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RAREŞ NICOARĂ

Developing the respiratory capacity of professional vocalists and wind instrumentalists through physiological and sports means

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content

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INTRODUCTION

Motivation

The present research comes to fill a gap that music professionals have pointed out to me on numerous occasions. Thus, students at the Academy of Music do not have a minimal and specific athletic training aimed at improving exactly the performances they are looking for. The intensity of the sound, the length of the phrase sustained on a single breath and even the vocal timbre depend on a performing breathing. Having the tools of modern research at our disposal, our study comes to fill this gap and to provide objective information intended to serve those who wish to increase their vocal or instrumental athletic performance. I am convinced that I will not be able to eliminate the empirical and subjective aspect of the breathing techniques of professionals, but knowledge of all the aspects treated in this work will be able to lead to a fairer and more efficient training of the respiratory system. The echoes that my research has already aroused in the world of vocal professionals make me believe in the chosen subject and in its immediate usefulness.

Degree of interdisciplinarity

The involvement of physical exercises in improving interpretive performances is a subject that has been approached too vaguely and too superficially so far, compared to the crucial importance it can have in the artistic growth of a musician. Music and physical education, these two seemingly unrelated fields are the ones that give this research the aspect of interdisciplinarity and, at the same time, lead to the practical utility component of this project. The combination of knowledge from the two fields and the specificity of the chosen theme are the main reason why this work has the quality of interdisciplinary research.

The role of breathing in professional singing

The main role of the respiratory system during singing is to regulate subglottic pressure , therefore it contributes greatly to vocal sustain. For singers, this concept also embodies other qualities, such as voice manageability, timbre and vocal projection, which are dependent on a number of additional factors, such as the position of the larynx and how it is used, and the conformation of the vocal tract (Miller, 1997).

In the evolution of a singer, the degree of artistic maturity is closely linked to the level of development and refinement of the respiratory system. This relationship determines the performer's ability to sustain extended musical phrases in a single breath, without excessive effort, using a variety of vocal nuances adapted to the character of the piece being performed. Correct breathing is an essential factor for the expressiveness and naturalness of vocal emission (Rusu, 2006). Breath control and support can be systematically cultivated by continuously practicing specific techniques for regulating this mechanism. Despite various attempts to theorize vocal art, the repetitive practice of exercises that stimulate the muscles involved in supporting the voice remains the most effective method of improvement.

Elements of originality

The originality of our study can be highlighted by several unique aspects, related to subjects, methods, and the specific combination of interventions:

- Target group (vocal and wind instrument professionals): There are studies investigating the respiratory capacity of athletes or other professional categories, but our research focuses on two very specific professional groups, which directly depend on respiratory function. Furthermore, the research may bring new information on how respiratory training and complementary methods, such as swimming and apnea, can optimize the performance of these professionals.
- Combining breathing training with swimming and apnea exercises: Swimming and apnea are less frequently used systematically to improve respiratory capacity in vocal or wind professionals. Our study explores the synergistic effect of these methods in improving lung function and breathing control, which represents an innovative approach.

• Spirometric assessments in this context: Although spirometry is a well-known tool for assessing pulmonary function, its application in monitoring progress within a program combining respiratory training and aquatic activities in these professional groups is relatively little explored.

• Possible practical applications: Our study could open new avenues for personalized training among vocal professionals and instrumentalists, helping to increase their performance. It could also have implications for music education and the prevention of respiratory health problems specific to these professions.

These elements highlight the originality of the study, through its interdisciplinary approach and the application of less conventional methods for developing respiratory capacity in particular professional contexts.

Research limitations

This research encountered several limitations, among which we would like to mention:

• practical limitations, such as access to a small number of vocal and instrumental professionals available for research, due to the pandemic;

• the small number of subjects may limit the statistical significance of the results and the generalizability of the conclusions to a larger population;

• the lack of other methods to assess respiratory function can be seen as a limitation, other complementary methods could be considered, such as VO2 max tests (to measure maximum oxygen consumption) or respiratory muscle function assessments (to assess the strength of the muscles involved in breathing);

• if the training and assessments were carried out within a short time frame, it may not be sufficient to observe significant changes in respiratory capacity;

• if subjects come from different backgrounds, variability in their levels of physical fitness and professional experience may introduce variability in the results.

