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# Stroboscopy while Lifting Weights: A New Assessment Technique for Observing the Larynx in Strength Athletes while Lifting Weights (with and without Valsalva maneuver)

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A B S T R A C T

Lifting weights is a popular exercise method for improving the physical characteristics underlying performance in a wide range of sports. In order to perform these lifts safely and efficiently, strength athletes use purposeful holding of breath, strong exhalation against closed vocal cords. These are commonly known as Valsalva Maneuvers (VM) or hard glottis closures to increase core stability and reduce some of the load on the spine, and to facilitate lifting by increasing glottis closure and subsequently increasing intra-thoracic and intra-abdominal pressure. This function may expose athletes to an increased risk of laryngeal irritation or injury due to excessive pressure on the vocal cords during VM performance. Despite extensive weight training exercises in sports, its effects on vocal cords and overall laryngeal health have not yet been systematically studied. This brief methodological report describes how to safely use sports stroboscopy in strength training with weightlifting. This technique was safe and allowed to receive high quality and stable images of the larynx with minimal impact on weightlifting.

***Keywords:*** *Valsalva Maneuvers; Weightlifting; Stroboscopy; Strength Training*

## 1. Introduction

The vocal cords are called the glottis and are located in the lower part of the larynx. The glottis consists of the true vocal cords, the anterior commissure, and the posterior commissure (1-3). The vocal cords play an important role during physically effortful tasks, as they block the airway and keep air inside the lungs to provide a source of support when lifting heavy objects. In most individuals, the larynx closes during maximum effort body movements, such as lifting weights and exerting maximum amounts of force. This technique, known as ‘‘air trapping’’ or the Valsalva Maneuver (VM), is present when an individual is producing maximum effort (4). During quiet respiration, the vocal cords are in a relaxed and abducted state. Breath-holding and VM brings the cords together in an adducted midline position (1-3). Reduced ability to produce power during lifting may occur when the ability to adduct the larynx is compromised. When this ability is reduced, the individual is unable to exert pressure inside the chest and trap the air needed to stabilize the trunk. It has been shown that 57% of people who have had their larynx removed after surgery have difficulty lifting heavy objects (4).

VM is used as an activation technique to help athletes in weightlifting, wrestling and powerlifting. VM while lifting weights creates a forced exhalation against the closed airway and leads to greater intra-abdominal pressure (IAP) and thoracic pressure. Closure of the glottis seems to help the diaphragm to maintain the IAP rise. As a result of this activating mechanism athletes are able to lift more weight (5, 6). It is a commonly held belief that exhaling forcefully against a closed glottis, VM, is the optimal breathing pattern for producing maximal force. Zatsiorsky and Kraemer (7) have stated that using VM during maximal effort increases IAP and intra-thoracic pressure, thereby improving trunk stability and providing additional stiffness for proximal muscle attachments to improve muscle force production in the extremities (8). Respiratory behavior during resistance exercise corresponds to the different stages of a lift. General recommendations include exhaling through the sticking point during the concentric phase and inhaling through the eccentric phase. However, when lifting heavy loads, a brief VM, or the forced exhalation against a closed glottis, is unavoidable. These observations suggest that the VM is a natural reflex that is evoked during resistance exercise when greater efforts are required. The proposed benefit of the VM during resistance exercise is increased stability of the spine due to augmented IAP (9). Shirley et al. (10) demonstrated that spinal stiffness, thus stability, is increased when IAP is elevated. Stability of the spine is crucial for providing a foundation for movement of the upper and lower extremities, to support loads, and for protection of structures of the lower back. Strength and conditioning experts acknowledge that a brief VM (no longer than 3 seconds in duration) could assist the experienced resistance trainer by maintaining proper vertebral alignment and support and reducing lower back injury risk (9).

Whether the type of self-reported laryngeal behaviors during weightlifting is associated with reported laryngeal symptoms has been investigated using a prospective self-administered questionnaire (11). Despite the widespread use of VM in exercise, the effects of these laryngeal behaviors on overall laryngeal health have not been systematically investigated. This behavior may expose strength athletes to an increased risk of laryngeal irritation or injury due to excessive pressure on the vocal cords during VM performance. The effect of lifting objects on the larynx remains unknown, and it is necessary to identify ways to maximize laryngeal safety while maximizing successful physical effort (11).

