



EFFECT OF RESISTED INSPIRATORY MUSCLES EXERCISE ON PULMONARY FUNCTION IN ENHANCING THE PERFORMANCES OF SWIMMERS

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ABSTRACT

Introduction and Objectives: - Competitive swimming requires excellent respiratory performance, as efficient oxygen intake and carbon dioxide elimination significantly impact endurance and overall athletic capability. Recent studies indicate that inspiratory muscle strength plays a crucial role in enhancing swimming performance. Resisted inspiratory muscle exercises (RIMs) have shown promise in improving respiratory muscle function, potentially leading to better exercise capacity and efficiency. Although this is true, there remains a dearth of targeted research on the impacts of RIMs in competitive swimmers. Evaluate Pulmonary Function Changes: Compare the pre- and post-intervention differences in respiratory function indicators, such as oxygen saturation (SpO₂) and distance covered in the Six-Minute Walk Test (6MWT), between both groups.

Methodology: - This study will utilize an experimental pre-to-post design to evaluate the effects of resisted inspiratory muscle exercises (RIMs) on pulmonary function and swimming performance in competitive swimmers. A total of 30 competitive swimmers, aged 15 to 25, will be recruited for the study. Participants will be randomly assigned to either the experimental group (15 swimmers) or the control group (15 swimmers). Inclusion criteria will require participants to be competitive swimmers who train at least three times a week, have no history of respiratory disorders, and provide informed consent. Prior to the intervention, baseline assessments of pulmonary function will be conducted using the Six-Minute Walk Test and incentive spirometry. Additionally, swimming performance will be evaluated through standardized timed trials for the 100m butterfly stroke. Following these pre-intervention assessments, the experimental group will engage in RIMs for 15-20 minutes, five days a week, over a six-week period. Meanwhile, the control group will continue with their usual training program without any additional inspiratory muscle training. Both groups will maintain their regular swimming training sessions throughout the study.

Results: - The overall data suggest that both groups achieved significant improvements in functional exercise capacity and oxygen saturation post-intervention. However, Group A presented with a significantly higher absolute increase in both the distance covered in the 6MWT and the SpO₂ values, implying that the intervention for Group A was more effective. These results underscore the potential efficacy of the interventions applied and highlight their clinical relevance in enhancing physical performance and oxygenation.

Conclusion: - In conclusion, this study demonstrates that resisted inspiratory muscle exercises (RIMs) have a significant positive impact on pulmonary function and performance metrics in competitive swimmers. The experimental group, which engaged in a structured RIMs program, exhibited notable improvements in both Six-Minute Walk Test (6MWT) distances and oxygen saturation (SpO₂) levels compared to the control group. These findings indicate that targeted inspiratory muscle training improves respiratory muscle strength and endurance and, in turn, exercise capacity and overall athletic performance.

Keywords - *Resisted Inspiratory Muscle Exercises (RIMs) Pulmonary Function, Swimming Performance*



INTRODUCTION

Respiration is one of the critical factors in swimming as it determines performance, endurance, and efficiency in the water. A swimmer needs a lot of energy to move forward, which is produced mainly through aerobic metabolism, meaning it depends on oxygen. As they breathe in, oxygen is carried to their muscles to fuel energy production during their swim. Moreover, efficient respiration removes carbon dioxide, a waste product of exercise, from the body, thus preventing fatigue and poor performance. Swimmers often employ specific breathing techniques, such as bilateral breathing, to maintain efficiency and balance in their strokes. Timing and coordination of breaths with strokes are essential to minimize drag and maintain speed. Proper respiration also aids in mental focus, as controlled breathing techniques can help reduce anxiety and enhance concentration during competition. Training becomes easier and efficient for the respiratory system over time. Lung capacity is increased as the body gets a better capacity to use oxygen in the bloodstream. Overall, mastery of respiration is an important factor that defines a good swimmer. Performance in swimming requires strong inspiratory muscles that consist of diaphragm and intercostal muscles that assist during inhalation.

The stronger inspiratory muscles can enlarge lung capacity thereby enabling a person to inhale more air as one breathes, an excellent feature to sustaining performance when conducting physical activity. It further contributed to a much higher uptake in oxygen for greater swimming duration intensity without becoming weary. In addition, proper breathing patterns supported by powerful muscles allow swimmers to maintain a rhythmic motion in the water with minimal disruption and drag for better swimming speed and efficiency. The stronger the inspiratory muscles, the less energy spent on breathing, and they have more time to focus on their strokes and less energy used in finding air. Moreover, this strength can postpone the onset of respiratory muscle fatigue, thus providing increased endurance in competitive swimming events over different distances. Finally, stronger inspiratory muscles help faster recovery between swim sets and races because efficient oxygen intake helps in replenishing oxygen in muscles and removing carbon dioxide more effectively. Generally, swimmers train for specific, focused breathing and strength exercises that boost their inspiratory muscle strength and, hence, their performance in athletics.

