to the ratters, although the literature states that both methods are important for voice analysis (Oates, 2009). The fact that voice quality is perceptual in nature and that the perceptual characteristics of voice have greater intuitive meaning and shared reality among listeners than do many instrumental measures. Other factors include limitations in the validity and reliability of instrumental methods and lack of agreement as to the most sensitive and specific instrumental measures of voice quality (Oates, 2009). Similar results were found in the study of Menoncin et al. (2010), where most of the dysphonic participants showed a significant dysphonia in the auditory-perceptual assessment compared with healthy participants.

Based on the acoustic analysis, there were no statistically significant differences between groups. This may be due to the small sample size. However, it was verified that in the maximum phonation time, the values obtained in this study were below the expected level (WVCG= 16.93 ± 3.97; VCG = 13.92 ± 4.28), especially in the VCG. According to Behlau and Pontes (1995), values below 14 seconds for women are indicative of non-normality with high significance, suggesting that these participants need air refills in the most frequently linked speech, directly influencing the pneumofonoarticulatory coordination, and may generate cervical tensions.

Regarding photogrammetry, there were no statistically significant differences between the groups. Similar results were found in the study of Menoncin et al. (2010), where the authors verified significant cervical abnormalities in both groups (healthy and dysphonic subjects) and that it could not be inferred that the changes were directly associated with dysphonia. However, the authors also found that most of the dysphonic participants showed a muscle shortening in the cervical region and the cervical x-ray in the nondysphonic group was normal, while the dysphonic participants showed that a reduction in interdiscal spaces prevailed. Another investigation that studied the relation between posture and dysphonia was that of Bigaton et al. (2010), where they compared 28 healthy and dysphonic women and, found that there was no difference between the evaluated groups regarding head position. However, dysphonic women presented a more severe craniocervical dysfunction than the control group. In the investigation of Franco et al. (2014) significant differences were found in some sagittal spine posture measures between normal and dysphonic speakers because for thoracic length curvature, and for the kyphosis index, a significant effect of dysphonia was observed, with the mean thoracic length curvature and the kyphosis index significantly higher for the dysphonic speakers than for the normal speakers. The authors concluded that postural measures can add useful information to voice assessment protocols and should be taken into account when considering particular treatment strategies. In another paper, Kooijman et al. (2005) investigated the associations between incorrect posture, excessive tension of the external muscles of the larynx, and voice handicap in 25 female teachers. They concluded that the combination of increased tension of the sternocleidomastoid and the geniohyoid muscles, and the center of gravity displaced back predisposes most to voice handicap. In these described examinations, in patients with dysphonia, excessive tension of the sternocleidomastoid muscle was diagnosed in 82.5% of patients, and the position of the centre of gravity moved to the front or the back was found in 40% of patients. The smallest proportion of patients were found to be affected by increased tonus of the geniohyoid muscle (only 25%). The authors concluded that the results are indicative for the importance of assessment of muscular tension and body posture in the diagnosis of voice disorders and also demonstrate that the higher muscular hypertonicity and deviant body posture the patient has, the more complaints about voice handicap she/he will have.

Concerning the muscle tension through palpation assessment, when compared with the WVCG, the participants of the VCG presented higher values of muscle tension in the cricothyroid, suprahyoids and thyrohyoids muscles. Corroborating these results, it was verified that the participants of the VCG group showed a statistically significant lower values of algometry, in the cricothyroid, suprahyoids, thyrohyoids and pharyngolaryngeal muscles, as shown in the literature (Khoddami, Ansari, & Jalaie, 2015; Van Houtte, Van Lierde, & Claeys, 2011). However, the diaphragm, scalenes, suboccipital muscles and trapezius muscles did not present any significant statistical differences.

Angsuwarangsee and Morrison, (2002) obtained similar results, where a strong relationship was found between thyrohyoid muscle tension and muscle misuse dysphonia ($p \leq 0.01$).

In fact, one should not focus only on the evaluation of posture without muscle tension through palpation and algometry because, as suggested by Khoddami's study, Ansari, and Jalaie (2015), muscle tension can both cause dysphonia and be a result of dysphonia as subjects increasingly add muscle effort to try to make their voices work. The small intrinsic laryngeal muscles are responsible for the movement of the arytenoid cartilages and thus for vocal fold adduction, abduction, and tension. The larger extrinsic musculature (suprahyoid and infrahyoid muscles) maintain the larynx in a stable and natural position in which the intrinsic laryngeal musculature can contract freely and undisturbed. In patients with muscle tension dysphonia, an altered tension of the extrinsic musculature results in a changed position of the larynx in the neck (a mostly higher position) and a disturbed inclination of the cartilaginous structures of the larynx (hyoid, thyroid, cricoid, and arytenoid) that immediately affects the intrinsic musculature. Tension of the vocal folds is altered, and the voice becomes disturbed (Cardoso, Lumini-Oliveira & Meneses, 2019; Rubin, Lieberman & Harris, 2000)

In the investigation by Menoncin et al. (2010), the women of the dysphonic group presented shortening in the sternocleidomastoid and upper trapezius muscles. It is important to note that most patients present functional dysphonia due to vocal abuse or poor voice use, which may be due to the muscular tension level, as well as shortening in the cervical region and, therefore, the laryngoscopic exam does not evidence characteristic structural changes (Imamura & Tsuji, 2006). The increase in tonus throughout the intrinsic and extrinsic laryngeal musculature simultaneously associated with the presence of posterior glottic cleft and elevated larynx define muscle tension dysphonia (Barkmeier & Case, 2000; Van Houtte, Van Lierde & Claeys, 2011). Furthermore, studies report that phonation constantly associated with an inappropriate laryngeal posture can lead to organic changes such as nodules or polyps, particularly in women, with the presence of posterior glottic cleft, associated with increased laryngeal tension and more directly to the imbalance of the posterior cricoarytenoid muscle during phonation (Angsuwarangsee & Morrison, 2002).

However, with respect to the external cervical or paralarengeal muscles in this investigation, there were no statistically significant differences in these muscles between both groups as it was the case in the investigation of Menoncin et al. (2010) where non-dysphonic women presented similar changes as dysphonic ones.

This research has however, the limitation of having a small sample and a dissimilar number of men and women (in both groups, though).

We suggest further research with more similar assessment methods in order to better compare the studies and systematize knowledge about the relationship between posture, muscle tension and voice complaints or dysphonia. We also suggest longitudinal studies, investigations with larger samples and that relate gold standard measurements of voice, like aerodynamic, acoustic and auditory-perceptual assessments, with objective measurements of posture, like photogrammetry or imaging exams such as magnetic resonance, as well as an evaluation of muscle tension through electromyography, algometry or muscle tension through palpation by validated scales. The posture assessment should be analyzed both in a fixed position and during a specific action or task. We suggest studies with two groups— healthy individuals and individuals with voice disorders— using experienced blinded examiners. Samples with professionals who are frequently affected with voice disorders, like teachers and singers, are suggested as well as samples with more males.

Conclusions

The findings of this study indicate that muscle tension of the cricothyroid muscles, suprahyoids, and thyrohyoids muscles were significantly higher for teachers with voice complaints versus teachers without voice complaints, and that, in algometry, teachers with voice complaints had statistically significant lower values in the cricothyroid, suprahyoids, thyrohyoids and pharyngolaryngeal muscles. However, the diaphragm, scalenes, suboccipital muscles and trapezius muscles did not present statistically significant differences between the groups. It was also observed that teachers with voice complaints had significantly higher values on the GRBASH subscales Grade and Roughness, compared with teachers without voice complaints. Regarding photogrammetry and acoustic measures, there were no statistically significant differences between the groups.

Moreover, the results are indicative of the importance assessing muscle tension and algometry in the diagnosis of voice disorders. Perhaps muscular tension in teachers is an early sign of the development of complaints and, on the treatment of voice disorders, attention should be paid to relaxation of the aforementioned muscles in this study and corrections of deviant body posture should be performed.

References

Anhaia, T.C., Klahr, P.D.S., Ourique, A.A.B., Gadenz, C.D., Fernandes, R.A., Spagnol, P.E. & Cassol, M. (2014). Effects of two interventions in teachers with voice complaints. *Audiology-Communication Research*, 9(2), 186-193. doi: 10.1590/S2317-64312014000200014

Angsuwarangsee, T., & Morrison, M. (2002). Extrinsic laryngeal muscular tension in patients with voice disorders. *Journal of Voice*, 16(3), 333-343. doi: 10.1016/S0892-1997(02)00105-4

Arboleda, B.M.W. & Frederick, A.L. (2008). Considerations for maintenance of postural alignment for voice production. *Journal of Voice*, 22(1), 90-9. doi: 10.1016/j.jvoice.2006.08.001

Barkmeier, J. M., & Case, J. L. (2000). Differential diagnosis of adductor-type spasmodic dysphonia, vocal tremor, and muscle tension dysphonia. *Current Opinion in Otolaryngology & Head and Neck Surgery*, *8*(3), 174-179.

Behlau, M. (2001). Voz: o livro do especialista. vol. 1. Rio de Janeiro: Revinter, p. 139-147.

Behlau M, Pontes P. Avaliação e Tratamento das Disfonias. São Paulo: Editora Lovise; 1995.

Behlau, M. e Pontes, P. (2001). Higiene vocal - Cuidando da voz. Rio de Janeiro, Revinter.

Bigaton, D. R., Silvério, K. C. A., dos Santos Berni, K. C., Distefano, G., Forti, F., & de Jesus Guirro, R. R. (2010). Postura crânio-cervical em mulheres disfônicas Craniocervical posture in dysphonic women. *Revista da Sociedade Brasileira de Fonoaudiologia*, *15*(3), 329-34. doi: 10.1590/S1516-80342010000300004

Brasolotto AG, Fabiano SRR. (2000). Uso profissional da voz pelo professor–análise acústica. *Revista da Sociedade Brasileira de Fonoaudiologia*, *6*, 6-11.

Camargo, Z. A., & Madureira, S. (2009). Dimensões perceptivas das alterações de qualidade vocal e suas correlações aos planos da acústica e da fisiologia. *DELTA: Documentação e Estudos em Linguística Teórica e Aplicada*, *25*(2), 285-317. doi: 10.1590/S0102-44502009000200004

Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019a). Associations between posture, voice, and dysphonia: a systematic review. *Journal of Voice*, 33(1), 124e1-12. DOI 10.1016/j.jvoice.2017.08.030

Carneiro, P.R. & Teles, L.C.D.S. (2012). Influência de alterações posturais, acompanhadas por fotogrametria computadorizada, na produção da voz. *Fisioterapia Movimento*, 25(1):13-20. doi:10.1590/S0103-51502012000100002

Cho, S. W., Yin, C. S., Park, Y. B., & Park, Y. J. (2011). Differences in self-rated, perceived, and acoustic voice qualities between high-and low-fatigue groups. *Journal of Voice*, *25*(5), 544-552. doi: 10.1016/j.jvoice.2010.07.006

Choi, S. H., Lee, J., Sprecher, A. J., & Jiang, J. J. (2012). The effect of segment selection on acoustic analysis. *Journal of Voice*, *26*(1), 1-7. doi: 10.1016/j.jvoice.2010.10.009

Fachinatto, A. P. A., de Campos Duprat, A., e Silva, M. A., Bracher, E. S. B., de Carvalho Benedicto, C., Luz, V. B. C., & Fonseca, B. S. G. (2015). Effect of spinal manipulative therapy on the singing voice. *Journal of Voice*, *29*(5), 645-e33. doi: 10.1016/j.jvoice.2014.10.005

Ferreira, L. P., & Costa, H. O. (2001). Voz Ativa: falando sobre a clínica fonoaudiológica. *Roca, São Paulo*.

Ferreira, L. P., Gianini, S. P., Figueira, S., Silva, E. E., Karmann, D. D. F., & de Souza, T. M. T. (2003). Condições de produção vocal de professores da prefeitura do município de São Paulo. *Distúrbios da Comunicação*, *14*(2).

Ferreira, L. P., Souza, T. M. T., Zambon, F., Barreto, R. K. A., & Maciel, M. C. B. T. (2010). Voz do professor: gerenciamento de grupos. *Distúrbios da Comunicação*, *22*(3).

Franco, D., Martins, F., Andrea, M., Fragoso, I., Carrão, L., & Teles, J. (2014). Is the sagittal postural alignment different in normal and dysphonic adult speakers?. *Journal of Voice*, *28*(4), 523-e1. doi: 10.1016/j.jvoice.2014.01.002

Freitas, S. V. (2006). Disfonia em professoras do Primeiro Ciclo do Ensino Básico: prevalência e factores de risco. *Arquivos de medicina*, *20*(5-6), 145-152.

Guimarães, I. (2007). A ciência e a arte da voz humana. Alcoitão, Escola Superior de Saúde do Alcoitão.

Halawa, W. E., Freire, A. R. F., Muñoz, I. V., & Pérez, S. S. (2014). Assessment of effectiveness of acoustic analysis of voice for monitoring the evolution of vocal nodules after vocal treatment. *European Archives of Oto-Rhino-Laryngology*, *271*(4), 749-756. doi: 10.1007/s00405-013-2685-8

Imamura, R., & Tsuji, D. H. (2006). Disfonia espasmódica de adução, tremor vocal e disfonia de tensão muscular: é possível fazer o diagnóstico diferencial?. *Revista brasileira de otorrinolaringologia*, *72*(4), 434.

Iunes, D. H., Castro, F. A., Salgado, H. S., Moura, I. C., Oliveira, A. S., & Bevilaqua-Grossi, D. (2005). Confiabilidade intra e interexaminadores e repetibilidade da avaliação postural pela fotogrametria. *Brazilian Journal of Physical Therapy*, *9*(3), 327-34.

Khoddami, S. M., Ansari, N. N., & Jalaie, S. (2015). Review on laryngeal palpation methods in muscle tension dysphonia: validity and reliability issues. *Journal of Voice*, *29*(4), 459-468. doi: 10.1016/j.jvoice.2014.09.023

Kooijman, P. G., De Jong, F. I. C. R. S., Oudes, M. J., Huinck, W., Van Acht, H., & Graamans, K. (2005). Muscular tension and body posture in relation to voice handicap and voice quality in teachers with persistent voice complaints. *Folia phoniatrica et logopaedica*, *57*(3), 134-147. doi:10.1159/000084134

Lieberman, J. (1998). Principles and techniques of manual therapy: application in the management of dysphonia. *The voice clinical handbook*, 91-138.

Marques, R. M. (2003). *Avaliação fisioterapêutica da postura natural da cabeça e pescoço em portadores de disfunções da articulação temporomandibular por meio da fotometria e radiografia* (Doctoral dissertation). Bauru: Faculdade de Odontologia da Universidade do Sagrado Coração, Brazil.

Marszałek, S., Niebudek-Bogusz, E., Woźnicka, E., Malińska, J., Golusiński, W., & Śliwińska-Kowalska, M. (2012). Assessment of the influence of osteopathic myofascial techniques on normalization of the vocal tract functions in patients with occupational dysphonia. *International journal of occupational medicine and environmental health*, *25*(3), 225-235. DOI 10.2478/S13382-012-0041-7

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C. A., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia*, 14(4), 461-6. doi: 10.1590/S1809-48722010000400014

Morrison, M. (1997). Pattern recognition in muscle misuse voice disorders: How I do it. Journal of Voice, 11(1), 108-114. doi: 10.1016/S0892-1997(97)80031-8

Na, Y., Joo, H. S., Yang, H., Kang, S., Hong, S. H., & Woo, J. (2014). Smartphone-based hearing screening in noisy environments. *Sensors*, 14(6), 10346-10360. doi:10.3390/s140610346

Nemr, K. & Lehn, C. (2010). Voz em Câncer de Cabeça e Pescoço. In: Fernandes, F.D.M., Mendes, B.C.A., Navas, A.L.P.G.P. (2ª Ed). Tratado de Fonoaudiologia. São Paulo, Editora Roca Ltda.: 787-802.

Oates, J. (2009). Auditory-perceptual evaluation of disordered voice quality. *Folia Phoniatrica et Logopaedica*, 61(1), 49-56. doi: 10.1159/000200768

Putnoki, D. D. S., Hara, F., Oliveira, G., & Behlau, M. (2010). Qualidade de vida em voz: o impacto de uma disfonia de acordo com gênero, idade e uso vocal profissional. *Revista da Sociedade Brasileira de Fonoaudiologia, 15*(4), 485-490.

Remacle, M., & Eckel, H. E. (Eds.). (2010). *Surgery of larynx and trachea*. Berlin: Springer. p. 12.

Rubin, J. S., Lieberman, J., & Harris, T. M. (2000). Laryngeal manipulation. *Otolaryngologic Clinics of North America*, *33*(5), 1017-1034. doi: 10.1016/S0030-6665(05)70261-9

Sacco, I.C.N., Alibert, S., Queiroz, B.W.C., Pripas, D., Kieling, I., Kimura, A. A Sellmer, A.E., Malvestio, R.A. & Sera, M.T. (2007). Confiabilidade da fotogrametria em relação a goniometria para avaliação postural de membros inferiores. *Revista Brasileira de Fisioterapia*,*11*(5), 411-417.

Santos, A. R. R. D. (2014). *Avaliação postural por biofotogrametria em crianças e adolescentes num agrupamento de escolas do concelho de Bragança* (Doctoral dissertation). Instituto Politécnico de Bragança, Portugal.

Santos, M. E. D. (2013). *GRBASH–Scale for Evaluating the Hoarse Voice* (Master dissertation, [sn]). Universidade Fernando Pessoa.

Smits, I., Ceuppens, P., & De Bodt, M. S. (2005). A comparative study of acoustic voice measurements by means of Dr. Speech and Computerized Speech Lab. *Journal of Voice*, 19(2), 187-196. doi: 10.1016/j.jvoice.2004.03.004

Spina, A. L., Maunsell, R., Sandalo, K., Gusmão, R., & Crespo, A. (2009). Correlação da qualidade de vida e voz com atividade profissional. *Revista Brasileira de Otorrinolaringologia*, 75(2), pp. 275-279. doi: 10.1590/S0034-72992009000200019

Teixeira, L. C., & Behlau, M. (2015). Comparison between vocal function exercises and voice amplification. *Journal of Voice*, *29*(6), 718-726. doi: 10.1016/j.jvoice.2014.12.012

Tixa, S. (2006). Atlas De Anatomía Palpatoria Tomo 1. Cuello, Tronco Y Extremidad Superior. Elsevier Masson.

Troni, C. R., Arakaki, F. N., Lima, F. S., Mott, L., Rodrigues, K. A., & Ferreira, L. P. (2006). Professores em contexto profissional e não profissional: análise objetiva e subjetiva dos aspectos da articulação e da postura. *Distúrbios da Comunicação*, *18*(2).

Uloza, V., Verikas, A., Bacauskiene, M., Gelzinis, A., Pribuisiene, R., Kaseta, M., & Saferis, V. (2011). Categorizing normal and pathological voices: automated and perceptual categorization. *Journal of Voice*, *25*(6), 700-708. doi: 10.1016/j.jvoice.2010.04.009

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, *25*(2), 202-207. doi: 10.1016/j.jvoice.2009.10.009

Vedovato, T. G., & Monteiro, M. I. (2008). Perfil sociodemográfico e condições de saúde e trabalho dos professores de nove escolas estaduais paulistas. *Revista da Escola de Enfermagem da USP*, *42*(2), 291-297. doi: 10.1590/S0080-62342008000200012

Vilkman, E. (2000). Voice Problems at work: a challenge for occupational safety and health arrangement. Folia Phoniatrica et Logopedica, 52, pp. 120-125.

Viola, I. C., Ferreira, L. P., Sene, C. D., Villas Boas, D. C., & Souza, S. M. (2000). A voz do professor: levantamento das publicações brasileiras. *Revista da sociedade brasileira de fonoaudiologia*, *5*(7), 36-47.

Vogel, A. P., & Morgan, A. T. (2009). Factors affecting the quality of sound recording for speech and voice analysis. *International journal of speech-language pathology*, 11(6), 431-437. doi: 10.3109/17549500902822189

Watson, A. W. S., & Mac Donncha, C. (2000). A reliable technique for the assessment of posture: assessment criteria for aspects of posture. *Journal of Sports Medicine and Physical Fitness*, *40*(3), 260.

Watts, C. R., Diviney, S. S., Hamilton, A., Toles, L., Childs, L., & Mau, T. (2015). The effect of stretch-and-flow voice therapy on measures of vocal function and handicap. *Journal of Voice*, *29*(2), 191-199. doi: 10.1016/j.jvoice.2014.05.008

Wytrążek, M., Huber, J., Lipiec, J., & Kulczyk, A. (2015). Evaluation of palpation, pressure algometry, and electromyography for monitoring trigger points in young participants. *Journal of manipulative and physiological therapeutics*, *38*(3), 232-243. doi: 10.1016/j.jmpt.2014.12.005

Zielińska-Bliźniewska, H., Pietkiewicz, P., Miłoński, J., Urbaniak, J., & Olszewski, J. (2013). Acoustic and capacity analysis of voice academic teachers with diagnosed hyperfunctional dysphonia by using DiagnoScope Specialist software. *Otolaryngologia Polska*, *67*(3), 144-148. doi: 10.1016/j.otpol.2013.02.001

Zonnenberg, A. J. J., Van Maanen, C. J., Elvers, J. W. H., & Oostendorp, R. A. B. (1996). Intra/interrater reliability of measurements on body posture photographs. *Cranio®*, *14*(4), 326-331. doi: 10.1080/08869634.1996.11745985

Chapter 5

Paper 5 - Associations between teachers' autonomic dysfunction and voice complaints

Abstract

Objective. The aim of this investigation was to verify if there were differences in autonomic nervous system function and voice between teachers with and without voice complaints.

Study Design. Cross-sectional study.

Methods. The Questionnaire of Autonomic Dysfunction was answered by 24 teachers, 6 males and 18 females, whose heart rate variability was also assessed. Aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice were done. Participants were divided into without voice complaints group (WVCG; *n*=11) and voice complaints group (VCG; *n*=13) based on Sociodemographic and Clinical Questionnaire completion.

Results. For auditory-perceptual analysis, VCG showed a significant higher values on GRBASH subscales Grade (p=0,001) and Roughness (p=0,011). Regarding the heart rate variability, it was found that in the VCG, the square root of the mean squared difference of successive RR intervals (RMSSD) and the percentage of adjacent NN intervals differing by more than 50 milliseconds (pNN50) were significantly lower than in the WVCG (p=0,023 and p=0,032, respectively). The VCG presented a higher occurrence of neurovegetative symptoms directly related with voice, namely in fluctuating nose obstruction (p=0,011), neck pain (while or after speaking) (p=0,017) and in fatigability when speaking (p=0,004). Concerning the aerodynamic assessment of voice, acoustic analysis of voice and neurovegetative symptoms not directly related to voice, no statistically significant differences between the groups were found.

Conclusions. Findings indicated significantly lower values in RMSSD and pNN50 of teachers with voice complaints when compared with teachers without voice complaints and that the teachers with voice complaints presented a higher occurrence of neurovegetative symptoms directly related with voice than the ones without voice complaints.

Key Words: Voice disorders, voice complaints, autonomic nervous system, autonomic dysfunction, teachers.

Introduction

Teachers have a higher risk of developing voice disorders when compared to the general population, which may affect their professional performance and cause economic losses for the educational system (Roy et al., 2004a; Roy et al., 2004b; Souza et al., 2011)

The literature shows a relation between functional voice disorders and a myriad of psychological factors (Van Houtte, Van Lierde & Claeys, 2011) where dysfunction of the autonomic nervous system (ANS) is one pathway implicated in the development and propagation of functional voice disorders, as the vagus nerve is one of the most important cranial nerves for speech prodution (Hisa et al., 1999).

Some studies indicate that the muscles of the larynx are sensitive to stress (Dietrich, Abbott, Gartner-Schmidt & Rosen, 2008; Seifert & Kollbrunner, 2005) showing that muscle tension dysphonia is a possible manifestation of stress and anxiety, often associated with an overactivity of the ANS (Demmink-Geertman & Dejonckere, 2008; Koufman & Blalock, 1991).

Individuals with voice disorders often refer symptoms that may be signs of dysfunction in the ANS. Voice disorders often increase frustration which may lead to the adoption of adaptive communication strategies. This event is believed to be a stress trigger. Stress is related to an increase in sympathetic activity and the number of symptoms associated with ANS dysfunction. To verify this relationship, assessment of ANS dysfunctions can be measured by a questionnaire composed of the main symptoms of ANS dysfunction, called The Questionnaire of Autonomic Dysfunction (QAD) (Demmink-Geertman & Dejonckere, 2008; Paes, Zambon & Behlau, 2014; Park & Behlau, 2011) and heart rate variability (HRV) (DeTurk & Cahalin, 2007; Vanderlei et al., 2009; Zuttin et al., 2008).

The use of the QAD can provide relevant information that favors the care of the dysphonic patient, since it opens the possibility for a therapeutic approach (concerning speech-language pathology, physiotherapy, and osteopathy) based on autonomic signs and symptoms that have direct relation with voice, as well as constant reassessments to verify the evolution with therapy (Demmink-Geertman & Dejonckere, 2008).

The parasympathetic activity induces a lower heart rate (HR) (e.g., during sleep), while sympathetic activity leads to an increase in HR (e.g., during exercise). The two circuits are constantly interrelating and this interaction is reflected in HRV. The HRV, consequently, provides a measure to express the activity of ANS, and may therefore provide a measure of stress (Benichou et al., 2018).

The HRV is a methodological tool that has been shown to be of great importance in the analysis of cardiac function and consequently of the ANS (Rajendra, Kannathal, Lim & Suri, 2006). It is obtained through electrocardiographic complexes and has the advantage of allowing a non-invasive evaluation of the autonomic function, as well as being a simple and easy to apply method (DeTurk & Cahalin, 2007; Vanderlei et al., 2009).

Through HRV it is possible to verify if the individual is adapted to respond to the most varied physiological and environmental stimuli (Rajendra, Kannathal, Lim & Suri, 2006). Therefore, an individual who presents greater variability, represents a healthier and more adapted individual and, in autonomic terms, there is a greater index of parasympathetic activity. On the other hand, low variability is an indicator of decreased vagal action and, consequently, a prognosis of health impairments (Cambri, Fronchetti, De-Oliveira & Gevaerd, 2008; Reis et al., 2010).

The HRV can be evaluated by time-domain (standard deviation of RR intervals (SDNN), percentage of adjacent NN intervals differing by more than 50 milliseconds (pNN50), square root of the mean squared difference of successive RR intervals (RMSSD)), frequency-domain (Very Low Frequency (VLF), Low Frequency (LF), High Frequency (HF), and LF/HF ratio) and non-linear indices (Cambri, Fronchetti, De-Oliveira and Gevaerd, 2008; Force, 1996). It can also be based on either short-term (e.g., 5 to 20 minutes) or long-term (e.g., 24 hours) analysis (Force, 1996).

