ORIGINAL ARTICLE

Effect of Singing on Respiratory Function, Voice, and Mood After Quadriplegia: A Randomized Controlled Trial

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Abstract

Objective: To explore the effects of singing training on respiratory function, voice, mood, and quality of life for people with quadriplegia.

Design: Randomized controlled trial.

Setting: Large, university-affiliated public hospital, Victoria, Australia.

Participants: Participants (N=24) with chronic quadriplegia (C4-8, American Spinal Injury Association grades A and B).

Interventions: The experimental group (n=13) received group singing training 3 times weekly for 12 weeks. The control group (n=11) received group music appreciation and relaxation for 12 weeks. Assessments were conducted pre, mid-, immediately post-, and 6-months postintervention.

Main Outcome Measures: Standard respiratory function testing, surface electromyographic activity from accessory respiratory muscles, sound pressure levels during vocal tasks, assessments of voice quality (Perceptual Voice Profile, Multidimensional Voice Profile), and Voice Handicap Index, Profile of Mood States, and Assessment of Quality of Life instruments.

Results: The singing group increased projected speech intensity (P=.028) and maximum phonation length (P=.007) significantly more than the control group. Trends for improvements in respiratory function, muscle strength, and recruitment were also evident for the singing group. These effects were limited by small sample sizes with large intersubject variability. Both groups demonstrated an improvement in mood (P=.002), which was maintained in the music appreciation and relaxation group after 6 months (P=.017).

Conclusions: Group music therapy can have a positive effect on not only physical outcomes, but also can improve mood, energy, social participation, and quality of life for an at-risk population, such as those with quadriplegia. Specific singing therapy can augment these general improvements by improving vocal intensity.

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Cervical spinal cord injury (SCI) can cause loss of function in respiratory muscles and subsequently decreases inspiratory and expiratory muscle strength—the degree of dysfunction being dependent on the level and completeness of the injury. Resultant reductions in chest wall compliance, ineffective cough, and increased respiratory tract infections[1,2] are a major cause of illness and death.[3] Respiratory dysfunction can also decrease voice projection and phonation length.[4] Further, health-related quality of life for people with SCI is significantly lower than that of the general population,[5-7] and depression is common.[8-10]

Respiratory muscle training improves respiratory muscle strength and endurance in quadriplegia.[11-17] Although training is effective, patients consider it cumbersome, boring, and without immediate reward.[18] Furthermore, function declines again when training ceases.[12]

An audio podcast accompanies this article.
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In able-bodied people, inspiration is performed by contraction of the diaphragm, expiration is essentially passive, and the accessory respiratory muscles are only used during exertion or for high-effort vocal tasks.[13,19-21] In quadriplegia, accessory respiratory muscles (sternocleidomastoid [SCM] for inspiration and pectoralis major for expiration) are commonly recruited at rest,[2,22] and to a greater degree during exertion.[23] The act of singing places significant demands on the respiratory system, requiring strong, fast inspirations, extended, regulated expirations, and recruitment of accessory respiratory muscles.[24] Therefore, singing may have positive effects on respiratory function in this population.[25] We also postulated that singing training may aid people with quadriplegia to develop effective breathing strategies that would improve respiratory and vocal function.

This study aimed to investigate the effect of a group therapeutic singing intervention on a range of outcomes for people with quadriplegia. We hypothesized that in order to sing and speak loudly, people with quadriplegia would increase recruitment of accessory respiratory muscles and that the deep, controlled breathing used during singing would train the respiratory muscles, improving respiratory function and voice. As music therapy has positively affected mood in other clinical populations,[26-31] we also examined mood and quality of life outcomes.