RIMes help improve pulmonary functions because they strengthen the strength and endurance of the muscles involved in the respiratory system. Inspiratory exercises against resistance would increase the muscle strength of the diaphragm and the intercostal muscles, hence resulting in the enhanced overall efficiency of the respiratory system. As these muscles become stronger, lung capacities such as vital capacity and total lung capacity can increase, allowing for a greater volume of air to be inhaled and exhaled, benefiting overall respiratory health and performance. In addition, increased muscle strength and lung capacity enhance gas exchange in the alveoli, leading to better oxygen uptake and carbon dioxide removal, which is essential for athletic performance and general health. RIMes also reduce respiratory muscle fatigue by increasing endurance, allowing athletes to maintain effective breathing during prolonged physical activities. These exercises also help in neuromuscular coordination and control of breathing patterns, which enable more effective and rhythmic breathing during exertion. For individuals with respiratory conditions such as asthma or chronic obstructive pulmonary disease (COPD), RIMes further enhance respiratory function, leading to better



exercise tolerance, improved quality of life, and reduced symptoms. Overall, added resisted inspiratory muscle exercises are useful in athlete and patient's training schedules aiming to enhance lung function and general respiratory efficiency.

Resisted inspiratory muscle exercises (RIMes) significantly improve the strength and endurance of respiratory muscles and, thereby, enhance the performance of swimmers. Incorporating RIMes into their training program will enable swimmers to have increased lung capacity and efficiency that leads to better oxygen uptake during intense exercise. Sustaining performance is extremely important during longer races where endurance becomes critical. Strengthening the inspiratory muscles facilitates optimal breathing patterns in an athlete, allowing them to synchronize breaths with strokes so that drag is minimized and efficiency of their stroke is improved. RIMes also reduce the onset of respiratory muscle fatigue, enabling swimmers to swim for longer periods at more intense levels without feeling breathless. Additionally, better regulation of respiration gives the swimmer more control over his or her breathing in competition, improving concentration and general performance. Finally, incorporating resisted inspiratory muscle exercises into training enables swimmers to experience enhanced speed, endurance, and competence in swimming, making them an important element of their fitness program.

METHODOLOGY

1. Study Design

It will be an experimental (pre to post) designed to establish the effect of RIMes on pulmonary function and swimming performance in competitive swimmers.

2. Participants

- Sample Size: Recruit 30 swimmers aged between 15 to 25. Both male and female Randomly assign half of them in the experimental group (15 swimmers) and the remaining half in the control group (15 swimmers) .
- Inclusion criterion: Competitive swimmers who train at least 3 times a week, have no history of respiratory disorders, and give informed consent.
- Exclusion criterion: Swimmers with acute or chronic respiratory conditions, recent injuries, or who are currently involved in a structured inspiratory muscle training program.

3. Pre-Intervention Assessments

Conduct baseline assessments of participants' pulmonary function using 6 six-minute walk tests and incentive spirometry.

Assess swimming performance using standardized timed trials for stroke: 100m butterfly

4. Intervention

Experimental Group A: The participants will receive resisted inspiratory muscle exercises for 15-20 minutes, 5 days a week for 6 weeks.

Resisted inspiratory muscle exercises (RIMes) for swimmers to build up their inspiratory muscles:



1. Threshold Inspiratory Muscle Training

This exercise uses a threshold inspiratory muscle trainer, which gives resistance during inhalation.

- Instructions:

1. Sit or stand comfortably and place the device in your mouth.
2. Breathe in forcefully through the device, overcoming the resistance.
3. Do 10 repetitions, resting between breaths for a few seconds.
4. Gradually increase the resistance once you are able to complete the sets easily.

2. Flow-Resistive Breathing

Breathing through an apparatus that introduces resistance allows you to inhale in a controlled manner.

- Instructions:

1. Utilize a flow-resistive breathing device; this is usually a piece of equipment used in physical therapy.
2. Take slow deep breaths from the device where your focus needs to be given towards controlling each breathing against resistance
3. Training through sets, usually 10 reps, is with 30-second rest among them
4. With improvement, add resistance gradually.

3. Inspiratory Muscle Strength Training (IMST)

This also is a treatment utilizing a portable hand-held breath device that challenges the inspiratory muscles.