The RMSSD and pNN50 are associated with high–frequency power and hence parasympathetic activity, whereas SDNN is correlated with low–frequency power (Otzenberger et al, 1998). In the spectral domain, one can analyze LF (0.05–0.15 hertz (Hz)), an index of both sympathetic and parasympathetic activity, and HF (0.15–0.4 Hz), representing the most efferent vagal (parasympathetic) activity to the sinus node. Very low frequency (0.003 – 0.04 Hz) partially reflects thermoregulatory mechanisms, fluctuation in activity of the renin– angiotensin system, and the function of peripheral chemoreceptors. The LF/HF ratio, i.e., the sympathovagal balance, can also be calculated (Benichou et al., 2018; Pomeranz et al., 1985).

In a previous review by the authors Cardoso, Lumini-Oliveira & Meneses (2019b), the ANS function was related to voice/dysphonia, since the individuals with dysphonia tend to show more ANS dysfunction. However, as far as the authors know, until now there is no study assessing ANS dysfunction through HRV and the QAD.

The objective of this investigation was to verify if there were differences in autonomic nervous system function and voice between teachers with and without voice complaints.

Materials and methods

Ethics statement

Initially the project protocol was submitted to the approval of the Ethics Committee of the UFP's University Hospital. During the first face-to-face contact with each participant, signed informed consent was obtained following the World Medical Association Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects), ensuring the anonymity and confidentiality of the data and that it would not be used for purposes other than this research. Participants were also informed that, if they wished, they could cease their participation in the study at any time without any consequences for themselves.

Sample selection

After obtaining the necessary authorizations to carry out the study in the UFP's University Hospital, the directors of the school groups of São Pedro da Cova and Rio Tinto were contacted by telephone to inform them about the nature, objectives, procedures and period of the study.

Subsequently, an email was sent to those directors with a cover letter and information about the study and to all teachers to recruit volunteers. Teachers who were on leave or had retired were excluded. After each teacher confirmed his/her participation via email, the day of the assessment in the Physical Medicine and Rehabilitation Service of the UFP's University Hospital was scheduled.

After the data collection period, a new email was sent to thank the interest of the teachers and their participation in the study. The final results of the study were also disclosed to teachers this way. The collected data was archived separately and, following the Ethics Committee instruction will be deleted when no longer serves for any research purpose.

Subjects

The convenience sample consisted of 24 teachers of both genders, between 27 and 60 years of age who signed an informed consent form. To standardize the sample regarding the vocal load, only participants who were teaching full-time were included (Anhaia et al., 2014).

The exclusion criteria were: to have hearing loss (Anhaia et al., 2014); to have undergone voice therapy or lessons for voice enhancement in the last six months (Anhaia et al., 2014); to have neurological diseases; to have been under pharmacological treatment for the last purpose; to have history of oncological pathology; to have dermatological lesions; to be tracheostomized or laryngectomized; to have extensive scar of any origin (surgery, radiotherapy, trauma) in the anterior region of the cervical and soft tissues surrounding the larynx; took medication for a heart condition or having consumed in the previous 24 hours substances that alter the cardiac or ANS (Angsuwarangsee & Morrison, 2002).

Participants were divided into two groups: without voice complaints (WVCG) and voice with complaints (VCG), based on the completion of a Sociodemographic and Clinical Questionnaire.

Experimental procedure

Participants completed a Sociodemographic and Clinical Questionnaire, to characterize the sample and identify possible exclusion criteria. The Sociodemographic and Clinical Questionnaire included: personal data (10 items), vocal habits (7 items), personal habits (5 items) and clinical background (2 items). The data collection was done in a room of the Physical Medicine and Rehabilitation Service of the UFP's University Hospital, in a calm environment, illuminated with soft white light and at a temperature between 20ºC and 23ºC. All the assessments were done within three months and took place in the afternoon, between 15:00 and 19:00 hours, to standardize their schedules.

After completing the Sociodemographic and Clinical Questionnaire, the subjects were divided into two groups designated by WVCG (n = 11) and VCG (n = 13). Initially, each individual was evaluated for their anthropometric composition, using a stadiometer (Seca® Medical Scales and Measuring Systems®, UK) to record their height and a scale (Seca® Medical Scales and Measuring Systems®, UK) to measure their weight.

The following evaluation parameters were collected by an experienced physiotherapist investigator, using a blinded approach and trained for the purpose. The average time to assess each participant was 60 minutes.

Voice assessment

The voice assessments were performed in an acoustically isolated room in the hospital, respecting the maximum threshold of 45dB ambient noise that was measured by the application of an Android smartphone, Sound Meter 3.5.0 (Na et al., 2014; Remacle & Eckel, 2010, p.12).

The participants produced the sustained vowel /a/. They were asked to stand with their backs straight, and with their head forming perpendicular to the line of the shoulders. This allowed better control under the respiratory system, better postural control, approximation to the habitual use of the voice and defined aerodynamic characteristics ideal for voice production (Behlau, 2001, p.139-147; Carneiro & Teles, 2012; Teixeira & Behlau, 2015).

The microphone was held by the participant´s hand, positioned at an angle of 90º and 20 cm away from the mouth (Behlau, 2001, p.139-147; Camargo & Madureira, 2009; Choi, Lee, Sprecher & Jiang, 2012; Uloza et al., 2011).

The vowel / a / was recorded in the habitual pitch and loudness. The vowel was sustained as long as participants were able – the task was then repeated three times (Carneiro & Teles, 2012; Watts et al., 2015). The recording of sustained vowels is very useful since it allows the sound to be analyzed without alterations derived from the articulation of the words, thus remaining in its most stable and clear form.

The vowel / a / was chosen because when acoustic analysis of vowels is performed, it tends to be the most affected among all vowels (Guimarães, 2007) and, as described by Behlau (2001), is the best vowel for verifying variations in frequency and intensity.

The maximum phonation time, an aerodynamic variable that indicates the voice's efficiency, was also assessed. This evaluation consisted in measuring, in seconds, the maximum phonation time of the vowel /a/ during exhalation. The assessment was repeated three times and the average was considered (Marszałek et al., 2012; Zielińska-Bliźniewska et al., 2013).

The acquisition and analysis of the acoustic signal was done with the opensource software PRAAT version 6.0.35 with a single channel, 16 bits resolution and a sampling rate of 44,100

Hz (Choi, Lee, Sprecher & Jiang, 2012; Smits et al., 2005; Teixeira & Behlau, 2015). The recording was done with the dynamic microphone Shure SM58, through the digital interface Behringer FCA 1616 connected to the HP Pavilion beatsaudio computer (Vogel & Morgan, 2009).

The studied variables for acoustic analysis were: fundamental frequency (F_0), standard deviation fundamental frequency (F_0SD), Jitter, Shimmer and Harmonic-to-Noise Ratio (HNR) (Carneiro & Teles, 2012; Cho, Yin, Park, & Park, 2011; Halawa, Freire, Muñoz & Pérez, 2014; Teixeira & Behlau, 2015; Zielińska-Bliźniewska et al., 2013). These variables were chosen because they provide information on vocal signal modifications that reflect physiological changes in the vocal folds (Carneiro & Teles, 2012). The F_0 was chosen because it is "the natural result of vocal fold length" and its aerodynamic characteristics in the interaction with subglottic pressure (Behlau, 2001, p. 139-147). The Jitter indicates "the variability of F_0 in the short term by measuring the differences between neighboring glottic cycles" (Behlau, 2001, p. 139-147). The Shimmer indicates "the variability of the amplitude of the sound wave in the short term" (Behlau, 2001, p. 139-147). As for HNR, it is an indicator capable of expressing the "vocal fold signal contrast with the irregular signal of the folds and vocal tract, offering an index that relates the harmonic component versus the noise component of the acoustic wave" (Behlau, 2001, p. 139-147). The auditory-perceptual analysis of the voice was performed by three experienced voice therapists (over five years of experience) who listened to the voice recordings in a blind and random manner (Fachinatto et al., 2015; Teixeira & Behlau, 2015). The three clinicians were asked to listen carefully to all the voice samples successively. Each voice sample was played, and the clinicians were asked to complete perceptual evaluation of the subjects' vocal quality on the Grade, Roughness, Breathiness, Astheny, Strain, Harshness (GRBASH) subscales using a four-point scale: 0 = normal, 1 = mild deviance, 2 = moderate deviance, and 3 = severe deviance. Afterwards the mean values of each subscale of GRBASH was calculated based on the three clinicians' perceptual evaluation (Cho, Yin, Park, & Park, 2011; Santos, 2013; Zielińska-Bliźniewska et al., 2013). In order to adapt the GRBAS, Nemr and Lehn (2010) included the term harshness -H to the original scale, giving rise to the GRBASH scale, with the aim of adapting the perceptive assessment of voice to the voices concomitant to a partial laryngectomy, with harshness being a perceptual parameter evident in these cases. The GRBASH scale maintains the remaining parameters originally proposed by the GRBAS scale.

Autonomic nervous system

Both groups were requested to fill in a QAD, which is a list of 46 neurovegetative symptoms, with “yes” or “no” response options; 22 are related to ANS but without direct relation to voice, 16 are related to ANS and voice, 6 are not-relevant, that is, without relation with neurovegetative or voice aspects, and 2 are reliability questions, in order to evaluate the participant’s consistence in answering the questions (Demmink-Geertman & Dejonckere, 2008; Paes, Zambon & Behlau, 2014; Park & Behlau, 2011). Permission for the use of the scale was performed to both authors of the original scale (Demmink-Geertman & Dejonckere, 2008), as well as for the authors of the translation and validation for Portuguese (Park & Behlau, 2011).

To assess HRV the participants were kept resting for 20 minutes on a massage table (Posturarte® Olympic), in supine, without inclination; during that period their breathing was controlled by a digital metronome - Android smartphone application (Metronome Beats 4.5.0) - to maintain a 15 cycles per minute (2 : 2) (Pomeranz et al., 1985). The last 5 minutes of the 20 minutes were utilized for the calculation of HRV variables. For the analysis of the intervals between the R waves, a Polar RS-800 heart rate monitor, which has been shown to be reliable and equivalent to the electrocardiogram in the evaluation of R-R intervals (Tröger et al., 2003), was placed in each participant around the upper trunk with the receptor slightly below the xiphoid appendix, placing a small amount of ultrasound gel between it and the skin to ensure better conduction. The data obtained by Polar was further processed for HRV analysis with the Kubios software (Vanderlei et al., 2009; Kleiger, Stein & Bigger, 2005). Variable values were collected in normalized units. In order to ensure that HRV analysis was as accurate and reliable as possible, artifacts were removed prior to the use of average filtering method in the Kubios HRV software (Vanderlei et al., 2009).

Statistical analyses

The data was analyzed with IBM SPSS Statistics 25. The Shapiro-Wilks test was used for assessment of normality and the Levene´s test for the homogeneity of variance. As both normality and variance homogeneity of variances were secured, parametric tests were used. The independent samples Student´s t-test was applied to compare both groups for HRV and acoustic analysis. Fisher's exact test was applied for nominative variables (auditory-perceptual and QAD). The Intraclass Correlation Coefficients was applied to evaluate the inter-rater reliability between the three raters of auditory-perceptual analysis of voice through GRBASH scale. A p value equal or lower than 0.05 was considered significant.

Results

The biometric characteristics of the sample variables are summarized in Table 1, for both groups. No difference was found between both study groups considering age, weight, height, and body mass index.

Table 1 - *Comparison between the groups in terms of biometric characteristics.*

Variables	Without voice complaints group	Voice complaints group	*p* between groups
n	11	13	
Gender (F)	8	10	
Age (years)	37,09 ± 2,13	43,53 ± 2,73	0,077
Weight (kg)	66,81 ± 2,79	69,46 ± 4,33	0,614
Height (cm)	167,18 ± 1,99	163,46 ± 2,30	0,236
Body mass index (kg/m^2)	23,81 ± 0,66	25,87 ± 1,32	0,181

There were no statistically significant differences between the two groups in any of the acoustic measures (Table 2). However, when maximum phonation time (MPT) was compared, it was found that the WVCG presented higher values (16,93 ± 3,97s) than the VCG (13,92 ± 4,28s).

In the auditory-perceptual analysis statistically significant differences between the groups in GRBASH subscales Grade (p=0,001) and Roughness (p=0,011) were found (Table 2). Reliability analysis was carried out on the three raters of auditory-perceptual analysis of voice through the GRBASH scale. The Intraclass Correlation Coefficients was superior than 0,92 in all GRBASH subscales.

Table 2 – *Differences between the groups in aerodynamic, acoustic and auditory-perceptual analysis of voice.*

		Without voice complaints group		Voice complaints group		*p*
	Variables	n	Mean ±SD	n	Mean ±SD	
Aerodynamic assessment	MPT (s)	11	16,93 ± 3,97	13	13,92 ± 4,28	0,088
Acoustic assessment	F_0 (Hz)	11	180,67 ± 51,74	13	177,96 ± 36,17	0,882
	F_0SD (Hz)	11	1,62 ± 0,33	13	1,41 ± 0,44	0,200
	Jitter (%)	11	0,33 ± 0,07	13	0,42 ± 0,21	0,168
	Shimmer (%)	11	2,89 ± 0,84	13	3,60 ± 1,89	0,121
	HNR (dB)	11	22,26 ± 1,66	13	21,48 ± 2,55	0,377
Auditory-perceptual assessment	Grade	11	0,09 ± 0,28	13	1,15 ± 0,53	0,001*
	Roughness	11	0,45 ± 0,49	13	1,38 ± 0,62	0,011*
	Breathiness	11	0,09 ± 0,28	13	0,31 ± 0,46	0,193
	Astheny	11	0,09 ± 0,28	13	0,31 ± 0,46	0,193
	Strain	11	0,09 ± 0,28	13	0,38 ± 0,48	0,098
	Harshness	11	0,09 ± 0,28	13	0,31 ± 0,46	0,193

* Significant values (p≤0.05)
Abbreviations: F_0, fundamental frequency; F_0SD, fundamental frequency standard deviation; HNR, Harmonic-to-Noise Ratio; MPT, maximum phonation time; SD, standard deviation.

Regarding the HRV, RMSSD and pNN50 were significantly lower in the VCG than in the WVCG (p=0,023 and p=0,032, respectively). In the SDNN, results did not show any significant differences. However, there was a tendency for decreased SDNN in the VCG compared with the WVCG (p=0,054). In the frequency-domain parameters, the results showed no significant differences (Table 3).

Table 3 – *Differences between the groups in heart rate variability.*

	Without voice complaints group		Voice complaints group		*p*
Variables	n	Mean ±SD	n	Mean ±SD	
SDNN (ms)	11	37,59 ± 5,50	13	33,03 ± 5,43	0,054
RMSSD (ms)	11	44,18 ± 6,81	13	38,09 ± 5,36	0,023*
pNN50 (%)	11	35,63 ± 9,63	13	25,38 ± 11,86	0,032*
VLF (ms^2)	11	32,50± 2,53	13	30,49 ± 4,06	0,170
LF (nu)	11	34,51 ± 2,34	13	31,90 ± 3,93	0,067
HF (nu)	11	58,38 ± 8,40	13	52,28 ± 10,29	0,164
LF/HF	11	0,88 ± 0,52	13	0,87 ± 0,60	0,946

* Significant values (p≤0.05)
Abbreviations: HF, High Frequency; HRV, heart rate variability; LF, Low Frequency; pNN50, percentage of adjacent NN intervals differing by more than 50 milliseconds; RMSSD, square root of the mean squared difference of successive RR intervals; SDNN, standard deviation of RR intervals; SD, standard deviation; VLF, Very Low Frequency.

In the QAD statistically significant differences between the groups were found in fluctuating nose obstruction (p=0,011), neck pain (while or after speaking) (p=0,017) and in fatigability when speaking (p=0,004) (Table 4).

Table 4 – *Differences between the groups in The Questionnaire of Autonomic Dysfunction.*

Signs and symptoms	Without voice complaints group n	Voice complaints group n	*p*
Symptoms not related to voice			
Cold hands	1	1	0,717
Cold feet	3	4	0,605
Excessive transpiration	2	2	0,637
Excessive sensitiveness to coldness	1	1	0,717
Excessive sensitiveness to heat	2	1	0,435
Diarrhea	1	1	0,717
Constipation	2	2	0,637
Puffiness	1	1	0,717
Aerophagia	2	1	0,435
Nausea	2	1	0,435
Eructations	1	1	0,717
Hiccups	1	2	0,565
Heartburn	1	2	0,565
Dizziness	2	1	0,435
Tinnitus	2	2	0,637
Dancing spots before the eyes	1	1	0,717
Difficult concentration	5	4	0,375
Disturbed sleep	4	4	0,556
Lack of energy	5	6	0,647
Palpitations	4	2	0,239
Nail biting	3	3	0,590
Sensation of extreme tiredness	4	7	0,329
Symptoms related to voice			
Need of constantly swallowing	2	6	0,156
Sore throat	1	6	0,059
Hyperventilation	3	4	0,605
Frequent sneezing	2	5	0,264
Fluctuating nose obstruction	1	8	0,011*
Difficulty breathing through the nose at rest	2	6	0,156
Habitual mouth breathing at rest	2	7	0,084
Feelings of tension in the head while speaking	2	6	0,156
Constant need to yawn	1	4	0,215
Gnashing of teeth	2	2	0,637
Temporomandibular pain or discomfort	1	6	0,059
Neck pain (while or after speaking)	2	9	0,017*
Chest discomfort (while or after speaking)	0	4	0,067
Fatigability when speaking	1	9	0,004*

Frequent throat clearing	1	4	0,215
Social (communicative) handicape	0	2	0,283
Nonrelevant issues			
Lack of apetite	1	2	0,565
Renal problems	0	1	0,542
Specific allergy	3	3	0,590
Hearing loss	1	2	0,565
Headache	4	6	0,437
Chronic illness	3	3	0,590
Reliability			
Feelings of mental stress	2	4	0,410
Feelings of psychictension	3	3	0,590
* Significant values ($p \leq 0.05$)			

Discussion

Concerning the biometric characteristics of the sample, in this study, the female gender was the most prevalent, fact that is corroborated by other related investigations (Brasolotto & Fabiano, 2000; Troni et al., 2006; Vedovato & Monteiro, 2008). Women also present a higher mean of occurrence of autonomic dysfunction symptoms in QAD and functional dysphonia which may be a manifestation of stress and anxiety, with hyperactivity of ANS (Cielo, Ribeiro & Hoffmann, 2015; Demmink-Geertman & Dejonckere, 2002, 2008; Paes, Zambon & Behlau, 2014). It should be stressed that there were no statistically significant differences between the groups in biometric characteristics of the sample.

In line with previous papers (Ferreira et al., 2003; Menoncin et al., 2010; Viola et al., 2000; Troni et al., 2006), in the auditory-perceptual analysis of the voice, it was verified that the VCG presented statistically significant higher values in GRBASH subscales Grade and Roughness. Regarding the acoustic analysis of voice, there were no statistically significant differences between groups. Muscle tension dysphonia is characterized by a hoarse voice with an admixture of roughness, with a certain strain, created with tension, which is illustrated by the results obtained in the analyzed group using the GRBASH scale. In this way, Grade and Roughness presented statistically significant higher values. Although it was not significant, the strain showed higher values in the group with dysphonia than in the group without dysphonia. Strain also presented higher values compared with the other 3 GRBASH´s subscales. In fact, there were no significant differences between groups in acoustic assessments, but there were higher values of Jitter and Shimmer, and lower values of Harmonic-to-Noise Ratio, in the group with voice complaints.

However, the differences observed may be due to the ratters, although both methods are considered important for voice analysis (Oates, 2009). The fact that voice quality is perceptual in nature, perceptual characteristics of voice have greater intuitive meaning and shared reality among listeners that many instrumental measures cannot do. Other factors that may explain the results include limitations in the validity and reliability of instrumental methods and lack of agreement as to the sensitive and specific instrumental measures of voice quality (Oates, 2009).

However, it was verified that in the maximum phonation time, the values obtained in this study were below the expected level in the VCG, because according to Behlau and Pontes (1995), values below 14 seconds for women are indicative of non-normality with high significance, suggesting that these participants need air refills in the most frequently linked speech, directly influencing the pneumofonoarticulatory coordination, and may generate cervical tensions.

There are several methods for assessing ANS activity, nonetheless in this study HRV was chosen because it was considered the best non-invasive marker in several studies (Copie et al., 1996; Farrell et al., 1991; Hartikainen et al., 1996; Sakakibara & Hayano, 1996; Thayer et al., 2012).

However, it is important to note that there are no standard values for HRV assessment, where any sinusoidal oscillation within the frequency of 0.15 and 0.4 Hz (HF), 0.05 and 0.15 Hz (LF) and less than 0.04 (VLF) is considered normal (Benichou et al., 2018; Pomeranz et al., 1985).

In this study, a protocol was used to control breathing at a rate of 15 cycles per minute provided by a digital metronome (Pomeranz et al., 1985; Sakakibara & Hayano, 1996; Patra & Telles, 2010). However, although it is a frequently used tool for controlling respiratory cycles and inspiratory / expiratory ratio, preventing the fusion of HF and LF components, thus making interpretation of data easier, it can also be a cause of stress related to performance (Malliani, 2005).

Relating the activation in the limbic system with the autonomic mechanism, it is observed that the increase of stress is related to the increase of sympathetic activity and decrease of HRV (Schubert et al., 2009). That is, if the increase in stress is related to the increase in sympathetic activity of the ANS, the inverse reasoning leads to the understanding that stress reduction is related to the parasympathetic activity of the ANS (Schubert et al., 2009).

Concerning time-domain parameters of HRV, in this investigation it was found that RMSSD and pNN50 were significantly lower in the VCG than in the WVCG. Corroborating these results, some papers refer that pNN50 (Taelman et al., 2011; Tharion, Parthasarathy & Neelakantan, 2009) and RMSSD (Li et al., 2009; Taelman et al., 2011; Tharion, Parthasarathy & Neelakantan, 2009) are both decreased during stress.

Regarding the SDNN, the results of the present investigation showed no significant differences. However, there was a tendency for decreased SDNN in the VCG compared with the WVCG. In the studies of Taelman et al., (2011) and Tharion, Parthasarathy and Neelakantan (2009), a decreased SDNN with stress was observed with a high level of significance. In another paper, Schubert et al. (2009) reported a discordant increase of SDNN in stress, which the authors suggest to be the result of a slow respiration rate and a relative reduction in ventilation, caused by the speech task used to induce stress in their study.

In the frequency-domain parameters, a tendency for higher values in the WVCG was observed, but without any statistical significance. Regarding LF, some papers showed similar results with the LF being decreased during stress (Taelman et al., 2011; Tharion, Parthasarathy & Neelakantan, 2009), but others (Traina, Cataldo, Galullo & Russo, 2011; Visnovcova et al., 2014), showed the opposite tendency. Concerning HF, a consensus was found among the different studies analyzed (Li et al., 2009; Taelman et al., 2011; Tharion, Parthasarathy & Neelakantan, 2009; Traina, Cataldo, Galullo & Russo, 2011; Visnovcova et al., 2014) as this measure was consistently found to be decreased during acute mental stress. Regarding LF/HF ratio, two papers (Schubert et al., 2009; Traina, Cataldo, Galullo & Russo, 2011) showed that it increases during stress, while other (Tharion, Parthasarathy & Neelakantan, 2009) reported an opposite trend, which, however, was not supported by significant statistical differences.

In their review, ChuDuc, NguyenPhan and NguyenViet (2013), verified that HRV variation techniques and indices were crucial in treating not just cardiovascular diseases, but unrelated conditions such as Alzheimer, renal failure, leukemia, epilepsy, chronic migraines, and obstructive sleep apnea. In another review (Paniccia et al., 2017), the authors found that in clinical populations of either depression or anxiety, HRV was lower compared to controls.

Regarding the QAD, the VCG showed statistically significant higher values in fluctuating nose obstruction, neck pain (while or after speaking) and fatigability when speaking. Although not statistically significant, overall, the other voice-related symptoms were higher in the VCG.

These results seems to suggest that teachers with voice complaints have more autonomic dysfunction than the ones without voice complaints. Perhaps this occurs due to the fact that teachers with voice disorders have to change their communication strategy in the classroom, which may affect the stress and, as consequence, the number of symptoms.

Corroborating the results of this study, Demmink-Geertman and Dejonckere (2002) found that the nonorganic voice disorder group had statistically significant higher values in fluctuating nose obstruction, neck pain while or after speaking and in fatigability when speaking, when compared to the control group. The researchers also concluded that female patients in all age categories with a nonorganic habitual dysphonia report significantly more autonomic symptoms and complaints than healthy controls. They also affirmed that the voice disorder seems to occur within a broader scale of complaints and symptoms, and the frustration elicited by the voice impairment may reinforce the stress.

Regarding the analysis of neurovegetative signs and symptoms that have a direct relationship with voice and in line with the results of the present study, Park and Behlau (2011) reported that individuals with behavioral dysphonia presented significant higher values in eight symptoms when compared with the group control: frequent throat clearing ($p<0.001$), need of constant swallowing ($p<0.001$), fatigability when speaking ($p<0.011$), sore throat ($p<0.011$), constant need to yawn ($p=0.002$), chest discomfort ($p=0.001$), neck pain (while or after speaking) ($p=0.013$), and feelings of tension in the head while speaking ($p=0.017$).

Similar results were found in a study by Paes, Zambon and Behlau (2014) where the sample was composed of teachers. The authors concluded that the group with voice complaints showed a higher number of neurovegetative symptoms, particularly on issues related to voice, than the group without complaints. When compared to the group without voice complaints, the most predominant voice related symptoms in the group with voice complaints were: fatigability when speaking ($p<0,001$), need of constantly swallowing ($p=0,014$), sore throat ($p=0,001$), neck pain while speaking ($p=0,003$), temporomandibular pain or discomfort ($p=0,017$), constant need to yawn ($p=0,023$), frequent throat clearing ($p=0,010$) and tension in the head while speaking ($p=0,019$).

In the same line, Cielo, Ribeiro and Hoffmann (2015), verified that women and individuals with voice complaints showed more signs and symptoms of autonomic dysfunction.

Analyzing the symptoms not related to voice of the QAD, significant differences between the groups were not found in the present study. However, Park and Behlau (2011) and Demmink-Geertman and Dejonckere (2008) verified that the dysphonic participants had a higher occurrence of some signs and symptoms not directly related with voice than the non-dysphonic individuals.

According to Park and Behlau (2011), dysphonic individuals attach greater importance to negative stressful events than non-dysphonic individuals. In addition, stress has numerous physical consequences as the autonomic nervous system can alter oral secretions and vocal folds, heart rate and gastric acid production (Demmink-Geertman & Dejonckere, (2008). Consequently, stress prevention and stress management programs should be widely available for teachers.