In many voice clinic settings, laryngologists and speech-language pathologists have access to rigid and flexible endoscopy, using one or both technologies to evaluate the structure and act of the larynx (12). Flexible stroboscopy allows stable, high-quality images to be obtained, thus successfully describing laryngeal movement during lifting weights (13, 14). This can be achieved by inserting and then tightening a flexible endoscope in the nasopharynx to visualize the continuous movement of the larynx while lifting weights (15). Stroboscopy is a useful device by which the movement and function of the vocal cords during lifting weights can be observed and evaluated (12, 16). This assessment helps to observe the structure and function of the larynx and to identify pathology and treatment planning (13).

Exercise stroboscopy is usually performed for sports in which laryngeal movements are performed under intense ventilation pressure, such as employing either a treadmill (17), cycle (18), rowing ergometers (19), or swimming (15). While in anaerobic sports such as weightlifting or wrestling, this assessment has received less attention. Therefore, we performed this evaluation to determine whether continuous stroboscopy during exercise can be performed safely during lifting weights. This preliminary report describes the methodology used to achieve this goal,


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focusing on reporting safety, quality of image acquisition, and ability to collect data during the Valsalva maneuver (VM).

## 2. Methods and Materials

### *2.1. Study Design and Participants*

The study protocols were approved by the Sports Science Research Institute (SSRI) by the code IR.SSRC.REC.1402.160 and were registered with the Iranian Clinical Trials Registration Organization. The subject was given informed consent and, according to the Helsinki Declaration, he could refuse to continue the test at any time. The subject was a 22-year-old male professional Jiu-jitsu athlete, height 174 cm, weight 83 kg, body mass index 27.4 BMI, fat percentage 20% (The subject less than 40 years old was chosen to limit age-related changes in the larynx (20). He was in good physical health, had not previously been diagnosed with a voice disorder or head or neck injury, and had not reported a severe suffocation reflex (cannot tolerate endoscopic procedures), and showed no evidence of laryngeal pathology (performed by a larynx specialist during the study). The subject had not taken any supplements or drugs in the month before the test. In addition, the user was not an audio professional to rule out possible differences between trained and untrained voices. He completed a brief questionnaire about his early history of voice and health. The participant completed all stages of the study and provided images that met the requirements for endoscopic work. Before lifting weights, stroboscopic evaluation of the subject was performed to verify normal laryngeal structure and function. The status of the vocal folds, the anatomical position of the larynx, the presence of mass or deformity on the vocal folds, the position and closure of vocal folds and symmetry, the performance of vocal folds were evaluated with the help of speech therapist and through the stroboscopic device. Data were collected by imaging the larynx by a stroboscopic device (21).

### *2.2. Implementation*

In order to find 1RM for the subject, we asked the subject to do a series of lifts. Then 70% 1RM (for lifting halter with VM) and 35% 1RM (for lifting halter without VM) were calculated according to the ability of the subject (22-26). The subject performed stretching movements for 10 to 15 minutes to warm up. Afterwards, a flexible lens was inserted through the nose into the upper part of the subject's larynx and the flexible lens of the stroboscope and the camera were fastened with straps in a comfortable yet fixed position on the forehead and the head of the subject (Figure 1). He was asked to lift the halters with a deadlift (i.e., from a standing position, lifting of dead (without momentum) weight from the ground to the level of the hips and back down to the ground). In order to select the best laryngeal imaging, each movement was performed twice. With an LxStrobe3 Digital Precision Stroboscopy device made in United Kingdom, Imaging was done while lifting weights. Flexible fiber optic laryngoscope was used to image the supraglottis and vocal cords. The assessments were performed by a speech and language pathologist in the presence of an otolaryngologist.