Research objectives:

- initial and final evaluation of respiratory capacity through specific tests (spirometry);
- comparing respiratory performance between the experimental group and the control group;
- analysis of the influence of respiratory training on muscle strength and endurance;
- proposing optimal training methods for vocal professionals and wind instrumentalists, in order to maximize respiratory efficiency.

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Research hypotheses:

- Training the respiratory muscles with the threshold device causes an increase in muscular strength and endurance in the subjects;
- using the respiratory threshold device will lead to an increase in vital capacity (VC), forced vital capacity (FVC) and forced expiratory volume in one second (FEV1) after a period of training;
- the group using the threshold device with real resistance will make significantly greater progress than the SHAM (control) group, which uses the same device with minimal or no resistance (simulated), demonstrating the specific effectiveness of inspiratory resistance training;
- ventilatory and spirometric adaptations: Spirometric measurements, such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and respiratory reserve volume, will improve as a result of physiological adaptations to the stress induced by apnea and swimming;
- Benefits for vocal and wind instrument professionals: Since these professionals require precise respiratory control and consistent pulmonary intake, improving respiratory muscles will facilitate maintaining consistent levels of airflow during performances, thus supporting superior performance.

Methodology

The study included a group of 22 young musicians (vocalists and wind instrumentalists), divided into experimental and control groups. The experimental group followed a combined program of respiratory training (with an adjustable resistance device) for 8 weeks and aquatic exercises in the pool, for 8 weeks. The experiment consisted of two separate studies: the SHAM method (respiratory training with a threshold device) and swimming and apnea exercises in the pool.

It is important to note that the time interval between the two interventions was sufficiently long (several months), allowing the initial spirometric parameters to return to baseline values. Spirometric assessments and functional observations were performed in two stages: initial and final.

The SHAM method

The SHAM method (sometimes written as "SHAM intervention" or "SHAM training") is not a respiratory rehabilitation technique per se, but rather a term used in clinical trials to designate a control group that receives a fake or simulated intervention - that is, an intervention that mimics the real procedure, but without any real therapeutic effects. The experimental group: uses the device with a progressive resistance (e.g. 15% to 60% of the MIP - maximum inspiratory pressure), and the SHAM group (the control group) uses the same device, but with a resistance of only 5%, which does not cause a real training, leading to a placebo effect.

The main aim of the research was to evaluate the effectiveness of a respiratory threshold device in developing respiratory muscles. The study aims to determine to what extent training with such a device can influence the strength and endurance of respiratory muscles, contributing to better lung function and improving respiratory performance in professional and semi-professional singers if a respiratory muscle training protocol is imposed. This protocol aims to strengthen respiratory muscles and should result in increased respiratory flow in singers.

Intervention program

We used a validated 8-week training program with a pressure threshold measurement device (Breathe Air® Powerlung®), designed for a combination of muscular and inspiratory training.

This portable device works by generating pressure against the respiratory flow during the inhalation and exhalation phases, based on the fundamental principles of resistance training. Similar to how weights are used to develop upper limb muscles, using the POWERbreathe ® device, by inhaling against a controlled resistance, allows the respiratory muscles to be trained, thus contributing to increasing their strength and endurance.

SHAM training (8 weeks) consisted of a routine training, breathing into the device, with resistance levels set at 15% - 40% - 60% of the maximum inspiratory and expiratory pressures PIM/PEM (PIM – maximum inspiratory pressure/PEM – maximum expiratory pressure) measured at baseline. We applied the following training scheme: two weeks, for five days, one set of 30 breaths (3 times 10 breaths, inspiration-expiration, with a 1-2 min. pause between repetitions), twice a day with a 6-hour difference between sessions, with the resistance set at max. 15% PIM/PEM, with two days of non-activity in between. This was immediately followed (without a break period) by a 3-week training program, five days each, with the resistance set at max. 40% of PIM/PEM, with two-day breaks each weekend, and another 3 weeks (same), with the resistance set at max. 60% of MIP/MEP. Adherence, time spent, and effort were individually monitored in a written diary.