Regarding the possible connections between the ANS and vocal cues, Demmink-Geertman and Dejonckere (2008) confirmed that muscle tension dysphonia mainly occurs in a context of a disturbed balance of the ANS and patients undergoing functional voice therapy differ in their evolution from control subjects. However, the authors remain unable to directly answer the question of whether autonomic dysfunction should be considered causal, correlational, or consequential of voice dysfunctions.

In this way, we are unable to say if dysphonia is the result of autonomic dysfunction or a precipitating factor. It is important to underline that longitudinal studies should be developed to clarify the relationship between the variables.

Study Limitations and Suggestions

This research has the limitation of having a small sample and a dissimilar number of men and women (in both groups).

Despite these limitations, this investigation is, as far as the authors are aware, the first to assess evidence of the associations between ANS dysfunction and voice complaints using HRV, the QAD, aerodynamic, acoustic and auditory-perceptual analysis of voice assessments in the same study, which may provide useful insight for further studies.

We suggest further research with similar assessment methods in order to better compare the studies and systematize knowledge about the relationship between ANS and voice complaints or dysphonia as well as with larger samples sizes.

We suggest studies comparing healthy individuals with participants with voice disorders; samples with professionals who are frequently affected with voice disorders, like teachers and singers as well as samples with more males and samples with different age groups. It would be clinically relevant to assess whether undergoing a stress prevention/management program has an impact on objective voice indicators and not only on subjective stress indicators, as is usually the case.

Conclusion

Teachers with voice complaints present higher occurrence of neurovegetative symptoms such as fluctuating nose obstruction, neck pain while or after speaking and fatigability when speaking. The RMSSD and pNN50 values were significantly lower in the teachers with voice complaints than in the teachers without voice complaints. According to the results obtained, teachers with voice complaints seem to show greater autonomic nervous system dysregulation compared to teachers without voice complaints. In this way, it would be clinically relevant to assess if an autonomic nervous system dysregulation treatment program could reduce teachers' voice complaints.

References

Anhaia, T.C., Klahr, P.D.S., Ourique, A.A.B., Gadenz, C.D., Fernandes, R.A., Spagnol, P.E. & Cassol, M. (2014). Effects of two interventions in teachers with voice complaints. *Audiology-Communication Research*, 9(2), 186-193. doi: 10.1590/S2317-64312014000200014

Angsuwarangsee, T., & Morrison, M. (2002). Extrinsic laryngeal muscular tension in patients with voice disorders. *Journal of Voice*, 16(3), 333-343. doi: 10.1016/S0892-1997(02)00105-4

Behlau, M. (2001). Voz: o livro do especialista. vol. 1. Rio de Janeiro: Revinter, p. 139-147.

Benichou, T., Pereira, B., Mermillod, M., Tauveron, I., Pfabigan, D., Maqdasy, S., & Dutheil, F. (2018). Heart rate variability in type 2 diabetes mellitus: A systematic review and meta–analysis. *PLoS One*, *13*(4), e0195166. doi: 10.1371/journal.pone.0195166

Brasolotto AG, Fabiano SRR. (2000). Uso profissional da voz pelo professor–análise acústica. *Revista da Sociedade Brasileira de Fonoaudiologia*, *6*, 6-11.

Camargo, Z. A., & Madureira, S. (2009). Dimensões perceptivas das alterações de qualidade vocal e suas correlações aos planos da acústica e da fisiologia. *DELTA: Documentação e Estudos em Linguística Teórica e Aplicada*, *25*(2), 285-317. doi: 10.1590/S0102-44502009000200004

Cambri, L. T., Fronchetti, L., De-Oliveira, F. R. & Gevaerd, M. S. (2008). Variabilidade da frequência cardíaca e controle metabólico. *Arquivos Sanny de pesquisa em saúde*, 1(1), 72-82.

Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019b, in press). Associations Between Autonomic Nervous System Function, Voice, and Dysphonia: A Systematic Review. *Journal of Voice*. In press. doi: 10.1016/j.jvoice.2019.07.022

Carneiro, P.R. & Teles, L.C.D.S. (2012). Influência de alterações posturais, acompanhadas por fotogrametria computadorizada, na produção da voz. *Fisioterapia Movimento*, 25(1):13-20. doi:10.1590/S0103-51502012000100002

Cho, S. W., Yin, C. S., Park, Y. B., & Park, Y. J. (2011). Differences in self-rated, perceived, and acoustic voice qualities between high-and low-fatigue groups. *Journal of Voice*, *25*(5), 544-552. doi: 10.1016/j.jvoice.2010.07.006

Choi, S. H., Lee, J., Sprecher, A. J., & Jiang, J. J. (2012). The effect of segment selection on acoustic analysis. *Journal of Voice*, *26*(1), 1-7. doi: 10.1016/j.jvoice.2010.10.009

ChuDuc, H., NguyenPhan, K., & NguyenViet, D. (2013). A review of heart rate variability and its applications. *APCBEE procedia*, *7*, 80-85.

Cielo, C. A., Ribeiro, V. V., & Hoffmann, C. F. (2015). Sinais e sintomas de disfunção autônoma em professores e sua relação com as queixas vocais e as variáveis ocupacionais. *Distúrbios da Comunicação*, *27*(3).

Copie, X., Heuzey, J. Y. L., Iliou, M. C., Khouri, R., Lavergne, T., Pousset, F., & Guize, L. (1996). Correlation between time-domain measures of heart rate variability and scatterplots in postinfarction patients. *Pacing and Clinical Electrophysiology*, *19*(3), 342-347. doi: 10.1111/j.1540-8159.1996.tb03336

Demmink-Geertman, L., & Dejonckere, P. H. (2002). Nonorganic habitual dysphonia and autonomic dysfunction. *Journal of Voice*, 16(4), 549-559. doi: 10.1016/S0892-1997(02)00130-3

Demmink-Geertman, L., & Dejonckere, P. H. (2008). Neurovegetative symptoms and complaints before and after voice therapy for nonorganic habitual dysphonia. *Journal of Voice*, *22*(3), 315-325. doi: 10.1016/j.jvoice.2006.10.011

Deturk, W. E., & Cahalin, L. P. (2007). *Fisioterapia Cardiorespiratória: baseada em evidências*. Artmed Editora.

Dietrich, M., Abbott, K. V., Gartner-Schmidt, J., & Rosen, C. A. (2008). The frequency of perceived stress, anxiety, and depression in patients with common pathologies affecting voice. *Journal of Voice*, 22(4), 472-488. doi: 10.1016/j.jvoice.2006.08.007

Fachinatto, A. P. A., de Campos Duprat, A., e Silva, M. A., Bracher, E. S. B., de Carvalho Benedicto, C., Luz, V. B. C., & Fonseca, B. S. G. (2015). Effect of spinal manipulative therapy on the singing voice. *Journal of Voice*, *29*(5), 645-e33. doi: 10.1016/j.jvoice.2014.10.005

Farrell, T. G., Bashir, Y., Cripps, T., Malik, M., Poloniecki, J., Bennett, E. D., Ward D. E. & Camm, A. J. (1991). Risk stratification for arrhythmic events in postinfarction patients based on heart rate variability, ambulatory electrocardiographic variables and the signal-averaged electrocardiogram. *Journal of the American College of Cardiology*, *18*(3), 687-697.

Ferreira, L. P., Gianini, S. P., Figueira, S., Silva, E. E., Karmann, D. D. F., & de Souza, T. M. T. (2003). Condições de produção vocal de professores da prefeitura do município de São Paulo. *Distúrbios da Comunicação, 14*(2).

Force, T. (1996). Standards of measurement, physiological interpretation and clinical use. Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Circulation*, *93*(5), 1043-1065.

Guimarães, I. (2007). A ciência e a arte da voz humana. Alcoitão, Escola Superior de Saúde do Alcoitão.

Halawa, W. E., Freire, A. R. F., Muñoz, I. V., & Pérez, S. S. (2014). Assessment of effectiveness of acoustic analysis of voice for monitoring the evolution of vocal nodules after vocal treatment. *European Archives of Oto-Rhino-Laryngology*, *271*(4), 749-756. doi: 10.1007/s00405-013-2685-8

Hartikainen, J. E., Malik, M., Staunton, A., Poloniecki, J., & Camm, A. J. (1996). Distinction between arrhythmic and nonarrhythmic death after acute myocardial infarction based on heart rate variability, signal-averaged electrocardiogram, ventricular arrhythmias and left ventricular ejection fraction. *Journal of the American College of Cardiology*, *28*(2), 296-304.

Hisa, Y., Bamba, H., Koike, S., Shogaki, K., Tadaki, N., & Uno, T. (1999). Neurotransmitters and neuromodulators involved in laryngeal innervation. *Annals of Otology, Rhinology & Laryngology*, 108(7), 3-14. doi: 10.1177/00034894991080S702

Kleiger, R. E., Stein, P. K., & Bigger Jr, J. T. (2005). Heart rate variability: measurement and clinical utility. *Annals of Noninvasive Electrocardiology*, *10*(1), 88-101. doi: 10.1111/j.1542-474X.2005.10101

Koufman, J. A., & Blalock, P. D. (1991). Functional voice disorders. *Otolaryngologic Clinics of North America*, 24(5), 1059.

Li, Z., Snieder, H., Su, S., Ding, X., Thayer, J. F., Treiber, F. A., & Wang, X. (2009). A longitudinal study in youth of heart rate variability at rest and in response to stress. *International Journal of Psychophysiology*, *73*(3), 212-217. doi: 10.1016/j.ijpsycho.2009.03.002

Malliani, A. (2005). Heart rate variability: from bench to bedside. *European journal of internal medicine*, *16*(1), 12-20. doi:10.1016/j.ejim.2004.06.016

Marszałek, S., Niebudek-Bogusz, E., Woźnicka, E., Malińska, J., Golusiński, W., & Śliwińska-Kowalska, M. (2012). Assessment of the influence of osteopathic myofascial techniques on normalization of the vocal tract functions in patients with occupational dysphonia. *International journal of occupational medicine and environmental health*, *25*(3), 225-235. DOI 10.2478/S13382-012-0041-7

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C. A., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia,* 14(4), 461-6. doi: 10.1590/S1809-48722010000400014

Na, Y., Joo, H. S., Yang, H., Kang, S., Hong, S. H., & Woo, J. (2014). Smartphone-based hearing screening in noisy environments. *Sensors*, 14(6), 10346-10360. doi:10.3390/s140610346

Nemr, K. & Lehn, C. (2010). Voz em Câncer de Cabeça e Pescoço. In: Fernandes, F.D.M., Mendes, B.C.A., Navas, A.L.P.G.P. (2ª Ed). Tratado de Fonoaudiologia. São Paulo, Editora Roca Ltda.: 787-802.

Oates, J. (2009). Auditory-perceptual evaluation of disordered voice quality. *Folia Phoniatrica et Logopaedica*, 61(1), 49-56. doi: 10.1159/000200768

Otzenberger, H., Gronfier, C., Simon, C., Charloux, A., Ehrhart, J., Piquard, F., & Brandenberger, G. (1998). Dynamic heart rate variability: a tool for exploring sympathovagal balance continuously during sleep in men. *American Journal of Physiology-Heart and Circulatory Physiology*, *275*(3), H946-H950.

Paes, C. F., Zambon, F. C., & Behlau, M. (2014). Signs and symptoms of the autonomic dysfunction in teachers. *Revista CEFAC, 16*(3), 957-966. doi: 10.1590/1982-021620141613

Park, K., & Behlau, M. (2011). Sinais e sintomas da disfunção autônoma em indivíduos disfônicos. *Jornal da sociedade brasileira de fonoaudiologia*, 23(2), 164-9. doi: 10.1590/S2179-64912011000200014

Patra, S., & Telles, S. (2010). Heart rate variability during sleep following the practice of cyclic meditation and supine rest. *Applied psychophysiology and biofeedback, 35*(2), 135-140. doi: 10.1007/s10484-009-9114-1

Paniccia, M., Paniccia, D., Thomas, S., Taha, T., & Reed, N. (2017). Clinical and non-clinical depression and anxiety in young people: a scoping review on heart rate variability. *Autonomic Neuroscience, 208,* 1-14. doi: 10.1016/j.autneu.2017.08.008

Pomeranz, B., Macaulay, R., Caudill, M. A., Kutz, I., Adam, D., Gordon, D., Kilborn, K. M., Barger, A. C., Shannon, D. C. & Cohen, R. J. (1985). Assessment of autonomic function in humans by heart rate spectral analysis. *American Journal of Physiology-Heart and Circulatory Physiology*, 248(1), H151-H153.

Rajendra, A. U., Kannathal, N., Lim, C. M. & Suri, J. S. (2006). Heart rate variability: a review. *Medical & Biological Engineering & Computing*, 44(12), 1031-51. doi: 10.1007/s11517-006-0119-0

Reis, M. S., Deus, A. P., Simões, R. P., Aniceto, I. A., Catai, A. M., & Borghi-Silva, A. (2010). Controle autonômico da frequência cardíaca de pacientes com doenças cardiorrespiratórias crônicas e indivíduos saudáveis em repouso e durante a manobra de acentuação da arritmia sinusal respiratória. *Brazilian Journal of Physical Therapy*, *14*(2), 106-13.

Remacle, M., & Eckel, H. E. (Eds.). (2010). *Surgery of larynx and trachea*. Berlin: Springer. p. 12.

Roy, N., Merrill, R. M., Thibeault, S., Gray, S. D., & Smith, E. M. (2004a). Voice disorders in teachers and the general population: effects on work performance, attendance, and future career choices. *Journal of Speech, Language, and Hearing Research*. 47:542-51.

Roy, N., Merrill, R. M., Thibeault, S., Parsa, R. A., Gray, S. D., & Smith, E. M. (2004b). Prevalence of voice disorders in teachers and the general population. *Journal of Speech, Language, and Hearing Research*. 47:281-93.

Sakakibara, M., & Hayano, J. (1996). Effect of slowed respiration on cardiac parasympathetic response to threat. *Psychosomatic Medicine*, *58*(1), 32-37.

Santos, M. E. D. (2013). *GRBASH–Scale for Evaluating the Hoarse Voice* (Master dissertation, [sn]). Universidade Fernando Pessoa.

Schubert, C., Lambertz, M., Nelesen, R. A., Bardwell, W., Choi, J. B., & Dimsdale, J. E. (2009). Effects of stress on heart rate complexity—a comparison between short-term and chronic stress. *Biological psychology*, *80*(3), 325-332. doi: 10.1016/j.biopsycho.2008.11.005

Seifert, E., & Kollbrunner, J. (2005). Stress and distress in non-organic voice disorders. *Swiss medical weekly*, 135(27/28), 387. doi: 2005/27/smw-10346

Smits, I., Ceuppens, P., & De Bodt, M. S. (2005). A comparative study of acoustic voice measurements by means of Dr. Speech and Computerized Speech Lab. *Journal of Voice*, 19(2), 187-196. doi: 10.1016/j.jvoice.2004.03.004

Souza, C. L. D., Carvalho, F. M., Araújo, T. M. D., Reis, E. J. F. B. D., Lima, V. M. C., & Porto, L. A. (2011). Fatores associados a patologias de pregas vocais em professores. *Revista de Saúde Pública*, *45*, 914-921. doi: 10.1590/S0034-89102011005000055

Taelman, J., Vandeput, S., Vlemincx, E., Spaepen, A., & Van Huffel, S. (2011). Instantaneous changes in heart rate regulation due to mental load in simulated office work. *European journal of applied physiology*, *111*(7), 1497-1505. doi: 10.1007/s00421-010-1776-0

Teixeira, L. C., & Behlau, M. (2015). Comparison between vocal function exercises and voice amplification. *Journal of Voice*, *29*(6), 718-726. doi: 10.1016/j.jvoice.2014.12.012

Tharion, E., Parthasarathy, S., & Neelakantan, N. (2009). Short-term heart rate variability measures in students during examinations. *The National Medical Journal of India*, *22*(2), 63-66.

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews*, *36*(2), 747-756. doi: 10.1016/j.neubiorev.2011.11.009

Traina, M., Cataldo, A., Galullo, F., & Russo, G. (2011). Effects of anxiety due to mental stress on heart rate variability in healthy subjects. *Minerva Psichiatrica*, 52(4):227-31.

Tröger, R. M., Rauh, R., Mahlke, C., Gotschalk, T. & Muck-Weymanm, M. (2003). Agreement of two diferente methods for measurement of heart rate variability. *Clinical Autonomic Research*, 13, 99-102.

Troni, C. R., Arakaki, F. N., Lima, F. S., Mott, L., Rodrigues, K. A., & Ferreira, L. P. (2006). Professores em contexto profissional e não profissional: análise objetiva e subjetiva dos aspectos da articulação e da postura. *Distúrbios da Comunicação*, *18*(2).

Uloza, V., Verikas, A., Bacauskiene, M., Gelzinis, A., Pribuisiene, R., Kaseta, M., & Saferis, V. (2011). Categorizing normal and pathological voices: automated and perceptual categorization. *Journal of Voice*, *25*(6), 700-708. doi: 10.1016/j.jvoice.2010.04.009

Vanderlei, L. C. M., Pastre, C. M., Hoshi, R. A., Carvalho, T. D. & Godoy, M. F. (2009). Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. *Revista Brasileira Circulação Cardiovascular*, 24(2), 205-217. doi: 10.1590/S0102-76382009000200018

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, 25(2), 202-207. doi: 10.1016/j.jvoice.2009.10.009

Vedovato, T. G., & Monteiro, M. I. (2008). Perfil sociodemográfico e condições de saúde e trabalho dos professores de nove escolas estaduais paulistas. *Revista da Escola de Enfermagem da USP*, *42*(2), 291-297. doi: 10.1590/S0080-62342008000200012

Viola, I. C., Ferreira, L. P., Sene, C. D., Villas Boas, D. C., & Souza, S. M. (2000). A voz do professor: levantamento das publicações brasileiras. *Revista da sociedade brasileira de fonoaudiologia*, *5*(7), 36-47.

Visnovcova, Z., Mestanik, M., Javorka, M., Mokra, D., Gala, M., Jurko, A., Calkovska, A. & Tonhajzerova, I. (2014). Complexity and time asymmetry of heart rate variability are altered in acute mental stress. *Physiological measurement*, *35*(7), 1319. doi: 10.1088/0967-3334/35/7/1319

Vogel, A. P., & Morgan, A. T. (2009). Factors affecting the quality of sound recording for speech and voice analysis. *International journal of speech-language pathology*, 11(6), 431-437. doi: 10.3109/17549500902822189

Watts, C. R., Diviney, S. S., Hamilton, A., Toles, L., Childs, L., & Mau, T. (2015). The effect of stretch-and-flow voice therapy on measures of vocal function and handicap. *Journal of Voice*, *29*(2), 191-199. doi: 10.1016/j.jvoice.2014.05.008

Zielińska-Bliźniewska, H., Pietkiewicz, P., Miłoński, J., Urbaniak, J., & Olszewski, J. (2013). Acoustic and capacity analysis of voice academic teachers with diagnosed hyperfunctional dysphonia by using DiagnoScope Specialist software. *Otolaryngologia Polska*, *67*(3), 144-148. doi: 10.1016/j.otpol.2013.02.001

Zuttin, R., Moreno, M., César, M., Martins, L., Catai, A. & Silva, E. (2008). Evaluation of autonomic heart rate modulation among sedentary young men, in sitting and supine postures. *Brazilian Journal of Physical Therapy*, *12*(1). doi: 10.1590/S1413-35552008000100003

Chapter 6

Paper 6 - Myofascial release effects in teachers' posture, muscle tension and voice quality

Abstract

Objective. Myofascial release (MFR) comprises a set of manual therapeutic techniques applied to many conditions, but specific evidence concerning its effects on body posture, muscle tension and voice has been lacking. Thus, the aim of this study was to verify the effects of MFR in teachers' posture, muscular tension and voice quality.

Study Design. Randomized controlled trial – crossover.

Methods. Twenty-four teachers, after completing a Sociodemographic and Clinical Questionnaire and providing written informed consent, were randomly distributed into two groups designated Group 1 (G1; n=12; received MFR first) and Group 2 (G2; n=12; belong to control group first). All participants received treatment and were into control group, since, after a 14-day period, procedures were switched between groups. Photogrammetry, muscle tension assessed through palpation, algometry, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice were performed before and after interventions.

Results. Regarding voice, statistically significant differences were found when intervention was applied to both groups for maximum phonation time (MPT) (G1 p=0,019; G2 p=0,004). The acoustic variables did not differ. Concerning the auditory-perceptual analysis of voice statistically significant differences were found when intervention was applied in both groups for Grade in G2 (p=0,046) and for Roughness in G1 (p=0,025). Regarding the photogrammetry assessment statistically significant differences were found when intervention was applied to both groups in many parameters while as control group they did not. Concerning the algometry and muscle tension assessed through palpation statistically significant differences were found when intervention was applied in all muscles.

Conclusions. Findings indicated that MFR seems to be an effective therapy in improving MPT, two subscales (Grade and Roughness) of the GRABASH scale, muscle tension assessed through palpation and algometry. Regarding photogrammetry, MFR had an immediately effect in improvement of the posture, especially related with head.

Key Words: Voice, posture, muscle tension, myofascial release, teachers.

Introduction

The prevalence of voice disorders among the general population is 6–15%. However, when teachers are considered, these values increase to 20–50%, reaching up to 80% (Roy et al., 2004; Simberg, Laine, Sala & Rönnemaa, 2000). Subjects using their voice as a professional tool are more prone to voice disorders, those which are induced by professional use are more likely to be chronic and may increase work absence (Da Costa et al., 2012; de Medeiros, Assunção & Barreto, 2012). Factors correlated with voice disorders in teachers are the gender (women are more frequently affected), the age between 40 and 59 years, to have a family history of voice disorders (Lauriello et al., 2011) and to have job stress where highly stressed teachers more often present voice disorders (Roy & Bless, 2000).

With rare exceptions, teachers make professional vocal use without any previous preparation, ignoring healthy vocal habits and acting under unfavorable environmental conditions, which causes an intense effort. Teachers often work in large rooms, under excessive internal and external environmental noises, and have to constantly speak with strong vocal intensity (Chan, 1994). Also, they have to deal with variables that are beyond their control, such as improper environmental conditions, lack of educational resources, and the constant risk of developing voice disorders due to exposure or close contact with children who frequently develop upper respiratory infections (Smith et al., 1997).

A good posture is necessary because it can help to harmonize muscle tension, which itself can cause postural changes. Also, muscle tension and dysphonia may influence each other. Muscle tension may cause dysphonia and, on the contrary, to be a result of dysphonia as subjects increasingly add muscle effort trying to make their voices work (Cardoso, Lumini-Oliveira & Meneses, 2019; Van Houtte, Van Lierde & Clayes, 2011).

Hyperfunctional dysphonia is related to excessive tension of the muscles not only of the pharynx, larynx, face and neck but often of the thorax and abdominal walls. In this way, the subjects with hyperfunctional dysphonia are prone to affect the muscular-fascial-ligamentous system and can change the posture of the whole body (Angsuwarangsee & Morrison, 2002; Kooijman et al., 2005).

Myofascial dysfunction can be described as an anomaly or lack of a correct stabilizing response of the fascial system which can overload all segments of the fascial system and alter the functioning of the body structure. In addition, a lack of coordination (temporary or definitive) of movements at all levels and body segments is created (Pilat, 2003). Fascia has a key role to play in musculoskeletal dynamics: its ability to spontaneously adapt and adjust to strain or stretch makes it as an active contributor to stability and mobility (Schleip et al., 2012).

Myofascial release (MFR) comprises a set of manual therapeutic techniques that promotes the release of fascial restraints to restore maximal functionality to the body (Ajimsha, Al-Mudahka & Al-Madzhar, 2015; Ajimsha & Shenoy, 2019; Laimi et al., 2018; Simmonds, Miller & Gemmell, 2012). Usually, it involves sustained and slow pressure of about 120 to 300 seconds in the fascia layers either directly or indirectly. In direct techniques fingers or knuckles, elbow or other instruments are used to slowly sink into the fascia, applying tension, or stretch the fascia, to release a restricted fascial tissue, while the indirect techniques include stretching until the motion becomes less limited, with the hands being placed in the direction of restriction and held in the same position until the fascia is released (Ajimsha, Al-Mudahka & Al-Madzhar, 2015; Ajimsha, Daniel & Chithra, 2014; Ajimsha & Shenoy, 2019). These techniques promote vasodilation and muscle relaxation, with the main results being an increased range of motion, decreased pain and restored tensegrity, tissue length, resulting in optimization of tissue function (Ajimsha, Al-Mudahka & Al-Madzhar, 2015; Simmonds, Miller & Gemmell, 2012). The fascia is located immediately before the motor barrier and as soon as it is reached, light pressure is applied to lengthen the restriction area (Saratchandran & Desai, 2013). This concept initially had more attention through manual therapies and there are currently several methods of fascial release (Day, Copetti & Rucli, 2012). This release of the restriction takes place due to the viscoelastic properties (the continuous technique individually requests the collagen strands), plastic (if the elongation is maintained in time the collagen that is in the tissues deforms) and piezoelectric, that is, the continuous movement of the liquid element that travels in the fascia maintains the proper electrical charge to maintain the adjacent tissue homeostasis (Day, Stecco & Stecco, 2009). Since fascia is a continuous tissue in our body, a restriction of it in one area can cause stress and dysfunction in other regions. The MFR can then decrease or eliminate the restrictions being reported as effective in relieving pain and relaxing tissues (Hou, et al., 2002; McKenney, Elder, Elder & Hutchins, 2013).

Hsieh et al. (2002) investigated the effectiveness of three manual treatments including MFR for patients with subacute low back pain. The back pain improved in all groups, but there were no differences between the groups. In another paper, Tozzi, Bongiorno and Vitturini (2011) studied pain perception and the mobility of fascial layers by using a dynamic ultrasound in patients with neck pain and low back pain. Sixty patients with nonspecific neck pain and 60 with nonspecific back pain were divided into experimental and control groups who were evaluated in the area of complaint, by 'Dynamic Ultrasound Topographic Anatomy Evaluation', before and after MFR was applied in situ, in the corresponding painful region, for not more than 12 minutes. The result highlighted that MFR can be effective in releasing areas of impaired sliding fascial mobility, and to improve pain perception over a short term duration in people with non-specific neck pain and low back pain. A study by Ajimsha (2011) on 63 tension headache patients compared the direct MFR technique and indirect MFR technique with a sham control receiving slow soft stroking. Patients in the direct MFR group, the indirect MFR group and the control group reported a 59.2%, 54% and 13.3% reduction respectively in their headache frequency in posttest compared to the baseline.

The purpose of this study was to verify the effects of MFR in teachers' posture, muscular tension and voice quality.