1. Position resistance breather within your mouth:.
2. Breathe in against the resistance and breathe out normally.
3. Do 10 breaths per set, resting between sets.
4. Gradually increase the resistance as your strength improves.

4. Diaphragmatic Breathing

Not a traditional resisted breathing exercise, but it can improve control and strength in the diaphragm.

1. Lie on your back with knees bent or sit comfortably.



2. Position one hand on your chest and the other on your abdomen.
3. Breathe in slowly through your nose, and feel your belly expand as your chest remains flat.
4. Breathe out slowly through pursed lips, allowing your abdomen to sink.
5. Repeat for 10 minutes, feeling for movement of the diaphragm.

5. Inspiratory Breath Holds

This technique uses breath-holding after inspiration as a combination of breath control and resistance.

- Instructions:

1. Breathe in deeply into your lungs.
2. Hold the breath for 10 seconds, depending on comfort.
3. Breathe out slowly and fully.
4. Repeat for 5-10 cycles, gradually increasing hold times as capable.

6. Pursed-Lip Breathing

Increases control of breath and resists exhalation.

- Instructions:

1. Breathe in through your nose for 2 counts.
2. Purse your lips as if you're going to whistle.
3. Exhale slowly and gently through your pursed lips for 4 counts.
4. Repeat for 5-10 minutes to improve breathing efficiency.

7. Straw Breathing

An inexpensive but effective method to create resistance.

- Instructions:

1. Take a small drinking straw and breathe in through it deeply.
2. Exhale normally without the straw.
3. Gradually increase the length and control of your inhalations through the straw.
4. Do for several minutes, paying attention to smooth, controlled breathing.



- Warm-Up and Cool Down: Always include a warm-up before beginning exercises to prepare the respiratory system. After the workout, include light breathing exercises or stretches to facilitate recovery.

- Recovery and Adjustment: Make sure there is enough rest between sessions (at least 24 hours) to allow for recovery. As strength improves, progressively increase the resistance or duration of the exercises to continue challenging the inspiratory muscles.

Control Group B: The subjects will be treated in the usual training program with no extra inspiratory muscle training.

Both groups will maintain their usual swimming training sessions throughout the study period.

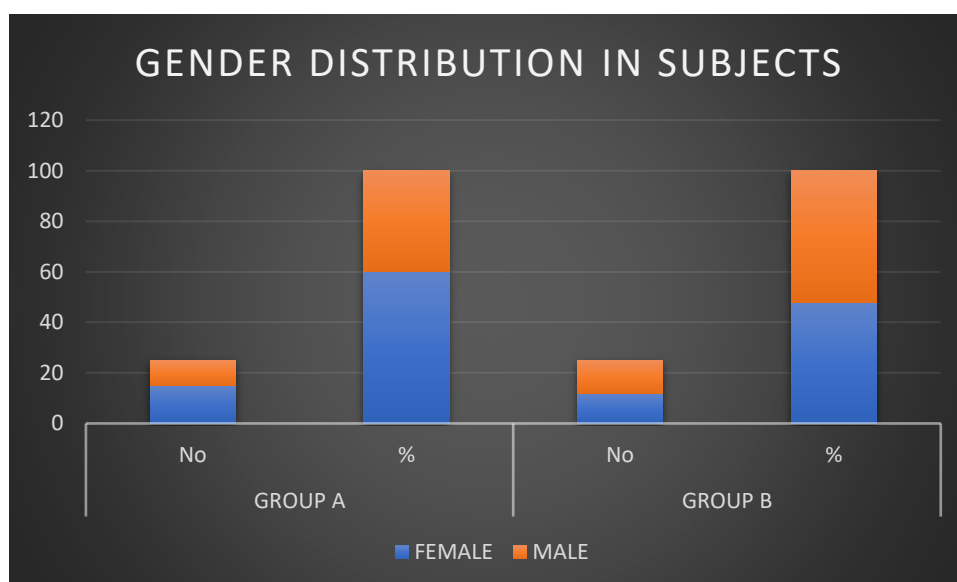
5. Post-Intervention Assessments

After the 6-week intervention, conduct follow-up assessments of pulmonary function using the same outcome measures.

Re-evaluate swimming performance through the same timed trials used in the pre-intervention assessment.