We performed three training sessions with different levels of resistance. Before the training session, we performed a series of tests to establish baseline values, and after the sessions, we performed another series of tests to assess the effects of training on lung function and respiratory flow.

During the first training session, the resistance setting of the hand-held device was at the SHAM level (max. 15% MIP/MEP – maximum inspiratory pressure/maximum expiratory pressure), during the second training session, the resistance setting of the hand-held device was set at the training level (max. 40% MIP/MEP), and during the third training session, we set the device at the training level (max. 60% MIP/MEP).

We performed spirometry measurements with the Vitalograph ALPHA Touch Spirometer (Ltd, Intl ., Maids Moreton , UK), before and after each training session. Subjects were tested in a sitting position , wearing a nose clip. After a maximal inspiration, they exhaled as hard and as quickly as possible. They were encouraged to continue exhaling for at least six seconds so that forced expiratory volume in one second (FEV1), forced expiratory volume in 6 seconds (FEV6) and forced vital capacity (FVC) could be measured. The tests were repeated three to five times until the two largest values recorded - forced vital capacity (FVC) and FEV1, FEV6 varied by less than 3%. Direct measurements include VC (vital capacity – measured in liters), FVC (forced vital capacity – measured in liters), FEV1 (forced expiratory volume in one second – measured in liters), FEV6 (forced expiratory volume in 6 seconds – measured in liters) and peak expiratory flow-PEF (liters/second). The forced expiratory ratio (FEV1/FVC × 100) is also calculated (percentage %).

In addition to this method, we included a set of exercises to tone the peripheral muscles to increase the elasticity of the rib cage, performed twice a week , for 50 min. per session . We grouped these exercises according to the three types of breathing used by singers: subclavicular breathing, costal-diaphragmatic breathing and abdominal breathing.

The measured indicators were analyzed descriptively, by calculating and comparing the most important descriptive statistics (mean, median, etc.). The descriptive values obtained for each measurement were evaluated to see if an improvement in the subjects' performance was observed from the initial to the final measurement, following the application of the method. Given that these are repeated measurements performed on small samples of subjects, 11, it is necessary to apply non-parametric tests. We applied the Wilcoxon test for respiratory measurements (these being 2 in number – initial and final), to present the test values and the probability obtained (p- value) and to evaluate the level of significance in order to validate the efficiency of the applied method. Also for descriptive purposes, we constructed various types of graphs, of which we present the boxplot . This, in turn, allows for descriptive and variation comparisons between the measurements performed.

Measurement conclusions

spirometric values obtained at the intermediate and final evaluation among the 11 subjects of the experimental group reveals a constant increase in respiratory parameters, especially FEV1 (forced expiratory volume in the first second) and FVC (forced vital capacity). All participants recorded progressive improvements, with average variations between +0.08 L and +0.27 L for FVC and between +0.05 L and +0.17 L for FEV1. These changes indicate a functional adaptation of the respiratory muscles following training with the threshold device , demonstrating its effectiveness in increasing respiratory capacity.

However, not all variables analyzed showed significant changes. For example, the forced expiratory volume ratio (FEV1/FVC) did not undergo relevant changes, suggesting that both FEV1 and FVC increased proportionally. This finding is important because it indicates that this method not only increased total lung capacity, but also maintained a functional balance in respiratory performance.

The small sample size is a limitation of the study, suggesting the need to expand the research to a larger group to obtain more robust statistical validation. Future studies could also investigate the long-term effects of maintaining respiratory training, as well as its influence on stage performance and vocal endurance in demanding contexts.

Respiratory muscle development in soloists and professional breathers through swimming and apnea exercises in the pool

This study aimed to investigate the effect of swimming on lung function among singers and wind instrument players. Previous studies indicate that swimming significantly influences lung function , demonstrating greater effectiveness in this aspect compared to other sports.

present research assumes the following hypotheses:

- Increase in muscle strength and endurance: Through swimming, the diaphragm and intercostal muscles are constantly trained, playing an essential role in the effort of breathing. Apnea brings an additional load on them, stimulating increased resistance and the ability to sustain longer periods of muscle contraction without fatigue, essential in supporting the respiratory effort in professional vocalists and wind instrument players.
- Swimming and apnea-based training improves respiratory coordination, helping to optimize the synchronization of breathing with movement and more precise control of the air flow required during musical performance.

