

A Review of Vocal Loading Tasks in the Voice Literature

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Summary: Vocal loading tasks (VLTs) are used to assess range of function and vulnerability of the laryngeal system. The manner in which VLTs compromise the laryngeal mechanism is multifaceted and only partially understood. This paper presents a scoping review of the literature on VLTs and their effects on the healthy voice. This review paper details the varied nature of VLT duration, task type, and additional factors including hydration and ambient noise that have been used to compromise the larynx. In addition, the voice measures used to assess the effects of VLTs on the healthy larynx are discussed. This study details the current state of the literature, draws conclusions from our current knowledge, and provides directions for further research.

Key Words: Vocal loading–Vocal fatigue–Larynx–Prolonged voice use–Review.

INTRODUCTION

Conditions that stress or challenge a physiological system can reveal heterogeneity in range of function and physiological limits. Stressors can be applied to both a healthy system and a system that is at-risk. For example, exercise testing on a treadmill is used to assess cardiac function and diagnose coronary disease.¹ Likewise, a bronchial challenge test investigates respiratory resilience and can diagnose pathology involving bronchiole constriction, such as asthma.² Similarly, researchers can study how the larynx responds to stress. Understanding the manner in which the healthy larynx responds to challenge offers a window into comprehending the mechanisms underlying optimal laryngeal function. In recent years, researchers have used vocally demanding tasks (hereafter called vocal loading task [VLT]) to challenge the vocal mechanism.^{3–5} Although VLTs have long been examined both in^{3,4} and outside^{6–8} the laboratory, they have not been consistently defined.

This review considers a VLT as a stressor that compromises optimal laryngeal function. This description of a VLT is broad but testable. The stressor can involve different durations, types, and amounts of voice use that can be measured.^{9,10} Likewise, a change in laryngeal function can also be quantified. In other words, the term VLT is used here to refer to the voice task itself rather than the compromised (ie, loaded) state of the larynx. Because of the demands of studying laryngeal function *in vivo* and differences in types of voice use, many questions regarding VLTs remain unanswered. The majority of studies using VLTs have focused on the healthy larynx, and there are a few studies on individuals with vocal pathologies.^{11–14} Understanding how a healthy larynx performs under stress informs our treatment for those with pathologies.

The long-term goal of studying VLTs is to develop a clinical tool to identify healthy speakers who are at-risk for developing vocal pathology. It is difficult to create a uniform VLT, however, due to the interaction of several intrinsic and extrinsic factors

which can compromise laryngeal function. Extrinsic factors include poor room acoustics,¹⁵ high ambient noise,^{16,17} low humidity levels,¹⁸ poor diet,¹⁹ and posture.²⁰ Intrinsic factors include aspects related to voice use (eg, task, duration of voice use, intensity of voice production, vocal quality, nonhabitual speech patterns) and biological variables (age, sex, vocal fold biochemistry, and genetic makeup of the individual). Research on VLTs has manipulated these intrinsic and extrinsic factors in various ways. In laboratory settings, tasks to load the larynx have included prolonged speaking,^{3,4} speaking in background noise,^{5,21} sustaining vowels,^{13,22} and singing.^{23,24} VLTs have also varied in range and intensity.^{25–29} The varied nature of VLTs speaks to the robust nature of the laryngeal mechanism and the difficult nature of determining safe methods of stressing the laryngeal apparatus.

Aerodynamic, acoustic, laryngeal visualization, auditory-perceptual assessment, and self-perceptual measures have been used to quantify the adverse effects of a VLT. Phonation threshold pressure (PTP) is the most common aerodynamic measure used in the literature.^{19,22,30,31} PTP estimates the minimum amount of subglottic pressure required to initiate and maintain vibration³² and is sensitive to subtle laryngeal changes induced by a VLT.^{19,31,33} Commonly used acoustic measures include jitter, shimmer, and fundamental frequency measures.^{3,34} Additionally, alterations in fundamental frequency have been documented after a VLT.^{3,35} Perceived phonatory effort (PPE) has consistently demonstrated sensitivity to both short- and long-duration VLTs.^{3,31,36} For the purposes of this review, studies that quantified vocal difficulty with loading were also included in the PPE category. In addition, some researchers have used stroboscopy to examine the physical appearance of the larynx following a VLT.^{3,21,37} Finally, auditory-perceptual assessment of vocal quality following VLTs has also yielded mixed results.^{21,38} The aim of this review is to summarize the current state of knowledge regarding the types of VLTs reported in the voice literature. This study also reports on voice measures that appear most sensitive to laryngeal change. Finally, we suggest potential directions for future research on VLTs.

METHODS

Abstracts for this review were identified using the Pubmed and Web of Science databases. Search terms included “vocal loading,” “vocal fatigue,” “speaking task,” “prolonged speaking task,” “vocal loading task,” and “vocal load.” The search was limited to the years 1970 through 2016. The search was conducted by the first