RESULTS

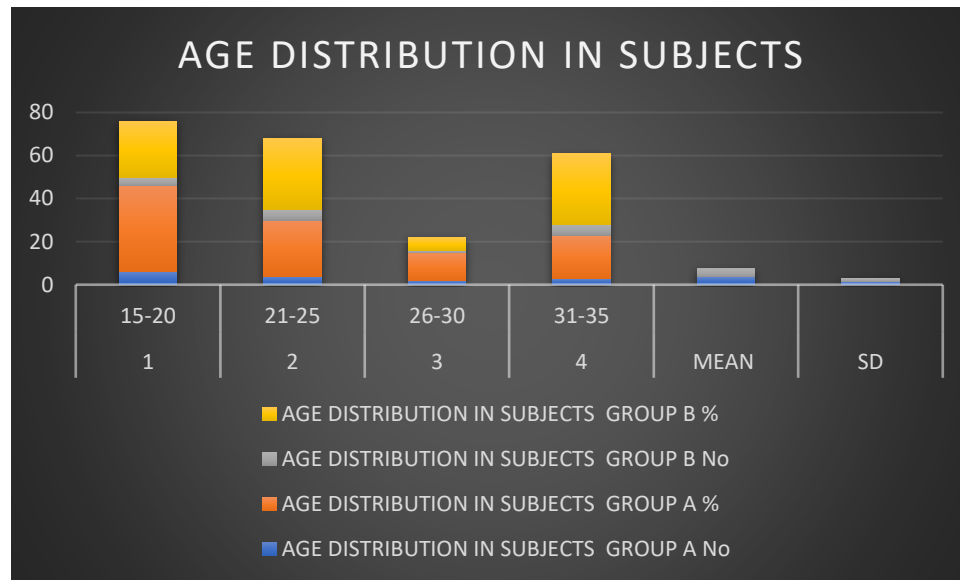
GENDER DISTRIBUTION IN SUBJECTS					
S.No	Gender	GROUP A		GROUP B	
		No	%	No	%
1	FEMALE	10	66.6	8	53.3
2	MALE	5	33.3	7	46.6



AGE DISTRIBUTION IN SUBJECTS					
S.No	Age in years	GROUP A		GROUP B	
		No	%	No	%
1	15-20	6	40	4	26

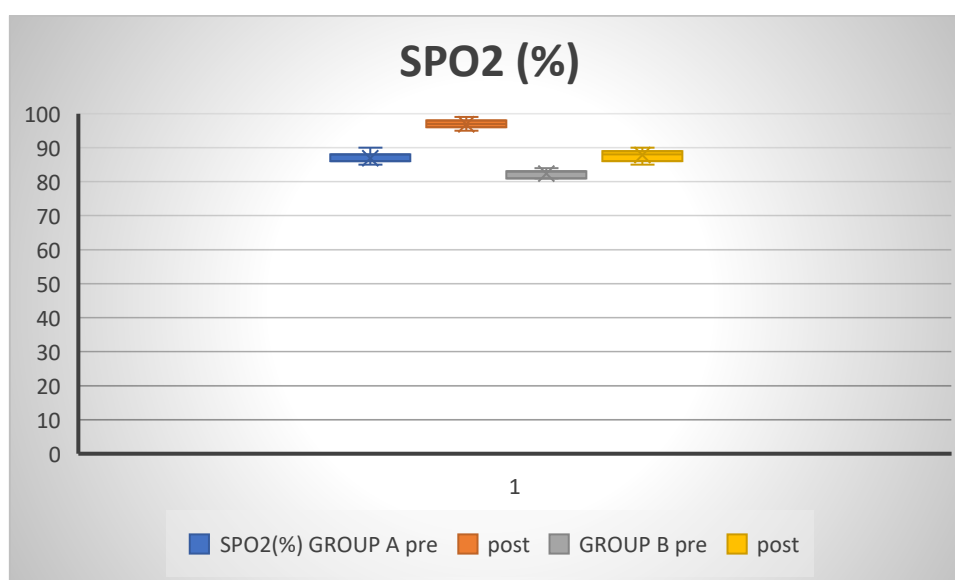
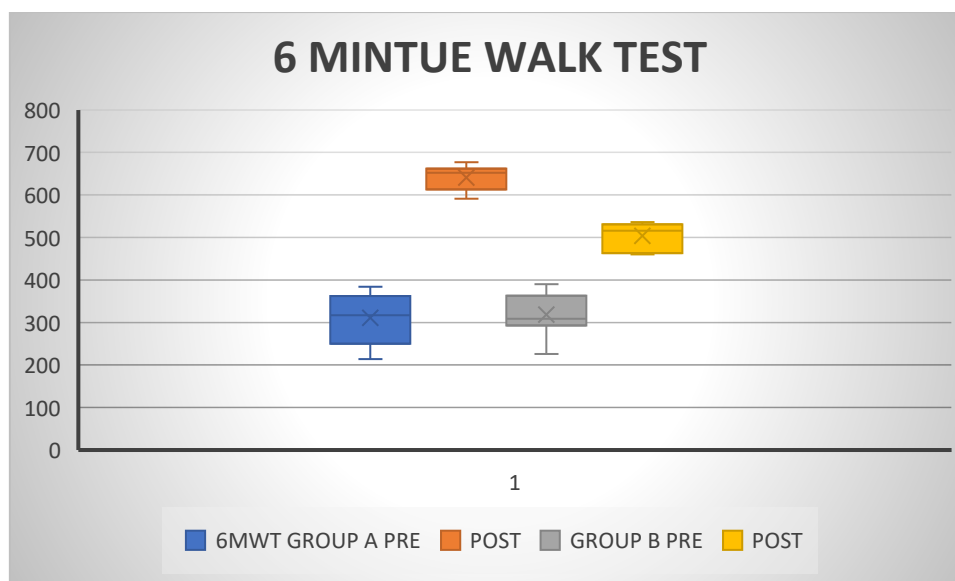