**Figure 1**

*Insert a flexible lens through the nose to the upper part of the subject's larynx.*

Evaluated parameters of Stroboscopy during weight lifting and VM include symmetry, vocal folds mobility, vocal folds edge, and vocal folds opening phase (27). Vocal folds mobility is an indispensable parameter in the diagnosis of laryngeal function. The vocal fold can be normally mobile, hypoactive, hyperactive and paralyzed. In case of normal motility, vocal cords appeared adducted symmetrically in midline during VM. The edges of the vocal cords are also examined for smoothness and roughness, which in some sources is characterized by the convex and concave edges of the vocal cords. In addition, the open phase of the vocal cords is evaluated in four modes: Abnormal, Weak, Normal, and Extensive. At the end of the Stroboscopy examination, together with the


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specialist report, the two important images are printed, in which the vocal folds are in the respiratory state and in the gluteal state / in the VM phase (27, 28).

## 3. Findings

The recorded stroboscopic video provided high-quality and stable diagnostic images of the larynx during the experiments, while once performing 70% 1RM lifting the halters with a deadlift with the VM and once performing a 35% 1RM weight lift without the VM (Figure 2 and Figure 3). There were no side effects during the test, and it took approximately 3 seconds for the subject to lift the weight and stand up straight, bending over again, and placing it on the floor (9).

In the subject, asymmetry in the movement of the vocal cords was observed during breathing to lift a weight of 70% 1RM, and because deep breathing was taken, the vocal cords were placed at the maximum open position (extra extension). During the VM, the thickness of the left ventricle decreased and the movement became hyper active during the closure, and the false vocal cords closed with high pressure and more bulky, helping to trap the intense exhalation (Figure 2) (Table 1).

**Table 1**

*Stroboscopy report for performing 70% 1RM lifting the halters with a deadlift with VM*

| | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Symmetry | | ✓ | | |
| Vocal fold mobility | Normally mobile | Hypoactive | Hyperactive | Paralyzed |
| Patient's right | | | ✓ | |
| Patient's left | | | ✓ | |
| Vocal fold edge | Smooth | Slightly rough | Moderately rough | Ext. rough |
| Patient's right | | ✓ | | |
| Patient's left | | ✓ | | |
| | Abnormal | Weak | Normal | Extensive |
| Opening phase | | | | ✓ |

**Figure 2**

*Performing 70% 1RM lifting the halters with a deadlift with the VM.*



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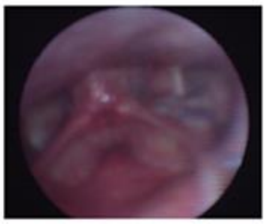

b-2

In the evaluated subject, the stroboscopic report for lifting 35% 1RM without VM was as follows: During breathing, the vocal cords opened normally and during lifting, the vocal cords closed without pressure and impact. The false vocal cords were in normal condition (Figure 3) (Table 2).

**Table 2**

*Stroboscopy report for performing 35% 1RM lifting the halters with a deadlift without VM*

| | Normal | Mild | Moderate | Severe |
|---|---|---|---|---|
| Symmetry | ✓ | | | |
| Vocal fold mobility | Normally mobile | Hypoactive | Hyperactive | Paralyzed |
| Patient's right | ✓ | | | |
| Patient's left | ✓ | | | |
| Vocal fold edge | Smooth | Slightly rough | Moderately rough | Ext. rough |
| Patient's right | | ✓ | | |
| Patient's left | | ✓ | | |
| | Abnormal | Weak | Normal | Extensive |
| Opening phase | | | ✓ | |