Materials and methods

Ethics statement

Initially the project protocol was submitted to the approval of the Ethics Committee of the UFP's University Hospital. During the first face-to-face contact with each participant, signed informed consent was obtained following the World Medical Association Declaration of Helsinki (Ethical Principles for Medical Research Involving Human Subjects), ensuring the anonymity and confidentiality of the data and that it would not be used for purposes other than this research. Participants were also informed that, if they wished, they could cease their participation in the study at any time without any consequences for themselves.

Sample selection

After obtaining the necessary authorizations to carry out the study in the UFP's University Hospital, the directors of the school groups of São Pedro da Cova and Rio Tinto were contacted by telephone to inform them about the nature, objectives, procedures and period of the study.

Subsequently, an email was sent to those directors with a cover letter and information about the study and to all teachers to recruit volunteers. Teachers who were on leave or had retired were excluded. After each teacher confirmed his/her participation via email, the day of the assessment in the Physical Medicine and Rehabilitation Service of the UFP's University Hospital was scheduled.

After the data collection period, a new email was sent to thank the interest of the teachers and their participation in the study. The final results of the study were also disclosed to teachers this way. The collected data was archived separately and, following the Ethics Committee instruction will be deleted when no longer serves for any research purpose.

Subjects

The convenience sample consisted of 24 teachers of both genders, between 27 and 60 years of age who signed an informed consent form. To standardize the sample regarding the vocal load, only participants who were teaching full-time were included (Anhaia et al., 2014). The participants had no knowledge of how MFR would be conducted.

The exclusion criteria were: to have hearing loss (Anhaia et al., 2014); to have undergone voice therapy or lessons for voice enhancement in the last six months (Anhaia et al., 2014); to have neurological diseases; to have been under pharmacological treatment for the last purpose; to have history of oncological pathology; to have dermatological lesions; to be tracheostomized or laryngectomized; to have extensive scar of any origin (surgery, radiotherapy, trauma) in the anterior region of the cervical and soft tissues surrounding the larynx (Angsuwarangsee & Morrison, 2002).

Experimental procedure

Participants completed a Sociodemographic and Clinical Questionnaire, to characterize the sample and identify possible exclusion criteria. The Sociodemographic and Clinical Questionnaire included: personal data (10 items), vocal habits (7 items), personal habits (5 items) and clinical background (2 items). The data collection was done in a room of the Physical Medicine and Rehabilitation Service of the UFP's University Hospital, in a calm environment, illuminated with soft white light and at a temperature between 20ºC and 23ºC. All the assessments were done within three months and took place in the afternoon, between 15:00 and 19:00 hours, to standardize their schedules.

After completing the Sociodemographic and Clinical Questionnaire, the subjects were randomly assigned into two groups designated Group 1 (G1; n = 12) (reveived MFR first) and Group 2 (G2; n = 12) (belong to control group first) using the software *www.graphpad.com/quickcals*. All participants received treatment, since, after a 14-day period (Fachinatto et al., 2015), procedures were switched between groups: participants who underwent MFR on the first day were subjected to control and vice versa. Each participant was assigned an odd number (who started in G1) or even (who started in G2).

After the randomization, participants were assessed to establish a baseline [Time 0 (T0)] in 6 separate main outcome variables: Photogrammetry, muscle tension assessed through palpation, algometry, aerodynamic assessment of voice, acoustic and auditory-perceptual analysis of voice. After the intervention or control, was carried out the second evaluation [Time 1 (T1)], which consisted in the same outcome measures. In this phase, a 14-day wash-out period was performed where procedures were switched between groups and, after that, was performed the third assessment [Time 2 (T2)]. After the intervention or control, was carried out the fourth assessment [Time 3 (T3)]. The outcome measures used in T2 and T3 were the same as in T0 (Figure 1).

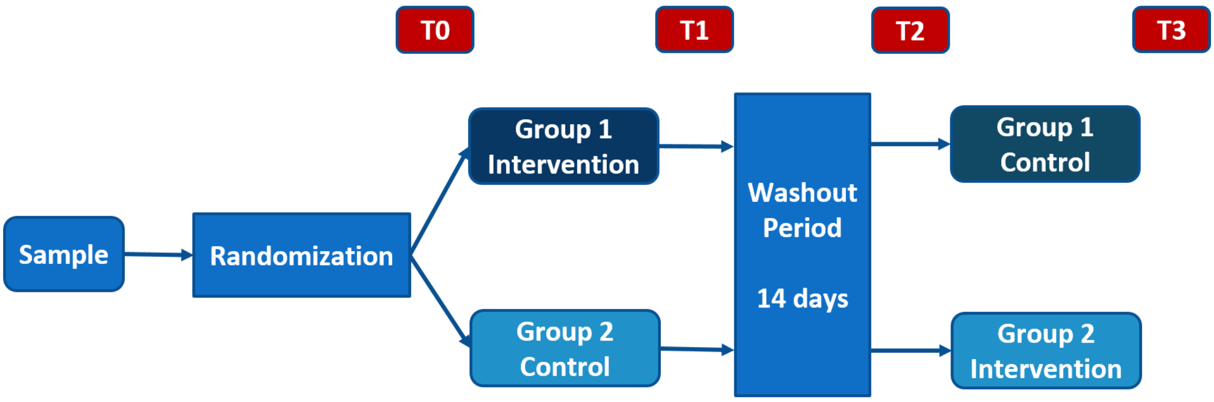

Figure 1 – Experiment flow-chart.

Initially, each individual was evaluated for their anthropometric composition, using a stadiometer (Seca® Medical Scales and Measuring Systems®, UK) to record their height and a scale (Seca® Medical Scales and Measuring Systems®, UK) to measure their weight.

The following evaluation parameters were collected by an experienced physiotherapist investigator, using a blinded approach and trained for the purpose. The average time to assess each participant was 60 minutes.

Voice assessment

The voice assessments were performed in an acoustically isolated room in the hospital, respecting the maximum threshold of 45dB ambient noise that was measured by the application of an Android smartphone, Sound Meter 3.5.0 (Na et al., 2014; Remacle & Eckel, 2010, p.12).

The participants produced the sustained vowel /a/. They were asked to stand with their backs straight, and with their head forming perpendicular to the line of the shoulders. This allowed better control under the respiratory system, better postural control, approximation to the habitual use of the voice and defined aerodynamic characteristics ideal for voice production (Behlau, 2001, p.139-147; Carneiro & Teles, 2012; Teixeira & Behlau, 2015).

The microphone was held by the participant´s hand, positioned at an angle of 90º and 20 cm away from the mouth (Behlau, 2001, p.139-147; Camargo & Madureira, 2009; Choi, Lee, Sprecher & Jiang, 2012; Uloza et al., 2011).

The vowel / a / was recorded in the habitual pitch and loudness. The vowel was sustained as long as participants were able – the task was then repeated three times (Carneiro & Teles, 2012; Watts et al., 2015). The recording of sustained vowels is very useful since it allows the sound to be analyzed without alterations derived from the articulation of the words, thus remaining in its most stable and clear form.

The vowel / a / was chosen because when acoustic analysis of vowels is performed, it tends to be the most affected among all vowels (Guimarães, 2007) and, as described by Behlau (2001), is the best vowel for verifying variations in frequency and intensity.

The maximum phonation time, an aerodynamic variable that indicates the voice's efficiency, was also assessed. This evaluation consisted in measuring, in seconds, the maximum phonation time of the vowel /a/ during exhalation. The assessment was repeated three times and the average was considered (Marszałek et al., 2012; Zielińska-Bliźniewska et al., 2013).

The acquisition and analysis of the acoustic signal was done with the opensource software PRAAT version 6.0.35 with a single channel, 16 bits resolution and a sampling rate of 44,100 Hz (Choi, Lee, Sprecher & Jiang, 2012; Smits et al., 2005; Teixeira & Behlau, 2015). The recording was done with the dynamic microphone Shure SM58, through the digital interface Behringer FCA 1616 connected to the HP Pavilion beatsaudio computer (Vogel & Morgan, 2009).

The studied variables for acoustic analysis were: fundamental frequency (F_0), standard deviation fundamental frequency (F_0SD), Jitter, Shimmer and Harmonic-to-Noise Ratio (HNR) (Carneiro & Teles, 2012; Cho, Yin, Park, & Park, 2011; Halawa, Freire, Muñoz & Pérez, 2014; Teixeira & Behlau, 2015; Zielińska-Bliźniewska et al., 2013). These variables were chosen because they provide information on vocal signal modifications that reflect physiological changes in the vocal folds (Carneiro & Teles, 2012). The F_0 was chosen because it is “the natural result of vocal fold length” and its aerodynamic characteristics in the interaction with subglottic pressure (Behlau, 2001, p. 139-147). The Jitter indicates “the variability of F_0 in the short term by measuring the differences between neighboring glottic cycles” (Behlau, 2001, p. 139-147). The Shimmer indicates “the variability of the amplitude of the sound wave in the short term” (Behlau, 2001, p. 139-147). As for HNR, it is an indicator capable of expressing the “vocal fold signal contrast with the irregular signal of the folds and vocal tract, offering an index that relates the harmonic component versus the noise component of the acoustic wave” (Behlau, 2001, p. 139-147). The auditory-perceptual analysis of the voice was performed by three experienced voice therapists (over five years of experience) who listened to the voice recordings in a blind and random manner (Fachinatto et al., 2015; Teixeira & Behlau, 2015). The three clinicians were asked to listen carefully to all the voice samples successively. Each voice sample was played, and the clinicians were asked to complete perceptual evaluation of the subjects’ vocal quality on the Grade, Roughness, Breathiness, Astheny, Strain, Harshness (GRBASH) subscales using a four-point scale: 0 = normal, 1 = mild deviance, 2 = moderate deviance, and 3 = severe deviance. Afterwards the mean values of each subscale of GRBASH was calculated based on the three clinicians’ perceptual evaluation (Cho, Yin, Park, & Park, 2011; Santos, 2013; Zielińska-Bliźniewska et al., 2013). In order to adapt the GRBAS, Nemr and Lehn (2010) included the term harshness -H to the original scale, giving rise to the GRBASH scale, with the aim of adapting the perceptive assessment of voice to the voices concomitant to a partial laryngectomy, with harshness being a perceptual parameter evident in these cases. The GRBASH scale maintains the remaining parameters originally proposed by the GRBAS scale.

Photogrammetry

The photogrammetry was assessed by following the recommendations of the postural evaluation software (SAPO). A plumb line (Rubi®) attached to the ceiling was used, with two strips of neuromuscular bands (Sportex®) spaced 50 cm from each other, glued on the wire for later calibration of the image. The participant was positioned in such a way that the plumb line would lie in the same plane perpendicular to the axis of the digital camera (CANON -S40, with a resolution of 4.1 megapixels, 3.0 x zoom) (Carneiro & Teles, 2012; Marques, 2003; Santos, 2014) that was placed on a support camera tripod (Cullmann primax 350) leveled to 1 meter from the ground, and the participant was at a distance of 3 meters, so as to allow their correct visualization from head to toe (Carneiro & Teles, 2012; Marques, 2003; Santos, 2014).

In a first phase, the points were marked, using the surface anatomy and palpation, according to the SAPO protocol. The following points were referenced with orange colored stickers (Santos, 2014):

Anterior view: Tragus of the right ear (2) and tragus of the left ear (3); right acromion (5) and left acromion (6); right antero-superior iliac spine (12) and left iliac spine (13); greater trochanter of the right (14) and left (15) femur; joint line of right (16) and left knee (19); medial point of the right (17) and left (20) kneecap; tuberosity of the right (18) and left (21) tibia; right (22) and left (25) lateral malleolus and right (23) and left (26) medial malleolus.

Side view: Ear tragus (2); acromion (5); spinous process C7 (8); anterosuperior iliac spine (21); posterior superior iliac spine (22); greater trochanter of the femur (23); medial articular line of the knee (24); lateral malleolus (30); and the point between the head of the 2nd and 3rd metatarsals (31).

Subsequently, the participants were instructed to stand in orthostatic position on the green card (Staples). Four photographs were taken for each participant: anterior view, right lateral view, left lateral view and posterior view, after the anatomical points marking (Carneiro & Teles, 2012; Marques, 2003; Santos, 2014). In an attempt to minimize the error, the photographs were carried out by the same investigator (Santos, 2014).

Muscle tension assessment through palpation

For muscle tension through palpation, the Lieberman method, which consists of a graduation system of four muscle groups surrounding the larynx (Lieberman, 1998), was used. Graduation varies from 0 to 3, with 0 indicating normal tonus, 1 for mild muscle tension, 2 for moderate tension and 3 for severe muscular tension (Angsuwarangsee & Morrison, 2002). The palpated muscle groups were the suprahyoids, thyrohyoids, cricothyroid and pharyngolaryngeal muscles. The evaluation was performed with the participants lying in the supine position.

Algometry

In algometry, the pressure pain threshold was evaluated using an algometer (Wagner Fdix®, USA) at the same points of the muscle tension assessment through palpation and in the same position. Trapezius, diaphragm, suboccipital muscles (Wytrążek et al, 2015) and scalenes were also assessed in algometry, in supine position (Tixa, 2006). The average of 3 measurements was collected. Participants were instructed to say "yes" when the pressure became uncomfortable in each assessment, averaging three measurements (Wytrążek et al., 2015).

Intervention

After the baseline assessment, the participants received the treatment according to the group to which they belong. The participants of the G2 kept resting for 20 minutes on a massage table (Posturarte® Olympic), in supine, without inclination; during that period their breathing was controlled by a digital metronome - an Android smartphone application (Metronome Beats 4.5.0) - to maintain 15 cycles per minute (2 : 2) (Pomeranz et al., 1985).

At G1, participants received MFR treatment in four distinct body areas according to the procedures described by Pilat (2003):

Diaphragm - participants remained seated while the therapist stood behind the patient and leaned against the patient with a cushion between them. The patient should be relaxed and slightly flexed in order to relax the abdominals while the therapist placed both hands under the rib cage, lateral to the xiphoid process of the sternum. The therapist then performed a slide from the center outward using the pulp of the fingers. At the end of the movement, the patient breathed deeply and took a more upright position. Three replicates were performed.

Induction of the suprahyoid and infrahyoid fascia:

Infrahyoid fascia - with the patient in the supine position, the therapist crossed the hands, one on the upper part of the thorax and other above the clavicle and below the hyoid bone, holding it between the thumb and indicator. The first hand exerted a gentle caudal traction and the second performed a cephalic traction. The pressure was three-dimensional and was applied for 3 to 5 minutes, until release occurred.

Supra-hyoid fascia - The therapist placed the lower hand below the hyoid bone, holding it between the thumb and forefinger. The index, middle and ring fingertips of the upper hand were placed in the inframandibular area. The lower hand exerted caudal traction and superior cephalic traction. The pressure was gentle and applied for 3 to 5 minutes until liberation was achieved.

Oblique elongation of the cervical fascia - With the patient in the supine position, the therapist supported the patient's head with one hand in a position of flexion, inclination and external rotation. The second hand was placed firmly on the patient's shoulder, making a caudal pressure.

Suboccipital induction - With the patient lying in the supine position, the therapist placed the hands together (palm of the hand facing the patient's head and with flexion of the fingers in order to press with the index, middle and annular fingers of each hand over the base of the skull) under the patient's head. This pressure was maintained (without reducing pressure and causing pain to the patient) for a few minutes until fascia release.

Depending on the direction and degree of restriction, the release movement may occur in either direction. The therapist was aware of changes in the location, direction, range and speed of movements.

The intervention was performed by a professional specialized in physiotherapy and osteopathy with seven years of experience. After the intervention, all participants were assessed again in the same way and with the same baseline parameters.

Statistical analyses

The data was analyzed with IBM SPSS Statistics 25. The Shapiro-Wilks test was used for assessment of normality and the Levene´s test for the homogeneity of variance. The independent Student´s t-test was applied to characterize the sample. As both normality and variance homogeneity of variances were not secured for all variables, therefore non-parametric tests were used. For intragroup comparison were used Friedman test and Wilcoxon’s T-test while to intergroup comparison MannWhitney’s U-test was used. The Intraclass Correlation Coefficients was applied to evaluate the inter-rater reliability between the three raters of auditory-perceptual analysis of voice through GRBASH scale and the intra-rater reliability in photogrammetry. A p value equal or lower than 0.05 was considered significant.

Results

The biometric characteristics of the sample variables are summarized in Table 1, for both groups. No difference was found between both study groups considering age, weight, height, and body mass index.

Table 1 – *Comparison between the groups in terms of biometric characteristics.*

Variables	Group 1	Group 2	*p* between groups
n	12	12	
Gender (F)	9	9	
Age (years)	42,50 ± 10,08	38,67 ± 8,01	0,314
Weight (kg)	67,42 ± 13,81	69,08 ± 12,50	0,760
Height (cm)	164,50 ± 7,63	165,83 ± 7,98	0,680
Body mass index (kg/m^2)	24,81 ± 4,24	25,04 ± 3,66	0,888

At baseline there were no statistically significant differences for the aerodynamic voice assessment, acoustic and auditory-perceptual analysis of voice, photogrammetry, muscle tension through palpation and algometry, with p values above 0,05 meaning there was homogeneity between the groups at T0.

For the aerodynamic assessment of voice statistically significant differences were found when intervention was applied in both groups for MPT (G1 p=0,019; G2 p=0,004). In a group by group analysis in the different moments were not found significant differences between groups at any moment. The acoustic analysis of voice parameters did not differ (Table 2).

Concerning the auditory-perceptual analysis of voice statistically significant differences were found when intervention was applied in both groups for Grade in G2 (p=0,046) and for Roughness in G1 (p=0,025). In a group by group analysis in the different moments were not found significant differences between groups at any moment. Reliability analysis was carried out on the three raters of auditory-perceptual analysis of voice through the GRBASH scale. The Intraclass Correlation Coefficients was superior than 0,92 in all GRBASH subscales.

Table 2 – *Differences within and between the groups in the different moments in aerodynamic, acoustic and auditory-perceptual analysis of voice.*

	Variables		T0		T1		*p#*	T2		T3		*p#*
			Median	interquartile range	Median	interquartile range		Median	interquartile range	Median	interquartile range	
Aerodynamic assessment	MPT (s)	G1	16,40	5,65	17,22	5,20	0,019*	16,40	5,48	16,56	5,42	1,000
		G2	15,25	8,20	15,13	8,00	0,937	15,24	8,25	16,84	7,74	0,004*
	p†		p < 0,488		p < 0,204			p < 0,564		p < 0,854		
Acoustic assessment	F_0 (Hz)	G1	188,86	72,94	189,69	72,75	0,239	188,68	72,62	191,09	73,83	0,060
		G2	178,84	81,07	179,29	82,33	0,158	177,74	79,25	179,44	81,85	0,308
	p†		p < 0,686		p < 0,686			p < 0,603		p < 0,686		
	F_0SD (Hz)	G1	1,57	0,69	1,57	0,75	0,480	1,58	0,65	1,59	0,71	0,814
		G2	1,41	0,85	1,40	0,89	0,272	1,39	0,85	1,36	0,89	0,875
	p†		p < 0,686		p < 0,453			p < 0,488		p < 0,488		
	Jitter (%)	G1	0,33	0,10	0,32	0,09	0,189	0,33	0,10	0,33	0,10	0,222
		G2	0,39	0,21	0,39	0,21	0,388	0,39	0,20	0,39	0,20	0,356
	p†		p < 0,419		p < 0,166			p < 0,341		p < 0,644		
	Shimmer (%)	G1	2,66	0,81	2,64	0,81	0,152	2,64	0,80	2,70	0,78	0,327
		G2	3,28	1,60	3,31	1,60	0,195	3,27	1,52	3,26	1,50	0,273
	p†		p < 0,184		p < 0,119			p < 0,184		p < 0,248		
	HNR (dB)	G1	22,12	2,55	22,17	2,57	0,146	22,07	2,47	22,12	2,65	0,388
		G2	21,52	3,01	21,50	3,06	0,346	21,51	3,01	21,52	3,02	0,282
	p†		p < 0,862		p < 0,149			p < 0,862		p < 0,624		
Auditory-perceptual assessment	Grade	G1	0,50	1,00	0,00	1,00	0,157	0,50	1,00	1,00	1,00	0,317
		G2	1,00	1,75	1,00	1,75	1,000	1,00	1,75	1,00	1,00	0,046*
	p†		p < 0,342		p < 0,122			p < 0,183		p < 1,000		
	Roughness	G1	1,00	0,00	1,00	1,00	0,025*	1,00	0,00	1,00	0,75	0,317
		G2	1,00	1,00	1,00	1,75	0,317	1,00	1,75	1,00	1,00	0,102
	p†		p < 0,558		p < 0,294			p < 0,799		p < 0,350		
	Breathiness	G1	0,00	0,75	0,00	0,75	1,000	0,00	0,75	0,00	0,75	1,000
		G2	0,00	0,00	0,00	0,75	0,317	0,00	0,75	0,00	0,00	0,317

	p†		p < 0,623		p < 1,000			p < 1,000		p < 0,623		
	Astheny	G1	0,00	0,00	0,00	0,00	1,000	0,00	0,00	0,00	0,00	1,000
		G2	0,00	0,75	0,00	0,75	1,000	0,00	0,75	0,00	0,75	0,317
	p†		p < 0,623		p < 0,623			p < 0,568		p < 0,623		
	Strain	G1	0,00	1,00	0,00	0,75	0,317	0,00	1,00	0,00	0,00	0,083
		G2	0,00	0,00	0,00	0,00	0,317	0,00	0,75	0,00	0,00	0,317
	p†		p < 0,356		p < 0,284			p < 0,660		p < 0,546		
	Harshness	G1	0,00	0,00	0,00	0,00	1,000	0,00	0,00	0,00	0,75	0,317
		G2	0,00	0,75	0,00	0,75	1,000	0,00	0,00	0,00	0,75	0,317
	p†		p < 0,623		p < 0,623			p < 1,000		p < 1,000		

* Significant values (p≤0.05); # For intragroup significance - Wilcoxon test; † For post-intervention inter-group significance – Mann-Whitney U-test
Abbreviations: F_0, fundamental frequency; F_0SD, fundamental frequency standard deviation; HNR, Harmonic-to-Noise Ratio; MPT, maximum phonation time.

For the photogrammetry assessment statistically significant differences were found when intervention was applied in both groups for vertical alignment of the head with the acromion in G2 (p=0,046), horizontal alignment of the pelvis in G1 (p=0,028), left vertical alignment of the head with the acromion (G1 p=0,036; G2 p=0,046), left horizontal alignment of the pelvis in G1 (p=0,017) and horizontal asymmetry of the scapula in relation to T3 in G1 (p=0,049). When participants belonged to control, there were not significant differences (Table 3). The Intraclass Correlation Coefficients was superior than 0,86 in all photogrammetry variables.

In a group by group analysis in the different moments significant differences were not found between groups at any moment, with exception of horizontal alignment of the head and vertical alignment of the head with the acromion in T1, respectively (p<0,040; p<0,021) and left vertical alignment of the head with the acromion in T3 (p<0,015).

Table 3 – *Differences within and between the groups in the different moments in photogrammetry.*

Variables (º)		T0		T1		p#	T2		T3		p#
		Median	*interquartile range*	*Median*	*interquartile range*		*Median*	*interquartile range*	*Median*	*interquartile range*	
HAH	G1	1,23	3,10	1,17	1,51	0,715	1,33	3,10	1,32	3,10	0,655
	G2	2,13	2,27	2,10	2,25	0,678	2,15	2,29	1,80	1,64	0,225
p†		p < 0,119		p < 0,040*			p < 0,126		p < 0,298		
HAA	G1	1,24	3,02	1,16	1,60	0,686	1,32	2,99	1,31	2,31	0,344
	G2	2,09	1,66	2,08	1,64	0,416	2,17	1,57	1,88	0,90	0,345
p†		p < 0,125		p < 0,099			p < 0,149		p < 0,272		
HAASIS	G1	1,22	3,04	1,16	1,60	0,686	1,26	2,99	1,28	3,00	0,715
	G2	2,12	1,08	2,11	0,91	0,674	2,12	0,94	1,99	0,88	0,123
p†		p < 0,223		p < 0,140			p < 0,272		p < 0,506		
VAHA	G1	2,24	2,98	1,23	1,23	0,063	2,14	2,99	2,17	2,97	0,173
	G2	2,85	4,36	2,84	4,27	0,066	2,84	4,38	2,11	2,16	0,046*
p†		p < 0,419		p < 0,021*			p < 0,355		p < 0,977		
HAP	G1	-3,67	5,58	-3,11	5,40	0,028*	-3,67	5,39	-3,65	5,67	0,892
	G2	-1,84	-9,21	-1,73	-9,18	0,528	-1,94	-9,21	-1,67	-8,35	0,116
p†		p < 0,603		p < 0,707			p < 0,603		p < 0,470		
VAB	G1	1,17	2,31	1,10	1,52	0,686	1,18	2,33	1,17	2,31	0,197
	G2	1,34	1,74	1,29	1,72	0,500	1,39	1,73	1,28	1,68	0,893
p†		p < 0,258		p < 0,247			p < 0,402		p < 0,338		
Left VAHA	G1	2,14	2,98	1,23	3,03	0,036*	2,24	2,99	2,34	1,24	0,609
	G2	3,51	3,61	3,50	3,52	0,066	3,50	3,64	2,78	1,91	0,046*
p†		p < 0,157		p < 0,236			p < 0,119		p < 0,015*		
Left HAP	G1	-4,22	5,55	-3,89	5,40	0,017*	-4,23	5,39	-4,26	5,67	0,336
	G2	-3,97	9,21	-3,96	9,18	0,528	-3,94	9,22	-3,95	8,35	0,225
p†		p < 0,840		p < 0,977			p < 0,862		p < 0,603		
Left VAB	G1	1,23	2,71	1,11	1,66	0,753	1,25	2,72	1,24	2,71	0,285
	G2	1,34	1,69	1,28	1,70	0,786	1,39	1,71	1,23	1,48	0,176
p†		p < 0,310		p < 0,259			p < 0,506		p < 0,877		
HAST3	G1	-3,51	6,22	-2,61	5,28	0,049*	-3,50	5,97	-3,66	6,51	0,102

	G2	0,33	7,16	0,44	7,00	0,581	0,23	7,15	0,45	6,94	0,735
p†		p < 0,248		p < 0,285			p < 0,260		p < 0,119		

* Significant values (p≤0.05); # For intragroup significance - Wilcoxon test; † For post-intervention inter-group significance – Mann-Whitney U-test
Abbreviations: G, Group; HAA, horizontal alignment of acromion; HAASIS, horizontal alignment of anterior superior iliac spine; HAH, horizontal alignment of the head; HAP, horizontal alignment of the pelvis; HAST3, horizontal asymmetry of the scapula in relation to T3; VAB, vertical alignment of the body; VAHA, vertical alignment of the head with the acromion.