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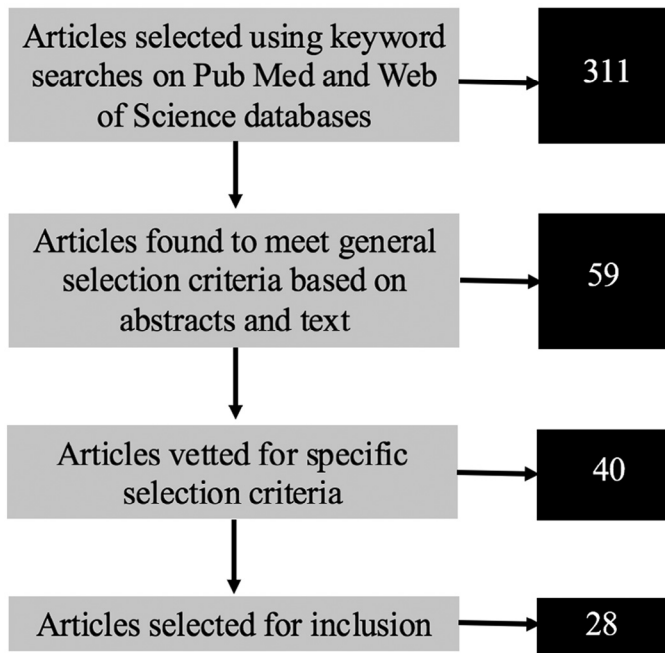


FIGURE 1. Flowchart depicting the selection process for articles.

author (RF). Two additional researchers repeated the searches using the same terms and compiled a list of articles. The three researchers then used consensus to determine articles to be included in this study. [Figure 1](#) presents a basic outline of the screening process.

To be eligible for inclusion in this analysis, studies had to present original data and include a defined VLT. The effect of the VLT was the primary focus of each study. Studies examining the effects of naturalistic VLTs were excluded, as were studies where the nature of the VLT was not clearly outlined. VLTs were required to be consistent across all participants in the study, and single participant studies were not included. In addition, VLTs were required to be at least 10 minutes in duration to ensure that laryngeal changes could occur.³⁹ For inclusion, studies were required to focus primarily on healthy adults and include consistent prechallenge and postchallenge measures. Because of the limited number of studies available, two studies were included that examined both healthy and disordered individuals.^{12,13} Only the portion of these studies examining healthy individuals was considered in this review. Manuscripts were written in English.

RESULTS

A total of 28 published studies met the aforementioned criteria for inclusion. The details of these studies, including sample size, VLT type, and changes in voice measures, are included in [Tables 1 and 2](#). [Table 1](#) presents studies that examined intrinsic vocal loading factors. [Table 2](#) lists studies that examined the interaction between intrinsic factors and extrinsic factors such as humidity, vocal training, and ambient noise. For studies involving multiple sessions within a single day, results included on [Tables 1 and 2](#) represent baseline and postfinal session data.

The duration of the VLT and the stimuli used in the VLT were the most commonly manipulated variables in the VLT literature. The most common VLT duration time was 2 hours (8 of

28 studies). However, VLT durations^{25,26} were as short as 15 minutes and as long as 3.75 hours. Eight of 28 studies involved multiple experimental sessions^{26,29,41} ranging between 2 and 7 sessions. Four of 28 studies allowed the experimental subject to end the VLT when they felt they could not continue.^{21,23,24,38} Although a variety of task types were used to stress the laryngeal system,^{22,23} the most common task type was prolonged, loud reading.^{31,38,43} Twenty-two of 28 studies used loud reading to load the larynx. Four of 28 studies used sustained vowels, and 2 of 28 studies used singing. Six of 28 studies examined the effects of ambient noise on vocal loading, making background noise the most commonly examined extrinsic loading factor.^{19,21,36,44} The interaction of hydration and vocal challenge was also examined in 5 of 28 studies. Two of 28 studies looked at the effects of systemic hydration and VLTs.^{5,33} One of 28 studies investigated the effects of vocal rest and hydration on a VLT.²³ Surface hydration mechanisms and VLTs were assessed in 2 of 28 studies.^{29,35} The interaction of caffeine and a VLT was examined in 1 of 28 studies,¹⁹ and the effects of thickened liquid intake before a VLT was examined in 1 of 28 studies.⁴² Four of 28 studies included subjects with varying levels of voice training,^{22,34,37,43} and 2 studies included both normophonic and disordered subjects.^{12,13} All studies examined adults, with the exception of Kelchner et al who examined healthy, adolescent males.⁴ Thirteen of 28 studies examined the effects of a VLT exclusively in female subjects,^{3,43} whereas 3 of 28 studies exclusively studied the effects of a VLT on male subjects.^{33,38} The remaining studies examined both male and female participants.^{26,30}

DISCUSSION

The notion of subjecting healthy individuals to controlled, high intensity tasks is commonly used in the medical world. These tasks provide insight regarding range of function and can even have diagnostic value. VLTs have been studied with these goals in mind.⁴⁵ Although VLTs continue to require adjustment, there are conclusions that can be drawn from the current body of available literature. The goal of an optimal VLT is to identify healthy speakers who are vulnerable to developing vocal pathology. A clinically useful VLT would be of short duration, well-controlled and easily replicable, safe, and easy to administer. Accordingly, the discussion below will summarize the literature along dimensions of types of VLTs, variables in VLTs that can compromise laryngeal function, and measures of VLT outcomes.

Vocal Loading Tasks

Because of the robust nature of the healthy laryngeal mechanism, effective VLTs manipulate duration and additional variables such as intensity and vocal quality to produce measureable laryngeal changes. Extended duration of phonation and elevated intensity of production are the most common variables in VLTs.^{3,5} However, the manner in which these factors should best be manipulated is still in question. This review of the literature would suggest that tasks using solely elevated intensity of production to compromise the larynx should likely be over 1 hour in duration. Tasks shorter than this duration have generally not produced changes in objective voice measures^{13,21,36} (with the exception of participant-reported voice changes). This is presumably

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