**Figure 3**

*Performing 35% 1RM lifting the halters without a deadlift with the VM.*


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## 4. Discussion

Weightlifting is a strength-based sport where the objective is to lift the maximum amount of weight. The term weightlifting is sometimes used as a generic term to encompass any lifting (29). Weightlifting exercises and their derivatives have become a popular training modality to improve physical attributes underpinning performance across a range of sports, largely owing to the high strength and power expressions during the movements. The magnitude of force production and the capacity to perform a given amount of work as rapidly as possible are often suggested as primary underpinning qualities of sport skills such as jumping, sprinting and change of direction tasks (30). In order to perform these lifts safely and efficiently, strength athletes use a purposeful breath keep, strongly exhaling against closed vocal cords. These are commonly known as the Valsalva maneuver (VM) or hard glottal closure, and are intended to increase core stability and alleviate part of the load placed on the vertebral column and facilitate the lift by increasing glottic closure and subsequently increasing intrathoracic and intra-abdominal pressure. Despite their widespread weight lifting exercises in sports, the effects of these laryngeal behaviors on overall laryngeal health have not yet been systematically explored. This behavior may put athletes at increased risk for laryngeal irritation or injury due to the excessive vocal fold contact pressure employed during execution of the VM. The influence of heavy lifting on the larynx remains unexplored. With the growing popularity of exercise paradigms that incorporate powerlifting techniques, identification of ways to maximize laryngeal safety while allowing successful maximum physical exertion is required (11).

This brief methodological report describes how to safely use sports stroboscopy in strength training with weight lifting. This assessment, which is one of the first, made it possible to obtain stable, high-quality images and thus successfully describe laryngeal movement while lifting weights with and without VM based on the subject's



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calculated 1RM. Recent technological advances have made it possible to develop portable stroboscopic systems with lightweight scoop systems and battery power supplies. It was clearly free to lift weights easily, both safely and functionally. Accordingly, the subject reported that the use of a flexible lens resulted in minimal interference with the weight lifting movement. In addition, the subject did not report any discomfort or distraction, and the trial proceeded without complications. The subject was healthy in the current assessment and did not report any respiratory symptoms. Although this does not provide evidence for the clinical diagnostic validity of this technique, it does emphasize the fact that the system was able to detect and indicate glottis changes when lifting weights with and without VM. Lifting weights creates special demands on the glottis, and complete closure of the vocal cords is important in certain parts of the weightlifting cycle. Therefore, in strength athletes, several factors may interfere with glottis closure. Visualization of the larynx during strength training is important to evaluate the VM to determine the nature of the glottis closure.

## 5. Conclusion

This methodological report has successfully demonstrated the safety and efficacy of continuous stroboscopy during strength training with weights, marking a significant advancement in the methods available for observing and understanding laryngeal behavior during intense physical activity. The technique has proven safe and effective, providing high-quality, stable images of the larynx with minimal interference in the weightlifting process. Notably, this allows for a detailed observation of the glottic changes that occur during weightlifting, both with and without the employment of the Valsalva maneuver (VM).

The use of this innovative stroboscopic technique represents a substantial step forward in sports science and medicine, particularly in the context of strength training. By enabling the clear visualization of laryngeal movements, practitioners can better understand the biomechanical impacts of heavy lifting on the larynx and vocal folds. This understanding is critical in developing training protocols that maximize performance while minimizing the risk of injury, particularly in the context of the high contact pressure exerted on the vocal folds during heavy lifts.

Moreover, the findings from this report provide a foundation for further research into the long-term effects of such laryngeal behaviors on athletes' vocal health. Understanding these implications is crucial in designing comprehensive training and rehabilitation programs that address not only the musculoskeletal demands of heavy lifting but also the potential laryngeal strain involved. Continued exploration in this area could lead to innovative strategies for preserving vocal health in athletes, especially those engaged in sports requiring heavy lifting and forceful vocalization techniques.

In conclusion, the application of continuous stroboscopy in strength training presents a novel and valuable tool for the detailed assessment of laryngeal function during weightlifting. Its ability to provide real-time, high-quality images of the larynx offers invaluable insights into the biomechanical processes at play, contributing to safer training practices and potentially enhancing performance outcomes. As research continues, it is expected that these insights will lead to more nuanced understanding and better management of laryngeal health in strength athletes, ultimately fostering safer and more effective training environments.

## Authors' Contributions

S. E.: Data collection, Data curation, Writing; M. A. R.: Conceptualization, Methodology, Formal analysis and investigation, Writing; M. G.: Supervision, Project administration, Funding acquisition, Writing; J. W. D.: Data collection, Data curation, Writing; M. B.: Software, Validation, Resources, Writing; A. A.: Conceptualization, Methodology, Formal analysis and investigation, Writing.

## Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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## Declaration of Interest

The authors report no conflict of interest.

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## Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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