About the muscle tension assessment through palpation were found statistically significant differences when intervention was applied in both groups for suprahyoids (G1 p=0,046; G2 p=0,008), thyrohyoids in G2 (p=0,002), cricothyroids (G1 p=0,046; G2 p=0,046) and pharyngolaryngeal muscles (G1 p=0,025; G2 p=0,046). When participants belonged to control, there were not significant differences (Table 4).

In a group by group analysis in the different moments significant differences were not found between groups at any moment, with exception of suprahyoids and thyrohyoids in T1 (p<0,015 in both).

Table 4 – *Differences within and between the groups in the different moments in muscle tension through palpation according to Lieberman method.*

Muscles		T0		T1		*p#*	T2		T3		*p#*
		Median	*interquartile range*	*Median*	*interquartile range*		*Median*	*interquartile range*	*Median*	*interquartile range*	
Suprahyoids	G1	1,00	1,00	0,50	1,00	0,046*	1,00	1,00	1,00	1,00	0,317
	G2	1,00	1,00	1,00	1,00	1,000	1,00	1,00	1,00	1,00	0,008*
p†		p < 0,172		p < 0,015*			p < 0,258		p < 0,527		
Thyrohyoids	G1	1,00	1,75	1,00	1,00	0,059	1,00	1,75	1,00	1,75	1,000
	G2	1,50	1,00	1,50	1,00	1,000	1,50	1,00	1,00	1,00	0,008*
p†		p < 0,272		p < 0,015*			p < 0,272		p < 0,592		
Cricothyroids	G1	1,00	1,00	0,00	1,00	0,046*	1,00	0,75	1,00	1,00	0,157
	G2	0,50	0,50	0,00	1,00	0,317	1,00	0,00	0,00	0,75	0,046*
p†		p < 0,724		p < 0,680			p < 0,292		p < 0,089		
Pharyngolaryngeal	G1	1,00	0,75	0,00	1,00	0,025*	1,00	1,00	1,00	1,00	0,317
	G2	0,00	1,00	0,00	1,00	1,000	1,00	1,00	0,00	1,00	0,046*
p†		p < 0,096		p < 0,889			p < 0,894		p < 0,229		

* Significant values ($p \leq 0.05$); # For intragroup significance - Wilcoxon test; † For post-intervention inter-group significance – Mann-Whitney U-test
Abbreviations: G, Group

For the algometry assessment were found statistically significant differences when intervention was applied in both groups for all muscles. When participants belonged to control, there were not significant differences (Table 5).

In a group by group analysis in the different moments significant differences were found between groups in T1 in all muscles, with exception of the right diaphragm point.

Table 5 – *Differences within and between the groups in the different moments in algometry.*

Muscles (Kgf/m²)		T0		T1		*p#*	T2		T3		*p#*
		Median	*interquartile range*	*Median*	*interquartile range*		*Median*	*interquartile range*	*Median*	*interquartile range*	
Right SUB	G1	2,52	0,98	3,39	0,91	0,002*	2,55	0,91	2,56	0,90	0,395
	G2	2,27	1,60	2,29	1,57	0,141	2,26	1,50	2,99	1,78	0,002*
p†		p < 0,225		p < 0,009*			p < 0,184		p < 0,564		
Left SUB	G1	2,46	0,52	3,39	0,88	0,002*	2,58	0,92	2,70	0,95	0,933
	G2	2,24	1,60	2,26	1,55	0,132	2,26	1,43	3,23	1,77	0,002*
p†		p < 0,525		p < 0,009*			p < 0,165		p < 0,326		
Right TA	G1	2,52	0,98	3,39	0,78	0,002*	2,55	0,91	2,76	0,87	0,108
	G2	2,50	1,90	2,58	1,86	0,092	2,45	1,91	3,12	1,72	0,002*
p†		p < 0,419		p < 0,019*			p < 0,371		p < 0,312		
Left TA	G1	2,56	0,93	3,39	0,78	0,003*	2,53	0,89	2,58	0,85	0,128
	G2	2,27	1,53	2,39	1,44	0,753	2,45	1,24	2,99	1,56	0,003*
p†		p < 0,356		p < 0,013*			p < 0,386		p < 0,470		
Right DIAPH point	G1	2,52	1,14	3,39	1,28	0,003*	2,50	1,01	2,52	0,97	0,134
	G2	2,57	1,26	2,56	1,56	0,479	2,50	1,62	3,01	1,31	0,004*
p†		p < 0,908		p < 0,065			p < 0,564		p < 0,225		
Left DIAPH point	G1	2,54	1,13	3,40	0,98	0,002*	2,55	1,08	2,65	1,00	0,112
	G2	2,58	1,26	2,56	1,56	0,636	2,51	1,62	3,08	1,31	0,002*
p†		p < 0,977		p < 0,038*			p < 0,525		p < 0,149		
Right SCAL	G1	2,52	0,70	3,39	0,86	0,002*	2,56	0,75	2,51	0,76	0,397
	G2	2,50	2,02	2,54	1,80	0,135	2,45	1,96	3,12	1,72	0,002*
p†		p < 0,507		p < 0,018*			p < 0,453		p < 0,106		
Left SCAL	G1	2,58	0,70	3,21	0,87	0,005*	2,51	0,82	2,58	0,72	0,098
	G2	2,40	1,92	2,48	1,79	0,135	2,45	1,90	3,12	1,72	0,002*
p†		p < 0,507		p < 0,018*			p < 0,386		p < 0,174		
Right SUP	G1	2,49	0,87	3,29	0,95	0,002*	2,43	0,98	2,51	0,95	0,077
	G2	1,94	1,51	1,97	1,46	0,365	1,99	1,41	2,87	1,36	0,003*
p†		p < 0,112		p < 0,001*			p < 0,083		p < 0,248		
Left SUP	G1	2,53	0,87	3,29	0,95	0,002*	2,54	0,99	2,53	0,96	0,063
	G2	1,95	1,41	1,97	1,44	0,168	1,97	1,33	2,93	1,35	0,002*
p†		p < 0,094		p < 0,001*			p < 0,080		p < 0,225		
Right THY	G1	2,41	1,35	3,22	0,88	0,004*	2,43	1,49	2,42	1,27	0,093

	G2	1,74	1,24	1,73	1,19	0,085	1,77	1,19	2,83	1,36	0,003*
p†		p < 0,069		p < 0,001*			p < 0,083		p < 0,119		
Left THY	G1	2,42	1,35	3,22	0,88	0,006*	2,42	1,46	2,42	1,30	0,103
	G2	1,70	1,25	1,74	1,21	0,094	1,68	1,17	2,76	1,33	0,002*
p†		p < 0,073		p < 0,001*			p < 0,078		p < 0,184		
Right CRICO	G1	2,52	0,99	3,29	1,06	0,005*	2,53	0,98	2,57	0,95	0,183
	G2	1,94	1,50	1,97	1,45	0,156	1,97	1,43	2,93	1,28	0,004*
p†		p < 0,106		p < 0,001*			p < 0,073		p < 0,248		
Left CRICO	G1	2,51	1,01	3,28	1,04	0,002*	2,54	0,97	2,59	0,93	0,083
	G2	1,94	1,51	1,97	1,48	0,107	1,98	1,43	2,92	1,30	0,002*
p†		p < 0,119		p < 0,001*			p < 0,060		p < 0,248		
Right PHARY	G1	2,52	1,00	3,29	0,98	0,002*	2,54	1,01	2,53	0,86	0,109
	G2	1,94	1,34	1,97	1,40	0,181	1,97	1,29	2,93	1,31	0,003*
p†		p < 0,126		p < 0,001*			p < 0,088		p < 0,260		
Left PHARY	G1	2,52	0,97	3,29	0,95	0,002*	2,53	1,03	2,59	0,93	0,108
	G2	1,92	1,38	1,95	1,41	0,082	1,97	1,33	2,93	1,28	0,002*
p†		p < 0,112		p < 0,001*			p < 0,069		p < 0,204		

* Significant values ($p \leq 0.05$); # For intragroup significance - Wilcoxon test; † For post-intervention inter-group significance – Mann-Whitney U-test
Abbreviations: CRICO, cricothyroids; DIAPH, diaphragm; G, Group; PHARY, pharyngolaryngeal muscles; SCAL, scalenes; SUP, Suprahyoids; SUB, suboccipital muscles; TA, trapezius; THY, thyrohyoids.

Discussion

Voice disorders are a common problem that occurs more frequently in teachers than in other professionals that use the voice frequently (Kooijman et al., 2005; Sala et al., 2001; Sliwinska-Kowalska et al., 2006). In a systematic review (Cardoso, Meneses, & Lumini-Oliveira, 2019) teachers were the most prevalent professionals in the included studies, with the predominance of female participants (225 out of 286 participants). The sample of this study corroborates the systematic review and the international literature, as the female gender is predominant in the teaching profession and has a higher prevalence of voice disorders, due to the demand of the profession (Behlau, Zambon, Guerrieri & Roy, 2012; Bovo, Galceran, Petruccelli & Hatzopoulos, 2007; Munier & Kinsella, 2008).

Individuals with functional or organofunctional dysphonia may have an increase in muscle tension in cervical and perilaryngeal muscles (Bigaton et al., 2010; Menoncin et al., 2010), muscle pain at rest or during function (Angsuwarangsee & Morrison, 2002; Menoncin et al., 2010), reduced range of motion in cervical spine (Angsuwarangsee & Morrison, 2002; Menoncin et al., 2010), hyperactivity of extrinsic laryngeal muscles (Angsuwarangsee & Morrison, 2002), and postural changes (Menoncin et al., 2010). Because of that, it is important to find therapeutic alternatives for the patients, such as MFR. The purpose of this study was to verify the effects of MFR in teachers' posture, muscular tension and voice quality.

In this investigation, the MFR showed a statistically significant improvement in MPT, which is an objective aerodynamic parameter that indicates voice efficiency. No differences were found among the acoustic parameters. Analogue results were found in the study of Marszałek et al. (2012), where statistically significant post-therapy improvement was observed in the phoniatric examination, including Voice Handicap Index scores, MPT results and parameters of videostroboscopic examination. In this investigation, when the intervention was performed, the MPT median of G1 improved from 16,40s to 17,22s (p=0,019), while in G2 MPT improved from 15,24s to 16,84s (p=0,004). Marszałek et al (2012) found a bigger improvement on average by 3,7s for MPT. Although no studies were found to corroborate these results with MFR in the other voice assessment parameters, it is known that massage has some effects on voice, as demonstrated in the study of Aghadoost et al. (2019), manual circumlaryngeal therapy (MCT) improved the Voice Handicap Index and Dysphonia Severity Index in teachers with muscle tension dysphonia. In another study, D'haeseleer, Claeys and Van Lierde (2013), where 16 vocal performers received a single treatment approach of MCT for 20 min, whereas the control group (CG) was instructed to have complete vocal rest for 20 min. In the experimental group, a significant difference in Dysphonia Severity Index was found before and after MCT. No differences in Dysphonia Severity Index were found in the CG between the two measurements. In line with this study, in the MCT group, improvements in MPT, Jitter, Shimmer and HNR were found, but not significant. In this investigation, F_0 did not show differences intra or inter groups; however, in the investigation of Ternström, Andersson and Bergman (2000), 31 amateur choir singers performed a 30 min massage. They found that massage improved F_0 and sound pressure level. In another paper, Kennard, Lieberman, Saaid and Rolfe (2015) conducted a crossover randomized controlled trial where 12 asymptomatic singers received specific laryngeal manipulation (30 min) or postural manual therapy (30 min). Both groups showed a significant improvement of F_0 (p=0,018; p=0,0143, respectively). No differences were verified in glottal closing time. The study of Leppänen, Laukkanen, Ilomäki and Vilkman (2009) was performed in 60 teachers that received a 3 hours long voice hygiene lecture (VHL). After that, they were divided into two groups: Voice Massage™ (VM) group (five times in 1 h sessions; the first three sessions were performed at intervals of 1 week, while the last two sessions were conducted at intervals of 1 month) and a VHL group that received the previous 3 hours long VHL. Measurements were performed at the beginning and end of the autumn school term, before and after a working day. The mean F_0 (in reading samples) was higher and more difficult phonation was reported in the VHL group. Perceived pitch in loud reading increased in the VHL group and decreased in the VM group. In the VM group, the perceived firmness of loud reading decreased (p=0,026). The results suggest that VM may help in sustaining vocal well-being during a school term.

Concerning the auditory-perceptual analysis of voice for the GRABASH scale, in this investigation statistically significant differences were found for Grade in G2 and Roughness in G1 – both after the intervention. In another study (Anhaia et al., 2014), 42 teachers were divided into two groups: perilaryngeal manual massage or vocal training. Participants performed eight sessions (30 min), once a week. The authors concluded that both groups had an improvement in vocal symptoms, no difference was verified in Vocal Activity and Participation Profile protocol between groups and perilaryngeal manual massage provided a slight improvement in teachers' global dysphonia level and reduced cervical tension, which was significantly reflected in the self-perceived pain score. In the same paper, concerning the GRBASI scale and before the vocal intervention, 80% of the subjects that performed perilaryngeal manual massage had light dysphonia, while only 5% had moderate dysphonia and 15% were non-dysphonic. After the intervention, the number of subjects with moderate dysphonia in this group remained the same, but the number of those with light dysphonia decreased to 70% and those with no dysphonia increased to 25%.

In this study MFR had an immediate effect on the posture, as it was confirmed in the results of the photogrammetry: improvement of vertical alignment of the head with the acromion in G2, horizontal alignment of the pelvis in G1, left vertical alignment of the head with the acromion in G1 and G2, left horizontal alignment of the pelvis in G1 and horizontal asymmetry of the scapula in relation to T3 in G1. When participants belonged to control, there were no significant differences. When the groups were compared in different moments, was verified that in T1, horizontal alignment of the head and vertical alignment of the head with the acromion got a significant improvement. The same results were found for the left vertical alignment of the head with the acromion in T3.

Regarding muscle tension assessment through palpation, MFR improved muscle tension in all four muscles when the intervention was applied. When the groups were compared, suprahyoids and thyrohyoids muscles in T1 improved muscle tension in a significant way. Concerning algometry assessment, MFR showed a statistically significant improvement in all muscles when pre and post-intervention were compared while in groups that belonged to control, they did not show any significant differences. In a group by group comparison, MFR significantly improved all muscles in T1, with the exception of right diaphragm point.

The MFR seems to be an interesting therapy to include in the rehabilitation of occupational dysphonia or in cases such as those of teachers where they have an increased risk of developing voice disorders, such as increased muscle tension. According to Kooijman et al. (2006), excessive muscular tension is a sign of problems with voice in teachers. Angsuwarangsee and Morrison (2002) verified that moving the chin forward increases the vocal effort and, consequently, increases the tension of muscles around the larynx during phonation. If this posture is not improved, it can lead to chronic overloading of “perilaryngeal muscles” during phonation and increased tension of the larynx. Rubin, Lieberman and Harris (2000) also concluded that incorrectly arranged head, excessive lordosis or kyphosis and center of gravity displaced forwards or backwards would be pathologically compensated in the form of excessive tension at the neck level and the laryngeal area.

An investigation with similar results to this study was performed by Marszałek et al. (2012), where the tension of the thyrohyoid muscle was not checked, but its function was investigated. This disorder was observed in the preliminary examination during glissando (in 37.5% of patients) and during yawning (in 27.5% of patients), while in the follow-up after the applied therapy a decrease in observed dysfunctions in 12.5 and 7.5% of patients, respectively, was noted. The authors found that voice therapy supplemented with MFR of the larynx resulted in a statistically significant decrease in tenderness of muscles raising the larynx (cricothyroid ligament, sternocleidomastoid muscles, and pharyngeal constrictor muscles) and in lowering the tonus (geniohyoid muscles, pharyngeal constrictor muscles and sternocleidomastoid muscles). A significant improvement was also observed in the case of dysfunction of the cricothyroid joint examined during glissando and yawning, as well as in asymmetry of the thyrohyoid apparatus. Moreover, the therapy resulted in significantly better normalization of the head position and better control of the center of gravity of the body.

Compensations tend to be asymmetrical and therefore generate discomfort, where the body remains under gravity action while it loses progressively the vertical alignment of its three-dimensional organization. In an attempt to avoid discomfort, new compensations are developed, progressively affecting the functionality of the whole organism, which can cause non-apparent retractions at the level of fascia and muscle. This is explained by the reciprocity between the systems, which remain connected by the connective tissue, being possible pathological implications on the health of the individual as a whole (Rêgo et al., 2012). When performing MFR, regions of the body are released from retractions, increasing flexibility, and, on the other hand, other regions retract in favor of a structural and biomechanical reorganization favorable to the posture and the accomplishment of the functional activities (Rêgo et al., 2012).

The effects of MRF may be due to the alpha motoneurons' afferent excitability reduction, which can be monitored with the Hoffman (H-) reflex. According to Behm and Wilke (2019), the local effects of MRF may be explained by thixotropic effects on muscle or myofascial. The often observed global or non-local changes in pain provide strong evidence that mechanical alterations of a non-treated muscle or myofascia do not seem to be consistently present in healthy individuals and, thus, increased stretch tolerance effects on ROM due to activation of global pain modulatory responses such as Diffuse noxious inhibitory control and gate control theory as well as increased parasympathetic nervous system relaxation of muscle would be likely mechanisms (Behm & Wilke, 2019).

This research has the limitation of having a small sample and only investigates the immediate effects of the MFR.

We suggest further research with more similar assessment methods in order to better compare the studies and systematize knowledge about MFR in posture, muscle tension and voice. We also suggest longitudinal studies, investigations with larger samples and that relate gold standard measurements of voice, like aerodynamic, acoustic and auditory-perceptual assessments, with objective measurements of posture, like photogrammetry or imaging exams such as magnetic resonance imaging, as well as an evaluation of muscle tension through electromyography, algometry or muscle tension through palpation by validated scales. The posture assessment should be analyzed both in a fixed position and during a specific action or task. We suggest studies with two groups — healthy individuals and individuals with voice disorders — using experienced blinded examiners. Samples with professionals who are frequently affected with voice disorders, like teachers and singers, are suggested as well as samples with more males. We suggest also studies that verify the long-term effects of MFR in posture, muscle tension and voice.

Conclusion

The findings of this study indicate that MFR seems to be an effective therapy in improving MPT, but not in the acoustic parameters of voice. It was also found that MFR improved two subscales (Grade and Roughness) of the GRABASH scale, in two groups, but not in both.

About muscle tension through palpation and algometry, MFR improved the results in all muscles when the intervention was applied, but when the groups were compared, the differences between groups were only significant in some parameters. Concerning photogrammetry, MFR had an immediate effect in improving posture, especially related to the head.

The presented study confirms the necessity for the cooperation of the physiotherapist or osteopath with a phoniatrician and voice therapist in the treatment of voice disorders. This is in accordance with the current trend of a transdisciplinary approach to the therapy of these disorders. These observations will allow us to increase the effectiveness of rehabilitation of patients with occupational disorders of the voice organ.

References

Aghadoost, S., Jalaie, S., Khatoonabadi, A. R., Dabirmoghaddam, P., & Khoddami, S. M. (2019). A Study of Vocal Facilitating Techniques Compared to Manual Circumlaryngeal Therapy in Teachers With Muscle Tension Dysphonia. *Journal of Voice*. In press. doi: 10.1016/j.jvoice.2019.06.002

Ajimsha, M. S. (2011). Effectiveness of direct vs indirect technique myofascial release in the management of tension-type headache. *Journal of bodywork and movement therapies*, *15*(4), 431-435. doi: 10.1016/j.jbmt.2011.01.021

Ajimsha, M. S., Al-Mudahka, N. R., & Al-Madzhar, J. A. (2015). Effectiveness of myofascial release: Systematic review of randomized controlled trials. *Journal of bodywork and movement therapies*, *19*(1), 102-112. doi: 10.1016/j.jbmt.2014.06.001

Ajimsha, M. S., Daniel, B., & Chithra, S. (2014). Effectiveness of myofascial release in the management of chronic low back pain in nursing professionals. *Journal of bodywork and movement therapies*, *18*(2), 273-281. doi: 10.1016/j.jbmt.2013.05.007

Ajimsha, M. S., & Shenoy, P. D. (2019). Improving the quality of myofascial release research–A critical appraisal of systematic reviews. *Journal of Bodywork and Movement Therapies*. 23(3), 561-567. doi: 10.1016/j.jbmt.2019.03.011

Anhaia, T.C., Klahr, P.D.S., Ourique, A.A.B., Gadenz, C.D., Fernandes, R.A., Spagnol, P.E. & Cassol, M. (2014). Effects of two interventions in teachers with voice complaints. *Audiology-Communication Research*, 9(2), 186-193. doi: 10.1590/S2317-64312014000200014

Angsuwarangsee, T., & Morrison, M. (2002). Extrinsic laryngeal muscular tension in patients with voice disorders. *Journal of Voice*, 16(3), 333-343. doi: 10.1016/S0892-1997(02)00105-4

Behlau, M. (2001). Voz: o livro do especialista. vol. 1. Rio de Janeiro: Revinter, p. 139-147.

Behlau, M., Zambon, F., Guerrieri, A. C., & Roy, N. (2012). Epidemiology of voice disorders in teachers and nonteachers in Brazil: prevalence and adverse effects. *Journal of voice*, *26*(5), 665-e9. doi: 10.1016/j.jvoice.2011.09.010

Behm, D. G., & Wilke, J. (2019). Do self-myofascial release devices release myofascia? Rolling mechanisms: A narrative review. *Sports Medicine*, 49(8), 1173-1181. doi: 10.1007/s40279-019-01149-y

Bigaton, D. R., Silvério, K. C. A., dos Santos Berni, K. C., Distefano, G., Forti, F., & de Jesus Guirro, R. R. (2010). Postura crânio-cervical em mulheres disfônicas Craniocervical posture in dysphonic women. *Revista da Sociedade Brasileira de Fonoaudiologia, 15*(3), 329-34. doi: 10.1590/S1516-80342010000300004

Bovo, R., Galceran, M., Petruccelli, J., & Hatzopoulos, S. (2007). Vocal problems among teachers: evaluation of a preventive voice program. *Journal of voice, 21*(6), 705-722. doi: 10.1016/j.jvoice.2006.07.002

Camargo, Z. A., & Madureira, S. (2009). Dimensões perceptivas das alterações de qualidade vocal e suas correlações aos planos da acústica e da fisiologia. *DELTA: Documentação e Estudos em Linguística Teórica e Aplicada*, *25*(2), 285-317. doi: 10.1590/S0102-44502009000200004

Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019a). Associations between posture, voice, and dysphonia: a systematic review. *Journal of Voice*, 33(1), 124e1-12. DOI 10.1016/j.jvoice.2017.08.030

Carneiro, P.R. & Teles, L.C.D.S. (2012). Influência de alterações posturais, acompanhadas por fotogrametria computadorizada, na produção da voz. *Fisioterapia Movimento*, 25(1):13-20. doi:10.1590/S0103-51502012000100002

Chan, R. W. K. (1994). Does the voice improve with vocal hygiene education? A study of some instrumental voice measures in a group of kindergarten teachers. *Journal of Voice*, *8*(3), 279-291. doi: 10.1016/S0892-1997(05)80300-5

Cho, S. W., Yin, C. S., Park, Y. B., & Park, Y. J. (2011). Differences in self-rated, perceived, and acoustic voice qualities between high-and low-fatigue groups. *Journal of Voice*, *25*(5), 544-552. doi: 10.1016/j.jvoice.2010.07.006

Choi, S. H., Lee, J., Sprecher, A. J., & Jiang, J. J. (2012). The effect of segment selection on acoustic analysis. *Journal of Voice*, *26*(1), 1-7. doi: 10.1016/j.jvoice.2010.10.009

Da Costa, V., Prada, E., Roberts, A., & Cohen, S. (2012). Voice disorders in primary school teachers and barriers to care. *Journal of voice*, *26*(1), 69-76. doi: 10.1016/j.jvoice.2010.09.001

Day, J. A., Copetti, L., & Rucli, G. (2012). From clinical experience to a model for the human fascial system. *Journal of bodywork and movement therapies*, *16*(3), 372-380. doi: 10.1016/j.jbmt.2012.01.003

Day, J. A., Stecco, C., & Stecco, A. (2009). Application of Fascial Manipulation© technique in chronic shoulder pain—Anatomical basis and clinical implications. *Journal of bodywork and movement therapies*, *13*(2), 128-135. doi: 10.1016/j.jbmt.2008.04.044

de Medeiros, A. M., Assunção, A. Á., & Barreto, S. M. (2012). Absenteeism due to voice disorders in female teachers: a public health problem. *International archives of occupational and environmental health*, *85*(8), 853-864. doi: 10.1007/s00420-011-0729-1

D'haeseleer, E., Claeys, S., & Van Lierde, K. (2013). The effectiveness of manual circumlaryngeal therapy in future elite vocal performers: a pilot study. *The Laryngoscope*, *123*(8), 1937-1941. doi: 10.1002/lary.24050

Fachinatto, A. P. A., de Campos Duprat, A., e Silva, M. A., Bracher, E. S. B., de Carvalho Benedicto, C., Luz, V. B. C., & Fonseca, B. S. G. (2015). Effect of spinal manipulative therapy on the singing voice. *Journal of Voice*, *29*(5), 645-e33. doi: 10.1016/j.jvoice.2014.10.005

Guimarães, I. (2007). A ciência e a arte da voz humana. Alcoitão, Escola Superior de Saúde do Alcoitão.

Halawa, W. E., Freire, A. R. F., Muñoz, I. V., & Pérez, S. S. (2014). Assessment of effectiveness of acoustic analysis of voice for monitoring the evolution of vocal nodules after vocal treatment. *European Archives of Oto-Rhino-Laryngology*, *271*(4), 749-756. doi: 10.1007/s00405-013-2685-8

Hou, C. R., Tsai, L. C., Cheng, K. F., Chung, K. C., & Hong, C. Z. (2002). Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. *Archives of physical medicine and rehabilitation*, *83*(10), 1406-1414. doi: 10.1053/apmr.2002.34834

Hsieh, C. Y. J., Adams, A. H., Tobis, J., Hong, C. Z., Danielson, C., Platt, K., Hoehler, F., Reinsch, S., & Rubel, A. (2002). Effectiveness of four conservative treatments for subacute low back pain: a randomized clinical trial. *Spine*, *27*(11), 1142-1148. doi: 10.1097/00007632-200206010-00003

Kennard, E. J., Lieberman, J., Saaid, A., & Rolfe, K. J. (2015). A preliminary comparison of laryngeal manipulation and postural treatment on voice quality in a prospective randomized crossover study. *Journal of Voice, 29*(6), 751-754. doi: 10.1016/j.jvoice.2014.09.026

Kooijman, P. G., De Jong, F. I. C. R. S., Oudes, M. J., Huinck, W., Van Acht, H., & Graamans, K. (2005). Muscular tension and body posture in relation to voice handicap and voice quality in teachers with persistent voice complaints. *Folia phoniatrica et logopaedica*, *57*(3), 134-147. doi:10.1159/000084134

Kooijman, P. G., De Jong, F. I. C. R. S., Thomas, G., Huinck, W., Donders, R., Graamans, K., & Schutte, H. K. (2006). Risk factors for voice problems in teachers. *Folia Phoniatrica et Logopaedica*, *58*(3), 159-174. doi: 10.1159/000091730

Laimi, K., Mäkilä, A., Bärlund, E., Katajapuu, N., Oksanen, A., Seikkula, V., Karppinen, J. & Saltychev, M. (2018). Effectiveness of myofascial release in treatment of chronic musculoskeletal pain: a systematic review. *Clinical rehabilitation*, *32*(4), 440-450. doi: 10.1177/0269215517732820

Lauriello, M., Angelone, A. M., Businco, D. L. R., Passali, D., Bellussi, L. M., & Passali, F. M. (2011). Correlation between female sex and allergy was significant in patients presenting with dysphonia. *Acta Otorhinolaryngologica Italica, 31*(3), 161.