Methods

Participants

A randomized, controlled trial design was used to assess the effect of singing on respiratory, voice, mood, and quality of life outcomes for participants with C4-8 quadriplegia. Thematic analysis of poststudy participant interviews also contributed qualitative data. Participants (>1-year postinjury) were recruited from the Victorian Spinal Cord Service (Victoria, Australia). All were English speaking, in stable general health, and able to travel for the assessments. Exclusion criteria were a history of speech disorder, psychiatric disorder, neurologic impairment, or respiratory disease prior to injury. Stratified, block randomization was performed (using a computer-generated sequence) with allocation concealed using sealed, opaque envelopes. Randomization was stratified by previous tracheostomy history, because this has been linked to abnormal phonation and impaired laryngeal function for this population.[4] All persons involved in recruitment, data collection, and analysis were blinded to group allocation. Attempts were made to blind participants by concealing which intervention was the experimental condition. The

project was approved by the institutional human research ethics committee, and all applicable institutional and governmental regulations concerning the ethical use of human volunteers were followed.

Measurements

All participants participated in pre, mid, post, and 6-month follow-up assessment sessions consisting of: (1) respiratory function tests, (2) vocal assessment, including surface electromyographic (sEMG) activity from accessory respiratory muscles, and (3) questionnaires. No participant wore abdominal binders or other aids likely to affect lung function during assessment or training. Respiratory function tests were conducted according to the guidelines of the American Thoracic Society[32,33] and were modified to incorporate the limitations associated with SCI.[34,35] Ventilatory and upper airway function were assessed using maximal inspiratory and expiratory flow-volume loops using an EasyOne spirometer.[a] Static lung volumes were measured by inert-gas dilution using a P K Morgan M8 rolling seal spirometer with a helium analyzer.[b] Respiratory muscle strength was assessed by measuring maximal inspiratory pressure (MIP), maximal expiratory pressure (MEP), and sniff nasal inspiratory pressure (SNIP)[36] using a portable MicroRPM respiratory pressure meter[c] in accordance with American Thoracic Society/European Respiratory Society guidelines.[32] To ensure that subjects were performing the tests well, maximal respiratory pressure measurements were repeated at least 6 times within each session, with the best 2 values matching to within 10%. All assessments were made by the same experienced operator. Lung function results were compared with able-bodied predicted values for spirometry,[37] lung volumes,[38] MIP/MEP,[39] and SNIP.[40]

During the vocal assessment, audio data were collected simultaneously with sEMG measurement of accessory respiratory muscle function during vocal tasks. These sEMG signals from the SCM, pectoralis major, and diaphragm muscles were amplified using the Micro1401 data acquisition system and Spike2 software.[d] Audio signals were recorded using a calibrated Ono Sokki MI-1211 Type 1 condenser microphone[e] positioned at a distance of 30cm from the participant's mouth and analyzed using an EASERA software analyzer.[41,f]

The audio recordings from the vocal assessment were used to measure sound pressure level (SPL) and assess voice quality both subjectively (Perceptual Voice Profile[42]) and objectively using computer analysis (Multidimensional Voice Profile on the Visipitch IV[g]). Questionnaires included: the Voice Handicap Index,[43] the Profile of Mood States (POMS),[44] the Assessment of Quality of Life,[45] and a musical background questionnaire. Poststudy music participation questionnaires and participant interviews were completed at the 6-month follow-up assessment. The affect grid[46] was completed before and immediately after each treatment session. This provided a measure of any immediate effects on pleasure and arousal (scored from 1–9 on a grid).

Assessment protocol

For the vocal assessment, each participant was seated in a sound-proofed room. An investigator directed participants through a protocol consisting of phonatory exercises, standardized reading passages, and familiar songs. Participants selected a song to sing using the karaoke game Singstar,[h] which scores performance

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List of abbreviations:

ASIA	American Spinal Injury Association
FEV$_1$	forced expiratory volume in 1 second
FVC	forced vital capacity
IC	inspiratory capacity
MEP	maximal expiratory pressure
MIP	maximal inspiratory pressure
POMS	Profile of Mood States
SCI	spinal cord injury
SCM	sternocleidomastoid
sEMG	surface electromyographic
SNIP	sniff nasal inspiratory pressure
SPL	sound pressure level
TLC	total lung capacity