 Vocal and wind instrument professionals who participate in swimming and apnea breathing training will record superior performance in controlling and sustaining airflow, which will contribute to better phonatory endurance and more efficient instrumental performance.

 Ventilatory and spirometric adaptations: Spirometric measurements , such as forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and respiratory reserve volume, will improve as a result of physiological adaptations to the stress induced by apnea and swimming.

 Benefits for vocal and wind instrument professionals: Since these professionals require precise respiratory control and consistent pulmonary intake, improving respiratory muscles will facilitate maintaining consistent levels of airflow during performances, thus supporting superior performance.

Intervention program

I designed a swimming program over eight weeks , three times a week (Monday, Wednesday, and Friday), with sessions lasting about 50-60 minutes.

Warm-up phase . Participants performed specific warm-up exercises for 10 minutes, aiming to prepare the circulatory and respiratory systems before entering the pool, as well as to stimulate the mobility of the lower and upper limbs, in order to prevent possible muscle injuries during swimming. In this phase, static joint mobility exercises were preferred (Zorba, 2001), with 10-second breaks between exercises, to allow muscle relaxation.

Basic stage. This stage consists of approximately 50-60 minutes of swimming training, performed weekly, which includes various exercises applied with the aim of achieving between 60-75% of maximum power capacity of moderate effort loads.

The measurements were performed using a laboratory spirometer (Turninac). Pneumotax , Pony FX - Cosmed Pulmonary Function Equipment , Italy). The parameters analyzed for the assessment of pulmonary function included: FVC (forced vital capacity, expressed in liters), FEV1 (forced expiratory volume in one second, expressed in liters), FEV1/FVC (the ratio of forced expiratory volume to forced vital capacity, expressed as a percentage), PEF (peak expiratory flow, measured in liters per second), FEV25-75 (the volume of air expelled between 25% and 75% of vital capacity, measured in liters per second), FEV6 (forced expiratory volume over six seconds, measured in liters) and FEV1/FEV6 (the ratio of forced expiratory volume in the first second to forced expiratory volume in six seconds, expressed as a percentage).

At this stage of the analysis, we applied comparison tests to confirm/disprove what was observed from the descriptive statistics. Given that measurements were performed on a small sample of subjects (11), it is necessary to apply non-parametric tests. Among these, we applied the Wilcoxon test for the measurements in the swimming test, as there were two measurements (initial and final). In this case, we presented the test values and the probability obtained, in order to evaluate the level of significance and validate the efficiency of the procedures applied.

Measurement conclusions

All main parameters of pulmonary function (FVC, FEV1, PEF, FEF25–75, FEV6) recorded statistically significant increases in the group that followed the swimming and apnea program. Wilcoxon and Sign tests confirm these increases ($p < 0.05$), indicating the effectiveness of aquatic training.

Specifically, significant increases were noted for the following parameters:

- forced vital capacity (FVC): average increase of approximately 17.6%;
- forced expiratory volume in one second (FEV1): increase of approximately 18%;
- peak expiratory flow (PEF): 17.8% increase;
- average flow recorded between 25% and 75% of vital capacity (FEF25-75): 22% increase;
- Forced expiratory volume in 6 seconds (FEV6): increase of approximately 19.7%.

In contrast, the FEV1/FVC and FEV1/FEV6 indicators did not undergo statistically significant changes, suggesting a proportional and balanced improvement in ventilatory parameters, without signs of obstruction or functional imbalance.

The results of the control group, which did not receive a specific training program, remained relatively constant, with no significant improvements. This finding confirms the hypothesis that the improvements observed in the experimental group are due to the swimming and apnea intervention, not to natural variations or routine activities.

In conclusion, the data obtained strongly support the hypothesis that aquatic training, by demanding the respiratory muscles and increasing resistance to effort, causes functional adaptations relevant to respiratory function. These improvements are particularly valuable for vocal and wind performers, who depend on fine respiratory control, increased lung capacity, and airflow stability in their artistic activity.