Leppänen, K., Laukkanen, A. M., Ilomäki, I., & Vilkman, E. (2009). A comparison of the effects of voice massage™ and voice hygiene lecture on self-reported vocal well-being and acoustic and perceptual speech parameters in female teachers. *Folia Phoniatrica et Logopaedica*, *61*(4), 227-238. doi: 10.1159/000228000

Lieberman, J. (1998). Principles and techniques of manual therapy: application in the management of dysphonia. *The voice clinical handbook*, 91-138.

Marques, R. M. (2003). *Avaliação fisioterapêutica da postura natural da cabeça e pescoço em portadores de disfunções da articulação temporomandibular por meio da fotometria e radiografia* (Doctoral dissertation). Bauru: Faculdade de Odontologia da Universidade do Sagrado Coração, Brazil.

Marszałek, S., Niebudek-Bogusz, E., Woźnicka, E., Malińska, J., Golusiński, W., & Śliwińska-Kowalska, M. (2012). Assessment of the influence of osteopathic myofascial techniques on normalization of the vocal tract functions in patients with occupational dysphonia. *International journal of occupational medicine and environmental health*, *25*(3), 225-235. doi: 10.2478/S13382-012-0041-7

McKenney, K., Elder, A. S., Elder, C., & Hutchins, A. (2013). Myofascial release as a treatment for orthopaedic conditions: a systematic review. *Journal of athletic training*, *48*(4), 522-527. doi: 10.4085/1062-6050-48.3.17

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C. A., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia*, 14(4), 461-6. doi: 10.1590/S1809-48722010000400014

Munier, C., & Kinsella, R. (2008). The prevalence and impact of voice problems in primary school teachers. *Occupational Medicine*, *58*(1), 74-76. doi: 10.1093/occmed/kqm104

Na, Y., Joo, H. S., Yang, H., Kang, S., Hong, S. H., & Woo, J. (2014). Smartphone-based hearing screening in noisy environments. *Sensors*, 14(6), 10346-10360. doi:10.3390/s140610346

Nemr, K. & Lehn, C. (2010). Voz em Câncer de Cabeça e Pescoço. In: Fernandes, F.D.M., Mendes, B.C.A., Navas, A.L.P.G.P. (2ª Ed). Tratado de Fonoaudiologia. São Paulo, Editora Roca Ltda.: 787-802.

Pilat, A. (2003). *Terapias miofasciales: Inducción miofascial*. McGraw-Hill Interamericana de España.

Pomeranz, B., Macaulay, R., Caudill, M. A., Kutz, I., Adam, D., Gordon, D., Kilborn, K. M., Barger, A. C., Shannon, D. C. & Cohen, R. J. (1985). Assessment of autonomic function in humans by heart rate spectral analysis. *American Journal of Physiology-Heart and Circulatory Physiology*, 248(1), H151-H153.

Rêgo, E. M., Martin, M. M., Filho, A. I. D., Fávero, F. M., Oliveira, A. S. B., & Fontes, S. V. (2012). Efeitos da Liberação Miofascial Sobre a Flexibilidade de um Paciente com Distrofia Miotônica de Steinert. *Revista Neurociências*, *20*(3), 404-409.

Remacle, M., & Eckel, H. E. (Eds.). (2010). *Surgery of larynx and trachea*. Berlin: Springer. p. 12.

Roy, N., & Bless, D. M. (2000). Personality traits and psychological factors in voice pathology: A foundation for future research. *Journal of Speech, Language, and Hearing Research*, *43*(3), 737-748.

Roy, N., Merrill, R. M., Thibeault, S., Parsa, R. A., Gray, S. D., & Smith, E. M. (2004). Prevalence of voice disorders in teachers and the general population. *Journal of Speech, Language, and Hearing Research*. 47:281-93.

Rubin, J. S., Lieberman, J., & Harris, T. M. (2000). Laryngeal manipulation. *Otolaryngologic Clinics of North America*, *33*(5), 1017-1034. doi: 10.1016/S0030-6665(05)70261-9

Sala, E., Laine, A., Simberg, S., Pentti, J., & Suonpää, J. (2001). The prevalence of voice disorders among day care center teachers compared with nurses: a questionnaire and clinical study. *Journal of Voice, 15*(3), 413-423. doi: 10.1016/S0892-1997(01)00042-X

Santos, A. R. R. D. (2014). *Avaliação postural por biofotogrametria em crianças e adolescentes num agrupamento de escolas do concelho de Bragança* (Doctoral dissertation). Instituto Politécnico de Bragança, Portugal.

Santos, M. E. D. (2013). *GRBASH–Scale for Evaluating the Hoarse Voice* (Master dissertation, [sn]). Universidade Fernando Pessoa.

Saratchandran, R., & Desai, S. (2013). Myofascial release as an adjunct to conventional occupational therapy in mechanical low back pain. *The Indian Journal of Occupational Therapy*, *45,* 3-7.

Schleip, R., Duerselen, L., Vleeming, A., Naylor, I. L., Lehmann-Horn, F., Zorn, A., Jaeger, H. & Klingler, W. (2012). Strain hardening of fascia: static stretching of dense fibrous connective tissues can induce a temporary stiffness increase accompanied by enhanced matrix hydration. *Journal of bodywork and movement therapies*, *16*(1), 94-100. doi: 10.1016/j.jbmt.2011.09.003

Simberg, S., Laine, A., Sala, E., & Rönnemaa, A. M. (2000). Prevalence of voice disorders among future teachers. *Journal of voice*, *14*(2), 231-235. doi: 10.1016/S0892-1997(00)80030-2

Simmonds, N., Miller, P., & Gemmell, H. (2012). A theoretical framework for the role of fascia in manual therapy. *Journal of bodywork and movement therapies*, *16*(1), 83-93. doi: 10.1016/j.jbmt.2010.08.001

Sliwinska-Kowalska, M., Niebudek-Bogusz, E., Fiszer, M., Los-Spychalska, T., Kotylo, P., Sznurowska-Przygocka, B., & Modrzewska, M. (2006). The prevalence and risk factors for occupational voice disorders in teachers. *Folia Phoniatrica et Logopaedica*, *58*(2), 85-101. doi: 10.1159/000089610

Smith, E., Gray, S. D., Dove, H., Kirchner, L., & Heras, H. (1997). Frequency and effects of teachers' voice problems. *Journal of voice*, *11*(1), 81-87. doi: 10.1016/S0892-1997(97)80027-6

Smits, I., Ceuppens, P., & De Bodt, M. S. (2005). A comparative study of acoustic voice measurements by means of Dr. Speech and Computerized Speech Lab. *Journal of Voice*, 19(2), 187-196. doi: 10.1016/j.jvoice.2004.03.004

Teixeira, L. C., & Behlau, M. (2015). Comparison between vocal function exercises and voice amplification. *Journal of Voice*, *29*(6), 718-726. doi: 10.1016/j.jvoice.2014.12.012

Ternström, S., Andersson, M., & Bergman, U. (2000). An effect of body massage on voice loudness and phonation frequency in reading. *Logopedics Phoniatrics Vocology*, *25*(4), 146-150. doi: 10.1080/140154300750067520

Tixa, S. (2006). Atlas De Anatomía Palpatoria Tomo 1. Cuello, Tronco Y Extremidad Superior. Elsevier Masson.

Tozzi, P., Bongiorno, D., & Vitturini, C. (2011). Fascial release effects on patients with non-specific cervical or lumbar pain. *Journal of bodywork and movement therapies*, *15*(4), 405-416. doi: 10.1016/j.jbmt.2010.11.003

Uloza, V., Verikas, A., Bacauskiene, M., Gelzinis, A., Pribuisiene, R., Kaseta, M., & Saferis, V. (2011). Categorizing normal and pathological voices: automated and perceptual categorization. *Journal of Voice*, *25*(6), 700-708. doi: 10.1016/j.jvoice.2010.04.009

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, 25(2), 202-207. doi: 10.1016/j.jvoice.2009.10.009

Vogel, A. P., & Morgan, A. T. (2009). Factors affecting the quality of sound recording for speech and voice analysis. *International journal of speech-language pathology*, 11(6), 431-437. doi: 10.3109/17549500902822189

Watts, C. R., Diviney, S. S., Hamilton, A., Toles, L., Childs, L., & Mau, T. (2015). The effect of stretch-and-flow voice therapy on measures of vocal function and handicap. *Journal of Voice*, *29*(2), 191-199. doi: 10.1016/j.jvoice.2014.05.008

Wytrążek, M., Huber, J., Lipiec, J., & Kulczyk, A. (2015). Evaluation of palpation, pressure algometry, and electromyography for monitoring trigger points in young participants. *Journal of manipulative and physiological therapeutics*, *38*(3), 232-243. doi: 10.1016/j.jmpt.2014.12.005

Zielińska-Bliźniewska, H., Pietkiewicz, P., Miłoński, J., Urbaniak, J., & Olszewski, J. (2013). Acoustic and capacity analysis of voice academic teachers with diagnosed hyperfunctional dysphonia by using DiagnoScope Specialist software. *Otolaryngologia Polska*, *67*(3), 144-148. doi: 10.1016/j.otpol.2013.02.001

CONCLUSION

The aim of this thesis was to verify the associations between voice (disorders), posture and ANS, as well as to identify the best treatment strategies, in the context of physiotherapy and complementary therapies, to treat (voice) disorders related to these parameters.

The deepening of this knowledge allows for a multiplicity of assessment and therapeutic actions, which are still underexplored, especially regarding physiotherapy and even speech therapy.

In fact, several similarities were found concerning the relationship between voice, dysphonia, posture and ANS, when the different assessments included in the systematic reviews (papers 1, 2 and 3) were compared to the experimental studies undertaken in teachers (papers 4, 5 and 6), which leads to the following idea across all dimensions: voice, dysphonia or voice complaints, posture, muscle tension, and ANS function are all closely related. Dysphonia can cause muscle tension, and on the other hand, poor posture through muscle tension can potentiate or lead to dysphonia. The same happens with the increase of ANS dysfunctions in teachers with voice complaints (paper 5), which reflect that human laryngeal muscles exhibit an elevated level of activation concurrent with ANS activation. However, in the teachers' sample of paper 4, no significant postural changes were found, although there was an increase in muscle tension in teachers with voice complaints, which is in agreement with other studies in the literature (Bigaton et al., 2010; Menoncin et al., 2010) and in discordance to other studies that confirm that dysphonic participants exhibit significant postural changes (Franco et al., 2014). The increase in muscle tension, which was consensual in these participants (paper 4) and in the literature, may lead to minor postural adjustments that are not easily detected via photogrammetry or do not create significant changes to modify the posture roughly.

It has been found that several therapeutic modalities related to physiotherapy or complementary therapies presented interesting results on the treatment of dysphonia, which shows that they may constitute effective therapeutic options, in a complementary way, for the treatment of functional dysphonia. Concerning general samples of the third systematic review (paper 3), massage, transcutaneous electrical nerve stimulation and acupuncture appear to be effective treatments to reduce voice complaints and improve voice quality. In the teachers' sample of paper 6, myofascial release (MFR) seemed to be an interesting therapeutic modality to include in treatments of voice disorders.

This research has some limitations. First of all, the reviews could have been done including additional languages, and paper 3, which was the first review carried out and published, could have been done considering more databases, as the other two reviews. To update the search for the three systematic reviews, a later search was conducted on the same databases in September 2019 to check for more recent publications on the subjects of the reviews. The selected articles from this research were added in the introduction of this thesis and in the final versions of the experimental papers.

In the experimental studies, the sample was small and it was not possible to obtain the collaboration of an otolaryngologist, although several efforts were undertaken, to perform a laryngoscopy to diagnose the possible type of dysphonia.

Regarding the sample size, the teachers' sample was not easy to obtain. The contacts occurred for a few months before the data collection started and culminated in the arrival of 24 teachers to the hospital. Although small, this sample size is in line with previous studies, as it can be observed in the systematic reviews (papers 1, 2, 3): the studies reported difficulties in obtaining large samples when physical assessments were performed or when interventions were applied to samples of voice professionals with voice complains. This difficulty is evident in the studies that assessed teachers, as was the case of Schneider et al. (2005) who studied 33 teachers and Troni et al. (2006) with 21 teachers. This difficulty was also felt with different samples in the studies included in the third systematic review, as was the case of D'haeseleer et al. (2013), Kennard et al. (2014), Fachinatto et al. (2015) and Silvério et al. (2015), with samples not above 21 participants.

In fact, this was the biggest difficulty of the research, as it was not easy to reconcile the schedules with the teachers so that they could come at the stipulated dates.

Future studies with the same assessment and intervention methods are suggested, but with larger samples. Samples with professionals who are frequently affected with voice disorders, like teachers and singers, are suggested as well as samples with more males. We also suggest studies that verify the long-term effects of MFR in posture, muscle tension and voice.

Considering the crucial role that teachers play in shaping society, and the fact that it is a common profession, the findings suggest the need to continue efforts to research, develop, implement and assess vocal health education programs for specific risk groups (such as teachers). It is important to refer that what now entails a financial burden to the teacher (and in some cases public investment), can be viewed from a totally different perspective given that investing in teachers' voice rehabilitation will probably reduce the expenses with voice-related paid sick leaves. If every municipality had a dedicated program and a service in place to assist teachers with their voice disorders, the number of professionals away from work because of voice-related complaints would likely decrease. This would lead to an improved voice health, better quality of life for teachers and, finally, better education. The same can be applied to other voice professionals.

Based on the results of the different studies which comprise this thesis, it can be argued that its objectives were reached, with the following conclusions worth highlighting:

Regarding general samples:

- The interaction between muscle tension, posture, and vocal use is very complex;
- Individuals with functional or organofunctional dysphonia may have an increase of muscle tension in cervical and perilaryngeal muscles, muscle pain at rest or during function, reduced range of motion in cervical spine, hyperactivity of extrinsic laryngeal muscles and postural changes;
- Muscle tension can both cause dysphonia and be a result of dysphonia as subjects increasingly add muscle effort to try to make their voices work;
- A good posture is necessary because it can help harmonize muscle tensions, which itself can cause postural changes, and permits free movement of the larynx without blockages that bring benefits to voice production;
- ANS function is related to voice as well as to dysphonia, since the individuals with dysphonia tend to show more symptoms of ANS dysfunction;
- Human laryngeal muscles exhibit an elevated level of activation concurrent with ANS activation;
- The transcutaneous electrical nerve stimulation, acupuncture and manual therapy through laryngeal massage and massage of the neck or shoulder girdle may be useful as either unique therapies or as adjunct therapies to other established treatments for voice disorders;
- The knowledge about associations between body posture, laryngeal muscles, autonomic dysfunction, voice production and dysphonia is of supreme importance because a

transdisciplinary action can optimize the assessment and treatment in order to provide benefits to patients with voice disorders.

Regarding teachers:

- Voice disorders are a common problem that occurs more frequently in teachers than in other professionals that use the voice frequently;
- The female gender is predominant in the teaching profession and has a higher prevalence of voice problems, due to the demand of the profession;
- Statistically significant differences in muscle tension in laryngeal intrinsic muscles and auditory-perceptual analysis of voice were found between teachers with voice complaints and teachers without voice complaints;
- There were no statistically significant differences between teachers with voice complaints and teachers without voice complaints in photogrammetry, aerodynamic and acoustic analysis of voice;
- Compared with teachers without voice complaints, teachers with voice complaints presented a higher occurrence of neurovegetative symptoms directly related with voice;
- Regarding heart rate variability, findings indicated significantly lower values in RMSSD and pNN50 of teachers with voice complaints when compared with teachers without voice complaints;
- Regarding the acoustic analysis of voice and neurovegetative symptoms not directly related to voice, there were no statistically significant differences between teachers with voice complaints and teachers without voice complaints;
- The myofascial release seemed to be an effective therapy in improving maximum phonation time, two subscales of the GRABASH scale (Grade and Roughness), muscle tension through palpation and algometry;
- Regarding photogrammetry, myofascial release showed an immediate effect in improving posture, especially related to the head;
- The myofascial release did not provide significant changes in F_0, F_0SD, Jitter, Shimmer and HNR.

REFERENCES

Aghadoost, S., Jalaie, S., Khatoonabadi, A. R., Dabirmoghaddam, P., & Khoddami, S. M. (2019). A Study of Vocal Facilitating Techniques Compared to Manual Circumlaryngeal Therapy in Teachers With Muscle Tension Dysphonia. *Journal of Voice*. In press. doi: 10.1016/j.jvoice.2019.06.002

Ajimsha, M. S. (2011). Effectiveness of direct vs indirect technique myofascial release in the management of tension-type headache. *Journal of bodywork and movement therapies*, *15*(4), 431-435. doi: 10.1016/j.jbmt.2011.01.021

Ajimsha, M. S., Al-Mudahka, N. R., & Al-Madzhar, J. A. (2015). Effectiveness of myofascial release: Systematic review of randomized controlled trials. *Journal of bodywork and movement therapies*, *19*(1), 102-112. doi: 10.1016/j.jbmt.2014.06.001

Ajimsha, M. S., Daniel, B., & Chithra, S. (2014). Effectiveness of myofascial release in the management of chronic low back pain in nursing professionals. *Journal of bodywork and movement therapies*, *18*(2), 273-281. doi: 10.1016/j.jbmt.2013.05.007

Ajimsha, M. S., & Shenoy, P. D. (2019). Improving the quality of myofascial release research–A critical appraisal of systematic reviews. *Journal of Bodywork and Movement Therapies*. 23(3), 561-567. doi: 10.1016/j.jbmt.2019.03.011

Aldabe, D., Milosavljevic, S., & Bussey, M. D. (2012). Is pregnancy related pelvic girdle pain associated with altered kinematic, kinetic and motor control of the pelvis? A systematic review. *European Spine Journal*, 21(9), 1777-1787. doi: 10.1007/s00586-012-2401-1

Alvear, R. M. B. D., Barón-López, F. J., Alguacil, M. D., & Dawid-Milner, M. S. (2013). Interactions between voice fundamental frequency and cardiovascular parameters. Preliminary results and physiological mechanisms. *Logopedics Phoniatrics Vocology*, 38(2), 52-58. doi:10.3109/14015439.2012.696140

Angsuwarangsee, T. & Morrison M. (2002). Extrinsic laryngeal muscular tension in patients with voice disorders. *Journal of Voice*, 16(3), 333-343. doi: 10.1016/S0892-1997(02)00105-4

Anhaia, T.C., Klahr, P.D.S., Ourique, A.A.B., Gadenz, C.D., Fernandes, R.A., Spagnol, P.E. & Cassol, M. (2014). Effects of two interventions in teachers with voice complaints. *Audiology-Communication Research*, 9(2), 186-193. doi: 10.1590/S2317-64312014000200014

Arboleda, B.M.W. & Frederick, A.L. (2008). Considerations for maintenance of postural alignment for voice production. *Journal of Voice*, 22(1), 90-9. doi: 10.1016/j.jvoice.2006.08.001

Artkoski, M., Tommila, J., & Laukkanen, A. M. (2002). Changes in voice during a day in normal voices without vocal loading. *Logopedics Phoniatrics Vocology*, 27(3), 118-123. doi: 10.1080/140154302760834840

Aronson, A.E. (1990). Therapy for voice disorders. In Aronson, A.E. *Clinical Voice Disorders*. 3rd ed. New York: Thieme/Stratton; 309-47.

Barkmeier, J. M., & Case, J. L. (2000). Differential diagnosis of adductor-type spasmodic dysphonia, vocal tremor, and muscle tension dysphonia. *Current Opinion in Otolaryngology & Head and Neck Surgery*, *8*(3), 174-179.

Beardsley, C., & Škarabot, J. (2015). Effects of self-myofascial release: A systematic review. *Journal of bodywork and movement therapies*, 19(4), 747-758. doi: 10.1016/j.jbmt.2015.08.007

Behlau, M. (2001). Voz: o livro do especialista. vol. 1. Rio de Janeiro: Revinter, p. 139-147.

Behlau, M., Feijó, D., Madazio, G., Rehder, M. I., Azevedo, R., & Ferreira, A. E. (2005). Voz profissional: aspectos gerais e atuação fonoaudiológica. *Voz: o livro do especialista*, *2*, 26-35.

Behlau, M. & Pontes, P. (1995). Avaliação e tratamento das disfonias. *São Paulo: Lovise*, 143-66.

Behlau, M. & Pontes, P. (2001). Higiene vocal - Cuidando da voz. Rio de Janeiro, Revinter.

Behlau, M., Madazio, G. & Oliveira, G. (2015). Functional dysphonia: strategies to improve patient outcomes. *Patient Related Outcome Measures,* 6, 243. doi: 10.2147/PROM.S68631

Behlau, M., Zambon, F., Guerrieri, A.C. & Roy, N. (2012). Epidemiology of voice disorders in teachers and nonteachers in Brazil: prevalence and adverse effects. *Journal of voice,* 26(5), 665-e9. doi: 10.1016/j.jvoice.2011.09.010

Behm, D. G., & Wilke, J. (2019). Do self-myofascial release devices release myofascia? Rolling mechanisms: A narrative review. *Sports Medicine*, 49(8), 1173-1181. doi: 10.1007/s40279-019-01149-y

Benichou, T., Pereira, B., Mermillod, M., Tauveron, I., Pfabigan, D., Maqdasy, S., & Dutheil, F. (2018). Heart rate variability in type 2 diabetes mellitus: A systematic review and meta–analysis. *PLoS One*, *13*(4), e0195166. doi: 10.1371/journal.pone.0195166

Benninger, M.S., Holy, C.E., Bryson, P.C. & Milstein, C.F. (2017). Prevalence and Occupation of Patients Presenting With Dysphonia in the United States. *Journal of Voice, 31*(5), 594-600. doi: 10.1016/j.jvoice.2017.01.011

Bigaton, D. R., Silvério, K. C. A., dos Santos Berni, K. C., Distefano, G., Forti, F., & de Jesus Guirro, R. R. (2010). Postura crânio-cervical em mulheres disfônicas Craniocervical posture in dysphonic women. *Revista da Sociedade Brasileira de Fonoaudiologia*, *15*(3), 329-34. doi: 10.1590/S1516-80342010000300004

Boone, D. R. (1996). Sua voz está traindo você. *Como encontrar e usar sua voz natural.1ª edição,* Artes Médicas, Porto Alegre.

Bouhuys, A. L., Schutte, H. K., Beersma, D. G., & Nieboer, G. L. (1990). Relations between depressed mood and vocal parameters before, during and after sleep deprivation: a circadian rhythm study. *Journal of affective disorders*, 19(4), 249-258. doi: 10.1016/0165-0327(90)90102-E

Bovo, R., Galceran, M., Petruccelli, J., & Hatzopoulos, S. (2007). Vocal problems among teachers: evaluation of a preventive voice program. *Journal of voice, 21*(6), 705-722. doi: 10.1016/j.jvoice.2006.07.002

Brasolotto AG, Fabiano SRR. (2000). Uso profissional da voz pelo professor–análise acústica. *Revista da Sociedade Brasileira de Fonoaudiologia*, *6*, 6-11.

Bruno, E., De Padova, A., Napolitano, B., Marroni, P., Batelli, R., Ottaviani, F., & Alessandrini, M. (2009). Voice disorders and posturography: variables to define the success of rehabilitative treatment. *Journal of Voice*, *23*(1), 71-75.

Camargo, Z. A., & Madureira, S. (2009). Dimensões perceptivas das alterações de qualidade vocal e suas correlações aos planos da acústica e da fisiologia. *DELTA: Documentação e Estudos em Linguística Teórica e Aplicada*, *25*(2), 285-317. doi: 10.1590/S0102-44502009000200004

Cambri, L. T., Fronchetti, L., De-Oliveira, F. R. & Gevaerd, M. S. (2008). Variabilidade da frequência cardíaca e controle metabólico. *Arquivos Sanny de pesquisa em saúde*, 1(1), 72-82.

Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019a). Associations between posture, voice, and dysphonia: A systematic review. *Journal of Voice*, 33(1), 124e1-12. doi: 10.1016/j.jvoice.2017.08.030

Cardoso, R., Lumini-Oliveira, J., & Meneses, R. F. (2019b, in press). Associations between autonomic nervous system function, voice, and dysphonia: A systematic review. *Journal of Voice*. doi: 10.1016/j.jvoice.2019.07.022

Cardoso, R., Meneses, R. F., & Lumini-Oliveira, J. (2017). The effectiveness of physiotherapy and complementary therapies on voice disorders: A systematic review of randomized controlled trials. *Frontiers in medicine 4*(45). doi: 10.3389/fmed.2017.00045

Carneiro, P. R. (2013). *A influência de diferentes posturas da coluna cervical na análise do sinal de voz* (Doctoral dissertation). Universidade de São Paulo, Brasil.

Carneiro, P. R., & Teles, L. C. D. S. (2012). Influência de alterações posturais, acompanhadas por fotogrametria computadorizada, na produção da voz. *Fisioterapia em Movimento*, 25(1):13-20. doi:10.1590/S0103-51502012000100002

Chan, R. W. K. (1994). Does the voice improve with vocal hygiene education? A study of some instrumental voice measures in a group of kindergarten teachers. *Journal of Voice, 8*(3), 279-291. doi: 10.1016/S0892-1997(05)80300-5

Cho, S. W., Yin, C. S., Park, Y. B., & Park, Y. J. (2011). Differences in self-rated, perceived, and acoustic voice qualities between high-and low-fatigue groups. *Journal of Voice, 25*(5), 544-552. doi: 10.1016/j.jvoice.2010.07.006

Choi, S. H., Lee, J., Sprecher, A. J., & Jiang, J. J. (2012). The effect of segment selection on acoustic analysis. *Journal of Voice*, *26*(1), 1-7. doi: 10.1016/j.jvoice.2010.10.009

ChuDuc, H., NguyenPhan, K., & NguyenViet, D. (2013). A review of heart rate variability and its applications. *APCBEE procedia*, *7*, 80-85.

Cialdini, R. D. C. V., & Behlau, M. S. (2005). Ação da postura corporal estática e da força dos músculos respiratórios e sua correlação com a produção e qualidade vocal em professores. *The Brazilian Journal of Physical Therapy*, 6(3), 168-174.

Cielo, C. A., Conterno, G., Carvalho, C. D. D. M., & Finger, L. S. (2008). Disfonias: relação s/ze tipos de voz. *Revista CEFAC*, *10*(4), 536-47. doi:10.1590/S1516-18462008000400014

Cielo, C. A., Ribeiro, V. V., & Hoffmann, C. F. (2015). Sinais e sintomas de disfunção autônoma em professores e sua relação com as queixas vocais e as variáveis ocupacionais. *Distúrbios da Comunicação*, 27(3).

Conde, M. D. C. M., Siqueira, L. T. D., Vendramini, J. E., Brasolotto, A. G., de Jesus Guirro, R. R., & Silverio, K. C. A. (2018). Transcutaneous electrical nerve stimulation (TENS) and laryngeal manual therapy (LMT): immediate effects in women with dysphonia. *Journal of Voice*, *32*(3), 385-e17. doi: 10.1016/j.jvoice.2017.04.019

Copie, X., Heuzey, J. Y. L., Iliou, M. C., Khouri, R., Lavergne, T., Pousset, F., & Guize, L. (1996). Correlation between time-domain measures of heart rate variability and scatterplots in postinfarction patients. *Pacing and Clinical Electrophysiology*, *19*(3), 342-347. doi: 10.1111/j.1540-8159.1996.tb03336

Corrêa, E. C., & Bérzin, F. (2007). Efficacy of physical therapy on cervical muscle activity and on body posture in school-age mouth breathing children. *International journal of pediatric otorhinolaryngology*, *71*(10), 1527-1535. doi: 10.1016/j.ijporl.2007.05.031

Craig, J., Tomlinson, C., Stevens, K., Kotagal, K., Fornadley, J., Jacobson, B., & Francis, D. O. (2015). Combining voice therapy and physical therapy: a novel approach to treating muscle tension dysphonia. *Journal of communication disorders*, *58*, 169-178. doi: 10.1016/j.jcomdis.2015.05.001

Da Costa, V., Prada, E., Roberts, A., & Cohen, S. (2012). Voice disorders in primary school teachers and barriers to care. *Journal of voice*, *26*(1), 69-76. doi: 10.1016/j.jvoice.2010.09.001

Day, J. A., Copetti, L., & Rucli, G. (2012). From clinical experience to a model for the human fascial system. *Journal of bodywork and movement therapies*, *16*(3), 372-380. doi: 10.1016/j.jbmt.2012.01.003

Day, J. A., Stecco, C., & Stecco, A. (2009). Application of Fascial Manipulation© technique in chronic shoulder pain—Anatomical basis and clinical implications. *Journal of bodywork and movement therapies*, *13*(2), 128-135. doi: 10.1016/j.jbmt.2008.04.044

de Brito Mota, A. F., Giannini, S. P. P., de Oliveira, I. B., Paparelli, R., Dornelas, R., & Ferreira, L. P. (2019). Voice Disorder and Burnout Syndrome in Teachers. *Journal of Voice*, *33*(4), 581-e7. doi: 10.1016/j.jvoice.2018.01.022

de Medeiros, A. M., Assunção, A. Á., & Barreto, S. M. (2012). Absenteeism due to voice disorders in female teachers: a public health problem. *International archives of* *occupational and environmental health*, *85*(8), 853-864. doi: 10.1007/s00420-011-0729-1

Demmink-Geertman, L., & Dejonckere, P. H. (2002). Nonorganic habitual dysphonia and autonomic dysfunction. *Journal of Voice*, 16(4), 549-559. doi: 10.1016/S0892-1997(02)00130-3

Demmink-Geertman, L., & Dejonckere, P. H. (2008). Neurovegetative symptoms and complaints before and after voice therapy for nonorganic habitual dysphonia. *Journal of Voice*, *22*(3), 315-325. doi: 10.1016/j.jvoice.2006.10.011

Demmink-Geertman, L., & Dejonckere, P. H. (2010). Differential effects of voice therapies on neurovegetative symptoms and complaints. *Journal of Voice*, *24*(5), 585-591. doi: 10.1016/j.jvoice.2008.12.013

Deturk, W. E., & Cahalin, L. P. (2007). *Fisioterapia Cardiorespiratória: baseada em evidências*. Artmed Editora.

D'haeseleer, E., Claeys, S., & Van Lierde, K. (2013). The effectiveness of manual circumlaryngeal therapy in future elite vocal performers: a pilot study. *The Laryngoscope*, *123*(8), 1937-1941. doi: 10.1002/lary.24050

Dietrich, M., Abbott, K. V., Gartner-Schmidt, J., & Rosen, C. A. (2008). The frequency of perceived stress, anxiety, and depression in patients with common pathologies affecting voice. *Journal of Voice*, 22(4), 472-488. doi: 10.1016/j.jvoice.2006.08.007

Do Brasil, O. D. O. C., Yamasaki, R., & de Souza Leão, S. H. (2005). Proposta de medição da posição vertical da laringe em repouso. *Brazilian Journal of Otorhinolaryngology*, *71*, 313-317. doi: 10.1590/S0034-72992005000300008

Dutton, M. (2008). *Orthopaedic examination, evaluation, and intervention*. 2nd ed. New York, NY: McGraw-Hill.

Erman, A. B., Kejner, A. E., Hogikyan, N. D., & Feldman, E. L. (2009). Disorders of cranial nerves IX and X. In Seminars in neurology, *Thieme Medical Publishers*, 29(01): 085-092.

Estenne, M., Zocchi, L., Ward, M., & Macklem, P. T. (1990). Chest wall motion and expiratory muscle use during phonation in normal humans. *Journal of Applied Physiology*, *68*(5), 2075-2082.

Fachinatto, A. P. A., de Campos Duprat, A., & Silva, M. A., Bracher, E. S. B., de Carvalho Benedicto, C., Luz, V. B. C., & Fonseca, B. S. G. (2015). Effect of spinal manipulative therapy on the singing voice. *Journal of Voice*, *29*(5), 645-e33. doi: 10.1016/j.jvoice.2014.10.005

Farrell, T. G., Bashir, Y., Cripps, T., Malik, M., Poloniecki, J., Bennett, E. D., Ward D. E. & Camm, A. J. (1991). Risk stratification for arrhythmic events in postinfarction patients based on heart rate variability, ambulatory electrocardiographic variables and the signal-averaged electrocardiogram. *Journal of the American College of Cardiology*, *18*(3), 687-697.

Ferreira, L., & Costa, H. (2000). Falando sobre o profissional da voz. São Paulo: Editora Roca Ltda.

Ferreira, L. P., & Costa, H. O. (2001). Voz Ativa: falando sobre a clínica fonoaudiológica. *Roca, São Paulo*.

Ferreira, L. P., Gianini, S. P., Figueira, S., Silva, E. E., Karmann, D. D. F., & de Souza, T. M. T. (2003). Condições de produção vocal de professores da prefeitura do município de São Paulo. *Distúrbios da Comunicação*, *14*(2).

Ferreira, L. P., Souza, T. M. T., Zambon, F., Barreto, R. K. A., & Maciel, M. C. B. T. (2010). Voz do professor: gerenciamento de grupos. *Distúrbios da Comunicação*, *22*(3).

Figueiredo, D. C. D., Souza, P. R. F., Gonçalves, M. I. R., & Biase, N. D. (2003). Análise perceptivo-auditiva, acústica computadorizada e laringológica da voz de adultos jovens fumantes e não-fumantes. *Revista Brasileira de Otorrinolaringologia*, *69*(6), 791-9. doi: 10.1590/S0034-72992003000600011

Force, T. (1996). Standards of measurement, physiological interpretation and clinical use. Task force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Circulation*, *93*(5), 1043-1065.

Franco, D., Martins, F., Andrea, M., Fragoso, I., Carrão, L., & Teles, J. (2014). Is the sagittal postural alignment different in normal and dysphonic adult speakers?. *Journal of Voice*, *28*(4), 523-e1. doi: 10.1016/j.jvoice.2014.01.002

Freitas, S. V. (2006). Disfonia em professoras do Primeiro Ciclo do Ensino Básico: prevalência e factores de risco. *Arquivos de medicina*, *20*(5-6), 145-152.

Giannini, S. P. P., Latorre, M. D. R. D. D., & Ferreira, L. P. (2012). Distúrbio de voz e estresse no trabalho docente: um estudo caso-controle. *Cadernos de Saúde Pública*, *28*, 2115-2124. doi: 10.1590/S0102-311X2012001100011

Gilman, M., & Johns, M. M. (2016). The effect of head position and/or stance on the self-perception of phonatory effort. *Journal of Voice*, *31*(1), 131-e1. doi: 10.1016/j.jvoice.2015.11.024

Golub, J. S., Chen, P. H., Otto, K. J., Hapner, E., & Johns, M. M. (2006). Prevalence of perceived dysphonia in a geriatric population. *Journal of the American Geriatrics Society*, *54*(11), 1736-1739.

Gonçalves, J. (2014). A influência do sistema nervoso autónomo na resposta inflamatória da sepsis. *Arquivos de Medicina*, *28*(1), 08-17.

Guimarães, I. (2007). A ciência e a arte da voz humana. Alcoitão, Escola Superior de Saúde do Alcoitão.

Guirro, R. R. D. J., Bigaton, D. R., Silvério, K. C. A., Berni, K. C. D. S., Distéfano, G., Santos, F. L. D., & Forti, F. (2008). Transcutaneous electrical nerve stimulation in dysphonic women. *Pró-Fono Revista de Atualização Científica*, *20*(3), 189-194. doi: 10.1590/S0104-56872008000300009

Guzman, M., Laukkanen, A. M., Krupa, P., Horáček, J., Švec, J. G., & Geneid, A. (2013). Vocal tract and glottal function during and after vocal exercising with resonance tube and straw. *Journal of Voice*, *27*(4), 523-e19. doi: 10.1016/j.jvoice.2013.02.007

Halawa, W. E., Freire, A. R. F., Muñoz, I. V., & Pérez, S. S. (2014). Assessment of effectiveness of acoustic analysis of voice for monitoring the evolution of vocal nodules after vocal treatment. *European Archives of Oto-Rhino-Laryngology*, *271*(4), 749-756. doi: 10.1007/s00405-013-2685-8

Hartikainen, J. E., Malik, M., Staunton, A., Poloniecki, J., & Camm, A. J. (1996). Distinction between arrhythmic and nonarrhythmic death after acute myocardial infarction based on heart rate variability, signal-averaged electrocardiogram, ventricular arrhythmias and left ventricular ejection fraction. *Journal of the American College of Cardiology*, *28*(2), 296-304.

Helou, L. B., Wang, W., Ashmore, R. C., Rosen, C. A., & Abbott, K. V. (2013). Intrinsic laryngeal muscle activity in response to autonomic nervous system activation. *The Laryngoscope*, 123(11), 2756-2765. doi: 10.1002/lary.24109

Hisa, Y., Bamba, H., Koike, S., Shogaki, K., Tadaki, N., & Uno, T. (1999). Neurotransmitters and neuromodulators involved in laryngeal innervation. *Annals of Otology, Rhinology & Laryngology*, 108(7_suppl), 3-14. doi: 10.1177/00034894991080S702

Hoit, J. D., Plassman, B. L., Lansing, R. W., & Hixon, T. J. (1988). Abdominal muscle activity during speech production. *Journal of Applied Physiology*, *65*(6), 2656-2664.

Hou, C. R., Tsai, L. C., Cheng, K. F., Chung, K. C., & Hong, C. Z. (2002). Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. *Archives of physical medicine and rehabilitation*, *83*(10), 1406-1414. doi: 10.1053/apmr.2002.34834

Hsieh, C. Y. J., Adams, A. H., Tobis, J., Hong, C. Z., Danielson, C., Platt, K., Hoehler, F., Reinsch, S., & Rubel, A. (2002). Effectiveness of four conservative treatments for subacute low back pain: a randomized clinical trial. *Spine*, *27*(11), 1142-1148. doi: 10.1097/00007632-200206010-00003

Imamura, R., & Tsuji, D. H. (2006). Disfonia espasmódica de adução, tremor vocal e disfonia de tensão muscular: é possível fazer o diagnóstico diferencial?. *Revista brasileira de otorrinolaringologia*, *72*(4), 434.

Iunes, D. H., Castro, F. A., Salgado, H. S., Moura, I. C., Oliveira, A. S., & Bevilaqua-Grossi, D. (2005). Confiabilidade intra e interexaminadores e repetibilidade da avaliação postural pela fotogrametria. *Brazilian Journal of Physical Therapy*, *9*(3), 327-34.

Iwarsson, J. (2001). Effects of inhalatory abdominal wall movement on vertical laryngeal position during phonation. *Journal of Voice*, *15*(3), 384-394. doi: 10.1016/S0892-1997(01)00040-6

Johnson, G., & Skinner, M. (2009). The demands of professional opera singing on craniocervical posture. *European Spine Journal*, *18*(4), 562. doi: 10.1007/s00586-009-0884-1

Kautzner, J., & Camm, A. J. (1997). Clinical relevance of heart rate variability. *Clinical cardiology*, *20*(2), 162-168. doi: 10.1002/clc.4960200214

Kennard, E. J., Lieberman, J., Saaid, A., & Rolfe, K. J. (2015). A preliminary comparison of laryngeal manipulation and postural treatment on voice quality in a prospective randomized crossover study. *Journal of Voice*, *29*(6), 751-754. doi: 10.1016/j.jvoice.2014.09.026

Khoddami, S. M., Ansari, N. N., & Jalaie, S. (2015). Review on laryngeal palpation methods in muscle tension dysphonia: validity and reliability issues. *Journal of Voice*, *29*(4), 459-468. doi: 10.1016/j.jvoice.2014.09.023

Kleiger, R. E., Stein, P. K., & Bigger Jr, J. T. (2005). Heart rate variability: measurement and clinical utility. *Annals of Noninvasive Electrocardiology*, *10*(1), 88-101. doi: 10.1111/j.1542-474X.2005.10101

Kooijman, P. G., De Jong, F. I. C. R. S., Oudes, M. J., Huinck, W., Van Acht, H., & Graamans, K. (2005). Muscular tension and body posture in relation to voice handicap and voice quality in teachers with persistent voice complaints. *Folia phoniatrica et logopaedica*, *57*(3), 134-147. doi:10.1159/000084134

Kooijman, P. G., De Jong, F. I. C. R. S., Thomas, G., Huinck, W., Donders, R., Graamans, K., & Schutte, H. K. (2006). Risk factors for voice problems in teachers. *Folia Phoniatrica et Logopaedica*, *58*(3), 159-174. doi: 10.1159/000091730

Koufman, J. A. (1991). Approach to the patient with a voice disorder. *Otolaryngologic Clinics of North America*, *24*(5), 989-998.

Koufman, J. A., & Blalock, P. D. (1991). Functional voice disorders. *Otolaryngologic Clinics of North America*, 24(5), 1059.

Lagier, A., Vaugoyeau, M., Ghio, A., Legou, T., Giovanni, A., & Assaiante, C. (2010). Coordination between posture and phonation in vocal effort behavior. *Folia Phoniatrica et Logopaedica*, *62*(4), 195-202. doi: 10.1159/000314264

Laimi, K., Mäkilä, A., Bärlund, E., Katajapuu, N., Oksanen, A., Seikkula, V., Karppinen, J. & Saltychev, M. (2018). Effectiveness of myofascial release in treatment of chronic musculoskeletal pain: a systematic review. *Clinical rehabilitation*, *32*(4), 440-450. doi: 10.1177/0269215517732820

Lauriello, M., Angelone, A. M., Businco, D. L. R., Passali, D., Bellussi, L. M., & Passali, F. M. (2011). Correlation between female sex and allergy was significant in patients presenting with dysphonia. *Acta Otorhinolaryngologica Italica*, *31*(3), 161.

Lefkowitz R.J., Hoffman B.B., & Taylor P. (1996). Neurotransmission: The autonomic and somatic motor nervous systems. *Goodman & Gilman´s. The Pharmacologyical Basis of Therapeutics*. 9th ed. Section II, Chap 6. New York: Mc Graw Hill. p.105-40.

Lehman, G. J., Vernon, H., & McGill, S. M. (2001). Effects of a mechanical pain stimulus on erector spinae activity before and after a spinal manipulation in patients with back pain: a preliminary investigation. *Journal of Manipulative and Physiological Therapeutics*, *24*(6), 402-406. doi: 10.1067/mmt.2001.116421

Leppänen, K., Laukkanen, A. M., Ilomäki, I., & Vilkman, E. (2009). A comparison of the effects of voice massage™ and voice hygiene lecture on self-reported vocal well-being and acoustic and perceptual speech parameters in female teachers. *Folia Phoniatrica et Logopaedica*, *61*(4), 227-238. doi: 10.1159/000228000

Li, Z., Snieder, H., Su, S., Ding, X., Thayer, J. F., Treiber, F. A., & Wang, X. (2009). A longitudinal study in youth of heart rate variability at rest and in response to stress. *International Journal of Psychophysiology*, *73*(3), 212-217. doi: 10.1016/j.ijpsycho.2009.03.002

Lieberman, J. (1998). Principles and techniques of manual therapy: application in the management of dysphonia. *The voice clinical handbook*, 91-138.

Maher, C. G., Sherrington, C., Herbert, R. D., Moseley, A. M., & Elkins, M. (2003). Reliability of the PEDro scale for rating quality of randomized controlled trials. *Physical therapy*, *83*(8), 713-721.

Maigne, J. Y., & Vautravers, P. (2003). Mechanism of action of spinal manipulative therapy. *Joint bone spine*, *70*(5), 336-341. doi: 10.1016/S1297-319X(03)00074-5

Malliani, A. (2005). Heart rate variability: from bench to bedside. *European journal of internal medicine*, *16*(1), 12-20. doi:10.1016/j.ejim.2004.06.016

Marques, N. R., Hallal, C. Z., & Gonçalves, M. (2010). Características biomecânicas, ergonômicas e clínicas da postura sentada: uma revisão. *Fisioterapia e pesquisa*, *17*(3), 270-276.

Marques, R. M. (2003). *Avaliação fisioterapêutica da postura natural da cabeça e pescoço em portadores de disfunções da articulação temporomandibular por meio da fotometria e radiografia* (Doctoral dissertation). Bauru: Faculdade de Odontologia da Universidade do Sagrado Coração, Brasil.

Marszałek, S., Niebudek-Bogusz, E., Woźnicka, E., Malińska, J., Golusiński, W., & Śliwińska-Kowalska, M. (2012). Assessment of the influence of osteopathic myofascial techniques on normalization of the vocal tract functions in patients with occupational dysphonia. *International journal of occupational medicine and environmental health*, *25*(3), 225-235. DOI 10.2478/S13382-012-0041-7

Mautner, H. D. (2015a). An acoustic and electroglottographic study of the aging voice with and without an open jaw posture. *Journal of Voice*, *29*(4), 518-e1. doi: 10.1016/j.jvoice.2014.09.024

Mautner, H. D. (2015b). Effects of an open jaw posture on vowel perception in the aging voice. *Journal of Voice*, *30*(6), 772-e23. doi: 10.1016/j.jvoice.2015.11.011

McKenney, K., Elder, A. S., Elder, C., & Hutchins, A. (2013). Myofascial release as a treatment for orthopaedic conditions: a systematic review. *Journal of athletic training*, *48*(4), 522-527. doi: 10.4085/1062-6050-48.3.17

Mello, E. L., Silva, M. A. D. A., Ferreira, L. P., & Herr, M. (2009). Voz do cantor lírico e coordenação motora: uma intervenção baseada em Piret e Béziers. *Revista da Sociedade Brasileira de Fonoaudiologia*, 352-361. doi: 10.1590/S1516-80342009000300011

Menoncin, L. C. M., Jurkiewicz, A. L., Silvério, K. C. A., Camargo, P. M., & Wolff, N. M. M. (2010). Alterações musculares e esqueléticas cervicais em mulheres disfônicas. *Arquivos Internacionais de Otorrinolaringologia,* 14(4), 461-6. doi: 10.1590/S1809-48722010000400014

Miller, N. A., Gregory, J. S., Semple, S. I., Aspden, R. M., Stollery, P. J., & Gilbert, F. J. (2012). The effects of humming and pitch on craniofacial and craniocervical morphology measured using MRI. *Journal of Voice*, *26*(1), 90-101. doi: 10.1016/j.jvoice.2010.10.017

Miller, N. A., Gregory, J. S., Aspden, R. M., Stollery, P. J., & Gilbert, F. J. (2014). Using active shape modeling based on MRI to study morphologic and pitch-related functional changes affecting vocal structures and the airway. *Journal of Voice*, *28*(5), 554-564.doi: 10.1016/j.jvoice.2013.12.002

Mitchinson, A. G. H., & Yoffey, J. M. (1948). Changes in the vocal folds in humming low and high notes. A radiographic study. *Journal of anatomy*, *82*(Pt 1-2), 88.

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., & Prisma Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *Annals of internal medicine*,151(4): 264-269. doi: 10.1371/journal.pmed.1000097

Morrison, M. (1997). Pattern recognition in muscle misuse voice disorders: How I do it. Journal of Voice, 11(1), 108-114. doi: 10.1016/S0892-1997(97)80031-8

Munier, C., & Kinsella, R. (2008). The prevalence and impact of voice problems in primary school teachers. *Occupational Medicine*, *58*(1), 74-76. doi: 10.1093/occmed/kqm104

Na, Y., Joo, H. S., Yang, H., Kang, S., Hong, S. H., & Woo, J. (2014). Smartphone-based hearing screening in noisy environments. *Sensors*, 14(6), 10346-10360. doi:10.3390/s140610346

Nemr, K. & Lehn, C. (2010). Voz em Câncer de Cabeça e Pescoço. In: Fernandes, F.D.M., Mendes, B.C.A., Navas, A.L.P.G.P. (2ª Ed). Tratado de Fonoaudiologia. São Paulo, Editora Roca Ltda.: 787-802.

Oates, J. (2009). Auditory-perceptual evaluation of disordered voice quality. *Folia Phoniatrica et Logopaedica*, 61(1), 49-56. doi: 10.1159/000200768

Orlikoff, R. F., & Baken, R. J. (1989). The effect of the heartbeat on vocal fundamental frequency perturbation. *Journal of Speech, Language, and Hearing Research*, 32(3), 576-582.

Ortiz, E., Costa, E. A. D., Spina, A. L., & Crespo, A. N. (2004). Multidisciplinary protocol proposal for professional dysphonia: preliminary study. *Revista Brasileira de Otorrinolaringologia*, *70*(5), 590-596. doi: 10.1590/S0034-72992004000500003

Otzenberger, H., Gronfier, C., Simon, C., Charloux, A., Ehrhart, J., Piquard, F., & Brandenberger, G. (1998). Dynamic heart rate variability: a tool for exploring sympathovagal balance continuously during sleep in men. *American Journal of Physiology-Heart and Circulatory Physiology*, *275*(3), H946-H950.

Paes, C. F., Zambon, F. C., & Behlau, M. (2014). Signs and symptoms of the autonomic dysfunction in teachers. *Revista CEFAC*, 16(3), 957-966. doi: 10.1590/1982-021620141613

Paniccia, M., Paniccia, D., Thomas, S., Taha, T., & Reed, N. (2017). Clinical and non-clinical depression and anxiety in young people: a scoping review on heart rate variability. *Autonomic Neuroscience, 208*, 1-14. doi: 10.1016/j.autneu.2017.08.008

Parent A. (1996). *Carpenter's Human Neuroanatomy*. Baltimore, MD: Williams & Wilkins, 9: 442-451.

Park, K., & Behlau, M. (2011). Sinais e sintomas da disfunção autônoma em indivíduos disfônicos. *Jornal da Sociedade Brasileira de Fonoaudiologia*, 23(2), 164-9. doi: 10.1590/S2179-64912011000200014

Park, C. K., Lee, S., Park, H. J., Baik, Y. S., Park, Y. B., & Park, Y. J. (2011). Autonomic function, voice, and mood states. *Clinical Autonomic Research*, 21(2), 103-110. doi: 10.1007/s10286-010-0095-1

Patel, R. R., Awan, S. N., Barkmeier-Kraemer, J., Courey, M., Deliyski, D., Eadie, T., Paul, D., Švec, J. G., & Hillman, R. (2018). Recommended Protocols for Instrumental Assessment of Voice: American Speech-Language-Hearing Association Expert Panel to Develop a Protocol for Instrumental Assessment of Vocal Function. *American journal of speech-language pathology*, 27(3), 887–905. https://doi.org/10.1044/2018_AJSLP-17-0009

Patra, S., & Telles, S. (2010). Heart rate variability during sleep following the practice of cyclic meditation and supine rest. *Applied psychophysiology and biofeedback*, *35*(2), 135-140. doi: 10.1007/s10484-009-9114-1

Pettersen, V., & Westgaard, R. H. (2004). Muscle activity in professional classical singing: a study on muscles in the shoulder, neck and trunk. *Logopedics Phoniatrics Vocology*, *29*(2), 56-65. doi: 10.1080/14015430410031661

Pettersen, V., & Westgaard, R. H. (2005). The activity patterns of neck muscles in professional classical singing. *Journal of Voice*, *19*(2), 238-251. doi: 10.1016/j.jvoice.2004.02.006

Phillips, B., Ball, C., Sackett, D., Badenoch, D., Strauss, S., Haynes, B., et al. (2009). Oxford Centre for Evidence-based Medicine Levels of Evidence. available from URL: http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/ (accessed 15/12/2016).

Pilat, A. (2003). *Terapias miofasciales: Inducción miofascial*. McGraw-Hill Interamericana de España.

Pinho, R.S. (2003). Fundamentos Em Fonoaudiologia, tratando os Distúrbios Da Voz. *2ª Edição*, Editora Guanabara Koogan, Rio de Janeiro, 24-28.

Pomeranz, B., Macaulay, R., Caudill, M. A., Kutz, I., Adam, D., Gordon, D., Kilborn, K. M., Barger, A. C., Shannon, D. C. & Cohen, R. J. (1985). Assessment of autonomic function in humans by heart rate spectral analysis. *American Journal of Physiology-Heart and Circulatory Physiology*, 248(1), H151-H153.

Putnoki, D. D. S., Hara, F., Oliveira, G., & Behlau, M. (2010). Qualidade de vida em voz: o impacto de uma disfonia de acordo com gênero, idade e uso vocal profissional. *Revista da Sociedade Brasileira de Fonoaudiologia, 15*(4), 485-490.