General conclusions

The methods used in this research clearly demonstrate that their application leads to a significant increase in respiratory capacity, an essential factor in the training of professional singers and wind instruments, having a strategic role in achieving the set objectives and obtaining outstanding performances. Improved breathing contributes to increasing vocal endurance, which influences the ability to interpret long-lasting musical phrases on a single breath, without considerable effort, allowing the use of a varied palette of nuances depending on the musical character. The level of artistic maturity of a singer or wind instrument player is closely linked to the progress made in the development and improvement of the respiratory system.

Complementary analysis of the differential changes in the experimental and control groups also revealed that improvements were greater in the second method, and the observed results confirm our initial hypothesis. The significant increase in expiratory muscle strength and its close correlation with the improvement of certain effort variables, strongly suggests a causative role in the increase in respiratory capacity . Although respiratory muscle training is volitional and therefore may be biased by learning, the absence of changes in the control group strongly argues for a real increase in expiratory muscle strength in trained subjects .

Confirmed hypotheses :

Threshold training significantly improves lung function:

- significant increases in vital capacity (VC) and forced vital capacity (FVC), statistically confirmed ($p < 0.05$);
- forced expiratory volume in one second (FEV1) increased by approximately 11-12% in the study group, indicating an improvement in the lung's ability to generate airflow quickly and efficiently;
- peak expiratory flow (PEF) and forced expiratory volume in 6 seconds (FEV6) also showed significant increases, indicating improved respiratory muscle strength and airflow control.

Swimming contributes to the development of respiratory capacity and respiratory efficiency in vocal and instrumental professionals:

- significant improvements in FVC and FEV1, with increases of approximately 17-18%, indicating an adaptation of the respiratory system to the high demands imposed by swimming;
- PEF and FEF25-75 increased significantly, suggesting better use of expiratory force during exercise;
- FEV6 increased by 20-23%, indicating an improved ability to expel air from the lungs.

The immediate effect of training leads to better use and control of respiratory flow.

- the results suggest that both training with the respiratory threshold device and swimming contributed to a rapid increase in respiratory flow after training;
- this aspect is reflected in increased acoustic efficiency and better airflow stability, essential for singers and wind instrument players;
- breath pressure control has been improved, facilitating the production of a more stable and better sustained sound.

Disproven/unconfirmed hypotheses

FEV1/FVC and FEV1/FEV6 did not show significant changes.

- these ratios represent the proportion of air forcibly exhaled in the first second compared to the total forced exhaled volume;
- the absence of a significant change suggests that the adaptations obtained through training did not change the ratio between expiratory flows, but only the total expiratory capacity;
- this means that the improvements observed are related to lung volume and respiratory muscle strength rather than proportional airflow efficiency.

SHAM training did not lead to significant improvements in peak inspiratory and expiratory flows .

- although SHAM training led to increases in inspiratory and expiratory pressures, these were not large enough to significantly influence peak airflow;
- a possible reason could be the relatively low resistance settings in the MIP/MEP training program, which would have limited the effect on respiratory flows ;
- this result suggests that to increase maximum airflow, training with higher resistance and longer duration is required.

FVC and FEV1 depend on the strength of the abdominal muscles. These muscles undergo hypertrophy due to prolonged exercise and increased FVC and FEV1 values. The diaphragm and accessory muscles of respiration also respond in the same manner.

Overall conclusion and implications

This study demonstrates that threshold breathing training and swimming can have a significant positive impact on lung function, especially on lung volume and respiratory muscle strength. Vocal professionals and instrumentalists can benefit from these methods, improving their lung capacity and airflow control, which may contribute to better artistic performance. The beneficial effects are more evident on total exhaled air volume and less on expiratory ratios, suggesting that these methods improve muscle strength more than proportional expiratory efficiency. Swimming had a stronger impact than threshold breathing training, generating greater increases in lung function parameters.

We believe that eight weeks of threshold resistance breathing training and eight weeks of swimming training appear to be sufficient to significantly increase both inspiratory and expiratory muscle strength .

Extensive research, involving a larger number of participants, conducted over a longer period and using higher quality measurement instruments, could provide more precise data regarding the effectiveness of the working methods applied in this study.

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