Rajendra, A. U., Kannathal, N., Lim, C. M. & Suri, J. S. (2006). Heart rate variability: a review. *Medical & Biological Engineering & Computing*, 44(12), 1031-51. doi: 10.1007/s11517-006-0119-0

Rammage, L. A., Nichol, H., & Morrison, M. D. (1987). The psychopathology of voice disorders. *Human Communication Canada*, 11(4), 21-25.

Rantala, L., Sala, E., & Kankare, E. (2018). Teachers' Working Postures and Their Effects on the Voice. *Folia Phoniatrica et Logopaedica*, *70*(1), 24-36. doi: 10.1159/000487593

Rêgo, E. M., Martin, M. M., Filho, A. I. D., Fávero, F. M., Oliveira, A. S. B., & Fontes, S. V. (2012). Efeitos da Liberação Miofascial Sobre a Flexibilidade de um Paciente com Distrofia Miotônica de Steinert. *Revista Neurociências*, *20*(3), 404-409.

Reis, M. S., Deus, A. P., Simões, R. P., Aniceto, I. A., Catai, A. M., & Borghi-Silva, A. (2010). Controle autonômico da frequência cardíaca de pacientes com doenças cardiorrespiratórias crônicas e indivíduos saudáveis em repouso e durante a manobra de acentuação da arritmia sinusal respiratória. *Brazilian Journal of Physical Therapy*, *14*(2), 106-13.

Remacle, M., & Eckel, H. E. (Eds.). (2010). *Surgery of larynx and trachea*. Berlin: Springer. p. 12.

Ribeiro, M. P., Brum, J. M., & Ferrario, C. M. (1992). Análise espectral da freqüência cardíaca: conceitos básicos e aplicação clínica. *Arquivos Brasileiros de Cardiologia*, 59(2), 141-9.

Ribeiro, V. V., Leite, A. P. D., Alencar, B. L. F. D., Bail, D. I., & Bagarollo, M. F. (2013). Avaliação vocal de crianças disfônicas pré e pós intervenção fonoaudiológica em grupo: estudo de caso. *Revista CEFAC*, *15*(2), 485-94. doi: 10.1590/S1516-18462012005000056

Roffey, D. M., Wai, E. K., Bishop, P., Kwon, B. K., & Dagenais, S. (2010). Causal assessment of awkward occupational postures and low back pain: results of a systematic review. *The Spine Journal*, 10(1), 89-99. doi: 10.1016/j.spinee.2009.09.003

Roy, N., & Bless, D. M. (2000). Personality traits and psychological factors in voice pathology: A foundation for future research. *Journal of Speech, Language, and Hearing Research*, *43*(3), 737-748.

Roy, N., Merrill, R. M., Thibeault, S., Gray, S. D., & Smith, E. M. (2004a). Voice disorders in teachers and the general population: effects on work performance, attendance, and future career choices. *Journal of Speech, Language, and Hearing Research*. 47:542-51.

Roy, N., Merrill, R. M., Thibeault, S., Parsa, R. A., Gray, S. D., & Smith, E. M. (2004b). Prevalence of voice disorders in teachers and the general population. *Journal of Speech, Language, and Hearing Research*. 47:281-93.

Rubin, J. S., Lieberman, J., & Harris, T. M. (2000). Laryngeal manipulation. *Otolaryngologic Clinics of North America*, *33*(5), 1017-1034. doi: 10.1016/S0030-6665(05)70261-9

Ruotsalainen, J., Sellman, J., Lehto, L., & Verbeek, J. (2008). Systematic review of the treatment of functional dysphonia and prevention of voice disorders. *Otolaryngology—Head and Neck Surgery*, *138*(5), 557-565. doi: 10.1016/j.otohns.2008.01.014

Sacco, I.C.N., Alibert, S., Queiroz, B.W.C., Pripas, D., Kieling, I., Kimura, A. A Sellmer, A.E., Malvestio, R.A. & Sera, M.T. (2007). Confiabilidade da fotogrametria em relação a goniometria para avaliação postural de membros inferiores. *Revista Brasileira de Fisioterapia*,*11*(5), 411-417.

Sakakibara, M., & Hayano, J. (1996). Effect of slowed respiration on cardiac parasympathetic response to threat. *Psychosomatic Medicine*, *58*(1), 32-37.

Sala, E., Laine, A., Simberg, S., Pentti, J., & Suonpää, J. (2001). The prevalence of voice disorders among day care center teachers compared with nurses: a questionnaire and clinical study. *Journal of Voice*, *15*(3), 413-423. doi: 10.1016/S0892-1997(01)00042-X

Santos, A. R. R. D. (2014). Avaliação postural por biofotogrametria em crianças e adolescentes num agrupamento de escolas do concelho de Bragança (Doctoral dissertation). Instituto Politécnico de Bragança, Portugal.

Santos, M. E. D. (2013). *GRBASH–Scale for Evaluating the Hoarse Voice* (Master dissertation). Universidade Fernando Pessoa, Potugal.

Saratchandran, R., & Desai, S. (2013). Myofascial release as an adjunct to conventional occupational therapy in mechanical low back pain. *The Indian Journal of Occupational Therapy*, *45*, 3-7.

Schleip, R., Duerselen, L., Vleeming, A., Naylor, I. L., Lehmann-Horn, F., Zorn, A., Jaeger, H. & Klingler, W. (2012). Strain hardening of fascia: static stretching of dense fibrous connective tissues can induce a temporary stiffness increase accompanied by enhanced matrix hydration. *Journal of bodywork and movement therapies*, *16*(1), 94-100. doi: 10.1016/j.jbmt.2011.09.003

Schneider, B., Enne, R., Cecon, M., Diendorfer-Radner, G., Wittels, P., Bigenzahn, W., & Johannes, B. (2006). Effects of vocal constitution and autonomic stress-related reactivity on vocal endurance in female student teachers. *Journal of Voice*, 20(2), 242-250. doi: 10.1016/j.jvoice.2005.03.002

Schubert, C., Lambertz, M., Nelesen, R. A., Bardwell, W., Choi, J. B., & Dimsdale, J. E. (2009). Effects of stress on heart rate complexity—a comparison between short-term and chronic stress. *Biological psychology*, *80*(3), 325-332. doi: 10.1016/j.biopsycho.2008.11.005

Scotto, N. D. C. (1998). Cervical spine abnormalities in professional singers. *Folia phoniatrica et logopaedica*, *50*(4), 212-218. doi: 10.1159/000021463

Seifert, E., & Kollbrunner, J. (2005). Stress and distress in non-organic voice disorders. *Swiss medical weekly*, 135(27/28), 387.

Silverio, K. C. A., Brasolotto, A. G., Siqueira, L. T. D., Carneiro, C. G., Fukushiro, A. P., & de Jesus Guirro, R. R. (2015). Effect of application of transcutaneous electrical nerve stimulation and laryngeal manual therapy in dysphonic women: clinical trial. *Journal of Voice*, *29*(2), 200-208. doi: 10.1016/j.jvoice.2014.06.003

Simberg, S., Laine, A., Sala, E., & Rönnemaa, A. M. (2000). Prevalence of voice disorders among future teachers. *Journal of voice*, *14*(2), 231-235. doi: 10.1016/S0892-1997(00)80030-2

Simmonds, N., Miller, P., & Gemmell, H. (2012). A theoretical framework for the role of fascia in manual therapy. *Journal of bodywork and movement therapies*, *16*(1), 83-93. doi: 10.1016/j.jbmt.2010.08.001

Sliwinska-Kowalska, M., Niebudek-Bogusz, E., Fiszer, M., Los-Spychalska, T., Kotylo, P., Sznurowska-Przygocka, B., & Modrzewska, M. (2006). The prevalence and risk factors for occupational voice disorders in teachers. *Folia Phoniatrica et Logopaedica*, *58*(2), 85-101. doi: 10.1159/000089610

Smith, E., Gray, S. D., Dove, H., Kirchner, L., & Heras, H. (1997). Frequency and effects of teachers' voice problems. *Journal of voice*, *11*(1), 81-87. doi: 10.1016/S0892-1997(97)80027-6

Smith, R. P., Veale, D., Pépin, J. L., & Lévy, P. A. (1998). Obstructive sleep apnoea and the autonomic nervous system. *Sleep medicine reviews*, 2(2), 69-92.

Smits, I., Ceuppens, P., & De Bodt, M. S. (2005). A comparative study of acoustic voice measurements by means of Dr. Speech and Computerized Speech Lab. *Journal of Voice*, 19(2), 187-196. doi: 10.1016/j.jvoice.2004.03.004

Souza, C. L. D., Carvalho, F. M., Araújo, T. M. D., Reis, E. J. F. B. D., Lima, V. M. C., & Porto, L. A. (2011). Fatores associados a patologias de pregas vocais em professores. *Revista de Saúde Pública*, *45*, 914-921. doi: 10.1590/S0034-89102011005000055

Spina, A. L., Maunsell, R., Sandalo, K., Gusmão, R., & Crespo, A. (2009). Correlação da qualidade de vida e voz com atividade profissional. *Revista Brasileira de Otorrinolaringologia*, 75(2): 275-9. doi: 10.1590/S0034-72992009000200019

Staes, F. F., Jansen, L., Vilette, A., Coveliers, Y., Daniels, K., & Decoster, W. (2011). Physical therapy as a means to optimize posture and voice parameters in student classical singers: a case report. *Journal of Voice*, *25*(3), 91-101. doi: 10.1016/j.jvoice.2009.10.012

Standring, S., Ellis, H., Healy, J., Johnson, D., Williams, A., Collins, P., & Wigley, C. (2005). Gray's anatomy: the anatomical basis of clinical practice. *American Journal of Neuroradiology*, *26*(10), 2703.

Sztajzel, J. (2004). Heart rate variability: a noninvasive electrocardiographic method to measure the autonomic nervous system. Swiss Medical Weekly, 134, 514-522. doi: 2004/35/smw-10321

Taelman, J., Vandeput, S., Vlemincx, E., Spaepen, A., & Van Huffel, S. (2011). Instantaneous changes in heart rate regulation due to mental load in simulated office work. *European journal of applied physiology*, *111*(7), 1497-1505. doi: 10.1007/s00421-010-1776-0

Teixeira, L. C., & Behlau, M. (2015). Comparison between vocal function exercises and voice amplification. *Journal of Voice*, *29*(6), 718-726. doi: 10.1016/j.jvoice.2014.12.012

Ternström, S., Andersson, M., & Bergman, U. (2000). An effect of body massage on voice loudness and phonation frequency in reading. *Logopedics Phoniatrics Vocology*, *25*(4), 146-150. doi: 10.1080/140154300750067520

Tharion, E., Parthasarathy, S., & Neelakantan, N. (2009). Short-term heart rate variability measures in students during examinations. *The National Medical Journal of India*, *22*(2), 63-66.

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers III, J. J., & Wager, T. D. (2012). A meta-analysis of heart rate variability and neuroimaging studies: implications for heart rate variability as a marker of stress and health. *Neuroscience & Biobehavioral Reviews*, *36*(2), 747-756. doi: 10.1016/j.neubiorev.2011.11.009

Tixa, S. (2006). Atlas De Anatomía Palpatoria Tomo 1. Cuello, Tronco Y Extremidad Superior. Elsevier Masson.

Tomlinson, C. A., & Archer, K. R. (2015). Manual therapy and exercise to improve outcomes in patients with muscle tension dysphonia: a case series. *Physical therapy*, *95*(1), 117-128. doi: 10.2522/ptj.20130547

Tozzi, P., Bongiorno, D., & Vitturini, C. (2011). Fascial release effects on patients with non-specific cervical or lumbar pain. *Journal of bodywork and movement therapies*, *15*(4), 405-416. doi: 10.1016/j.jbmt.2010.11.003

Traina, M., Cataldo, A., Galullo, F., & Russo, G. (2011). Effects of anxiety due to mental stress on heart rate variability in healthy subjects. *Minerva Psichiatrica*, 52(4):227-31.

Tröger, R. M., Rauh, R., Mahlke, C., Gotschalk, T. & Muck-Weymanm, M. (2003). Agreement of two diferente methods for measurement of heart rate variability. *Clinical Autonomic Research*, 13, 99-102.

Troni, C. R., Arakaki, F. N., Lima, F. S., Mott, L., Rodrigues, K. A., & Ferreira, L. P. (2006). Professores em contexto profissional e não profissional: análise objetiva e subjetiva dos aspectos da articulação e da postura. *Distúrbios da Comunicação*, *18*(2).

Uloza, V., Verikas, A., Bacauskiene, M., Gelzinis, A., Pribuisiene, R., Kaseta, M., & Saferis, V. (2011). Categorizing normal and pathological voices: automated and perceptual categorization. *Journal of Voice*, *25*(6), 700-708. doi: 10.1016/j.jvoice.2010.04.009

Vanderlei, L. C. M., Pastre, C. M., Hoshi, R. A., Carvalho, T. D. & Godoy, M. F. (2009). Noções básicas de variabilidade da frequência cardíaca e sua aplicabilidade clínica. *Revista Brasileira Circulação Cardiovascular*, 24(2), 205-217. doi: 10.1590/S0102-76382009000200018

Van Houtte, E., Claeys, S., Wuyts, F., & Van Lierde, K. (2011). The impact of voice disorders among teachers: vocal complaints, treatment-seeking behavior, knowledge of vocal care, and voice-related absenteeism. *Journal of voice*, *25*(5), 570-575. doi: 10.1016/j.jvoice.2010.04.008

Van Houtte, E., Van Lierde, K., & Claeys, S. (2011). Pathophysiology and treatment of muscle tension dysphonia: a review of the current knowledge. *Journal of Voice*, 25(2), 202-207. doi: 10.1016/j.jvoice.2009.10.009

Vas, J., Méndez, C., Perea-Milla, E., Vega, E., Panadero, M. D., León, J. M., & Jurado, R. (2004). Acupuncture as a complementary therapy to the pharmacological treatment of osteoarthritis of the knee: randomised controlled trial. *Bmj*, *329*(7476), 1216. doi: 10.1136/bmj.38238.601447.3A

Vedovato, T. G., & Monteiro, M. I. (2008). Perfil sociodemográfico e condições de saúde e trabalho dos professores de nove escolas estaduais paulistas. *Revista da Escola de Enfermagem da USP*, *42*(2), 291-297. doi: 10.1590/S0080-62342008000200012

Vilkman, E. (2000). Voice Problems at work: a challenge for occupational safety and health arrangement. Folia Phoniatrica et Logopedica, 52, pp. 120-125.

Viola, I. C., Ferreira, L. P., Sene, C. D., Villas Boas, D. C., & Souza, S. M. (2000). A voz do professor: levantamento das publicações brasileiras. *Revista da sociedade brasileira de fonoaudiologia*, *5*(7), 36-47.

Visnovcova, Z., Mestanik, M., Javorka, M., Mokra, D., Gala, M., Jurko, A., Calkovska, A. & Tonhajzerova, I. (2014). Complexity and time asymmetry of heart rate variability are altered in acute mental stress. *Physiological measurement*, *35*(7), 1319. doi: 10.1088/0967-3334/35/7/1319

Vogel, A. P., & Morgan, A. T. (2009). Factors affecting the quality of sound recording for speech and voice analysis. *International journal of speech-language pathology*, 11(6), 431-437. doi: 10.3109/17549500902822189

Watson, A. W. S., & Mac Donncha, C. (2000). A reliable technique for the assessment of posture: assessment criteria for aspects of posture. *Journal of Sports Medicine and Physical Fitness*, *40*(3), 260.

Watts, C. R., Diviney, S. S., Hamilton, A., Toles, L., Childs, L., & Mau, T. (2015). The effect of stretch-and-flow voice therapy on measures of vocal function and handicap. *Journal of Voice*, *29*(2), 191-199. doi: 10.1016/j.jvoice.2014.05.008

Wehrwein, E. A., Orer, H. S., & Barman, S. M. (2016). Overview of the anatomy, physiology, and pharmacology of the autonomic nervous system. *Comprehensive Physiology*, 6, 1239-1278. doi: 10.1002/cphy.c150037

Wells, G., Shea, B., O’Connell, D., Peterson, J., Welch, V., Losos, M. & Tugwell, P. (2011) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in metaanalyses [WWW document]. URL http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp [accessed on 01 May 2017].

Wolf, S., & Finestone, A. J. (1986). *Occupational stress: health and performance at work*. Littleton (MA): PSG Publishing Company.

Wytrążek, M., Huber, J., Lipiec, J., & Kulczyk, A. (2015). Evaluation of palpation, pressure algometry, and electromyography for monitoring trigger points in young participants. *Journal of manipulative and physiological therapeutics*, *38*(3), 232-243. doi: 10.1016/j.jmpt.2014.12.005

Yamawaki, Y. (2003). Forward movement of posterior pharyngeal wall on phonation. *American journal of otolaryngology*, *24*(6), 400-404.

Yiu, E. M., Chan, K. M., Kwong, E., Li, N. Y., Ma, E. P., Fred, W. T., & Tsang, R. (2016). Is acupuncture efficacious for treating phonotraumatic vocal pathologies? A randomized control trial. *Journal of Voice*, *30*(5), 611-620. doi: 10.1016/j.jvoice.2015.07.004

Yiu, E. M., Chan, K. M., Li, N. Y., Tsang, R., Abbott, K. V., Kwong, E., Estella, P. M. & Lin, Z. (2016). Wound-healing effect of acupuncture for treating phonotraumatic vocal pathologies: A cytokine study. *The Laryngoscope*, *126*(1), E18-E22. doi: 10.1002/lary.25483

Zielińska-Bliźniewska, H., Pietkiewicz, P., Miłoński, J., Urbaniak, J., & Olszewski, J. (2013). Acoustic and capacity analysis of voice academic teachers with diagnosed hyperfunctional dysphonia by using DiagnoScope Specialist software. *Otolaryngologia Polska*, *67*(3), 144-148. doi: 10.1016/j.otpol.2013.02.001

Zonnenberg, A. J. J., Van Maanen, C. J., Elvers, J. W. H., & Oostendorp, R. A. B. (1996). Intra/interrater reliability of measurements on body posture photographs. *Cranio®*, *14*(4), 326-331. doi: 10.1080/08869634.1996.11745985

Zuttin, R., Moreno, M., César, M., Martins, L., Catai, A. & Silva, E. (2008). Evaluation of autonomic heart rate modulation among sedentary young men, in sitting and supine postures. *Brazilian Journal of Physical Therapy/Revista Brasileira de Fisioterapia*, *12*(1). doi: 10.1590/S1413-35552008000100003

APPENDIX I – Facsimile of the published papers 1st page

PAPER 1

Journal of Voice

Volume 33, Issue 1, January 2019, Pages 124.e1-124.e12

Associations between Posture, Voice, and Dysphonia: A Systematic Review

Ricardo Cardoso *†‡, José Lumini-Oliveira †§‖, Rute F. Meneses *†‡

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PAPER 2

Journal of Voice

Available online 29 August 2019

In Press, Corrected Proof

Associations Between Autonomic Nervous System Function, Voice, and Dysphonia: A Systematic Review

Ricardo Cardoso *†‡, José Lumini-Oliveira *§‖, Rute F. Meneses *†‡¶#

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PAPER 3

frontiers in Medicine

REVIEW
published: 24 April 2017
doi: 10.3389/fmed.2017.00045

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The Effectiveness of Physiotherapy and Complementary Therapies on Voice Disorders: A Systematic Review of Randomized Controlled Trials

Ricardo Cardoso[1,2,3], Rute F. Meneses[2,3,4] and José Lumini-Oliveira[3,5,6]*

PAPER 4

ELSEVIER

Journal of Voice
Available online 14 March 2020
In Press, Corrected Proof

Associations between Teachers' Posture, Muscle Tension and Voice Complaints

Ricardo Cardoso [*, †], Rute F. Meneses [*, †, ‖, ¶], José Lumini-Oliveira [*, ‡, §], Pedro Pestana [#], Bruno Guimarães [**, ††]

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PAPER 5

Journal of Voice
Available online 26 April 2020
In Press, Corrected Proof

Associations Between Teachers' Autonomic Dysfunction and Voice Complaints

Ricardo Cardoso [*, †, ‡], Rute F. Meneses [*, †, ‡, ‖], José Lumini-Oliveira [*, §, ¶], Pedro Pestana [**]

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APPENDIX II – Authorization of the Physical Medicine and Rehabilitation Department Coordination, UFP's University Hospital

Ines Dias 09:55 (Há 57 minutos)

para Vanessa, mim

Exmo Sr Terapeuta Ricardo,
Bom dia,

Pela parte da Coordenação da MFR tem parecer positivo para a realização do projeto de investigação.

Grata pela atenção,

Com os meus melhores cumprimentos,

Inês Dias
Coordenação Terapeutas
Medicina Física e de Reabilitação
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APPENDIX III – Ethical committee approval

PARECER N.º 22

A Comissão de Ética para a Saúde do Hospital-Escola da Fundação Fernando Pessoa (CES-HE-FFP) após análise do projeto **"Voice, Posture and autonomic nervous system: Relations and treatment"** apresentado por Ricardo Manuel Cardoso, dá parecer positivo ao projeto, na condição de:

I. Manter anónimos os dados a colher aos doentes, assim como as imagens e som;
II. Ser incluído um diferente anexo que deverá ser assinado pelo doente em que se refere que o mesmo está de acordo com aquisição e registo de som e imagens;
III. Ser solicitada autorização ou dado conhecimento à "Comissão Nacional de Proteção de Dados" de forma a acautelar os direitos dos participantes.

Jorge Rodrigues
Presidente da Comissão de Ética para a Saúde do Hospital-Escola da Fundação Fernando Pessoa

30.01.2017

APPENDIX IV – Informed consent

Declaração de Consentimento

Considerando a "Declaração de Helsínquia" da Associação Médica Mundial (Helsínquia 1964; Tóquio 1975; Veneza 1983; Hong Kong 1989; Somerset West 1996 e Edimburgo 2000)

Designação do Estudo

"Voice, posture and autonomic nervous system: Relations and treatment"

Eu, abaixo-assinado, (nome completo) ____

___________________________, compreendi a explicação que me foi fornecida acerca da minha participação na investigação que se tenciona realizar, bem como do estudo em que serei incluído. Foi-me dada oportunidade de fazer as perguntas que julguei necessárias e de todas obtive resposta satisfatória.

Tomei conhecimento de que, de acordo com as recomendações da Declaração de Helsínquia, a informação ou explicação que me foi prestada versou os objetivos e os métodos e, se ocorrer uma situação de prática clínica, os benefícios previstos, os riscos potenciais e o eventual desconforto. Além disso, foi-me afirmado que tenho o direito de recusar a todo o tempo a minha participação no estudo, sem que isso possa ter como efeito qualquer prejuízo pessoal.

Por isso, consinto que me seja aplicado o método ou o tratamento, se for caso disso, propostos pelo investigador. Adicionalmente, autorizo a aquisição e registo de som e imagens no âmbito do presente estudo.

Data: ___ /___/______

Assinatura do inquirido: _____________________________

O Investigador Responsável: _______________________

APPENDIX V – Authorization from the National Data Protection Commission

Autorização n.º 2642/ 2017

Ricardo Cardoso notificou à Comissão Nacional de Protecção de Dados (CNPD) um tratamento de dados pessoais com a finalidade de realizar um Estudo Clínico com Intervenção, denominado Relação entre voz, postura e sistema nervoso autónomo .

Existe justificação específica para o tratamento de dados comportamentais, psicológicos ou volitivos, os quais estão diretamente relacionados com a investigação.

O participante é identificado por um código especificamente criado para este estudo, constituído de modo a não permitir a imediata identificação do titular dos dados; designadamente, não são utilizados códigos que coincidam com os números de identificação, iniciais do nome, data de nascimento, número de telefone, ou resultem de uma composição simples desse tipo de dados. A chave da codificação só é conhecida do(s) investigador(es).

É recolhido o consentimento expresso do participante ou do seu representante legal.

A informação é recolhida diretamente do titular.

As eventuais transmissões de informação são efetuadas por referência ao código do participante, sendo, nessa medida, anónimas para o destinatário.

A CNPD já se pronunciou na Deliberação n.º 1704/2015 sobre o enquadramento legal, os fundamentos de legitimidade, os princípios aplicáveis para o correto cumprimento da Lei n.º 67/98, de 26 de outubro, alterada pela Lei n.º 103/2015, de 24 de agosto, doravante LPD, bem como sobre as condições e limites aplicáveis ao tratamento de dados efetuados para a finalidade de investigação clínica.

No caso em apreço, o tratamento objeto da notificação enquadra-se no âmbito daquela deliberação e o responsável declara expressamente que cumpre os limites e condições aplicáveis por força da LPD e da Lei n.º 21/2014, de 16 de abril, alterada pela Lei n.º 73/2015, de 27 de junho – Lei da Investigação Clínica –, explicitados na Deliberação n.º 1704/2015.

O fundamento de legitimidade é o consentimento do titular.

A informação tratada é recolhida de forma lícita, para finalidade determinada, explícita e legitima e não é excessiva – cf. alíneas a), b) e c) do n.º 1 do artigo 5.º da LPD.

Assim, nos termos das disposições conjugadas do n.º 2 do artigo 7.º, da alínea a) do n.º 1 do artigo 28.º e do artigo 30.º da LPD, bem como do n.º 3 do artigo 1.º e do n.º 9 do artigo 16.º ambos da Lei de Investigação Clínica, com as condições e limites explicitados na Deliberação da CNPD n.º 1704/2015, que aqui se dão por reproduzidos, autoriza-se o presente tratamento de dados pessoais nos seguintes termos:

Responsável – Ricardo Cardoso

Finalidade – Estudo Clínico com Intervenção, denominado Relação entre voz, postura e sistema nervoso autónomo

Categoria de dados pessoais tratados – Código do participante; idade/data de nascimento; género; dados antropométricos; dados da história clínica; dados dados de exame físico; dados de meios complementares de diagnóstico; medicação prévia concomitante; dados de qualidade de vida/efeitos psicológicos; relativos à atividade profissional com conexão com a Investigação; comportamentais, psicológicos ou volitivos com conexão com a Investigação

Exercício do direito de acesso – Através dos investigadores, presencialmente

Comunicações, interconexões e fluxos transfronteiriços de dados pessoais identificáveis no destinatário – Não existem

Prazo máximo de conservação dos dados – A chave que produziu o código que permite a identificação indireta do titular dos dados deve ser eliminada 5 anos após o fim do estudo.

Da LPD e da Lei de Investigação Clínica, nos termos e condições fixados na presente Autorização e desenvolvidos na Deliberação da CNPD n.º 1704/2015, resultam obrigações que o responsável tem de cumprir. Destas deve dar conhecimento a todos os que intervenham no tratamento de dados pessoais.

Lisboa, 06-03-2017

A Presidente

Filipa Calvão