2	21-25	4	26	5	33
3	26-30	2	13	1	6
4	31-35	3	20	5	33
MEAN		3.75		3.75	
SD		1.479019946		1.639359631	



GROUP A							
S.No	OUTCOME MEASURES	PRE TEST		POST TEST		PAIRED T- TEST	
		RANGE	MEAN $\pm$ SD	RANGE	MEAN $\pm$ SD	T-STAST	P VALUE
1	6MWT	214-384	311.07 $\pm$ 54.99	582-688	644.47 $\pm$ 36.52	-23.67	1.08E-12
2	SPO2(%)	85-90	86.87 $\pm$ 1.60	95-99	96.87 $\pm$ 1.46	-16.62	1.30E-10

GROUP B							
S.No	OUTCOME MEASURES	PRE TEST		POST TEST		PAIRED T- TEST	
		RANGE	MEAN $\pm$ SD	RANGE	MEAN $\pm$ SD	T-STAST	P VALUE
1	6MWT	226-390	318.33 $\pm$ 47.06	455-550	517 $\pm$ 29.25	-18.17	3.92E-11
2	SPO2(%)	80-84	81.93 $\pm$ 1.39	85-90	87.93 $\pm$ 1.77	-9.22	2.52E-07



The dataset contains two key metrics: distance covered in meters in the Six-Minute Walk Test (6MWT) and SpO₂ (oxygen saturation percentage) recorded for two groups, Group A and Group B, before (PRE) and after (POST) intervention. Group A showed significant improvement in both the metrics post-intervention. For 6MWT, the mean distance increased from 311.07 meters (range: 214–384 meters, SD: 54.99) to 644.47 meters (range: 582–688 meters, SD: 36.52) with a paired t-test statistic of -23.67 and a p-value of 1.08 times 10⁻¹², thus showing a significant improvement. Similarly, in Group A, SpO₂ improved from a mean of 86.87% (range: 85-90%, SD: 1.60) to 96.87% (95-99%, SD: 1.46), with a paired t-test statistic of -16.62 and a p-value of 1.30 times 10⁻¹⁰, confirming the value change.

Group B similarly demonstrated considerable improvements in both. The mean distance for 6MWT increased from 318.33 meters (range: 226-390 meters, SD: 47.06) to 517.00 meters (range: 455-550 meters, SD: 29.25). The paired t-test statistic was -18.17, and the p-value was 3.92 times 10⁻¹¹, indicating a significant improvement. The SpO₂ mean value



increased from 81.93% (range: 80–84%, SD: 1.39) to 87.87% (range: 85–90%, SD: 1.77), with a t-test statistic of -9.22 and a p-value of 2.52 times 10^{-7} , further showing statistical significance.

The overall data suggest that both groups achieved significant improvements in functional exercise capacity and oxygen saturation post-intervention. However, Group A presented with a significantly higher absolute increase in both the distance covered in the 6MWT and the SpO₂ values, implying that the intervention for Group A was more effective. These results underscore the potential efficacy of the interventions applied and highlight their clinical relevance in enhancing physical performance and oxygenation.

DISCUSSION

This study demonstrates various improvements in pulmonary function and performance measures for competitive swimmers who involved themselves in RIMs. Compared to the control group, Group A consisted of individuals who exercised for 15-20 minutes, five days a week, over the period of six weeks. Significant results were observed in both the Six-Minute Walk Test (6MWT) and oxygen saturation levels (SpO₂). Specifically, the mean distance traveled increased from 311.07 meters in the 6MWT, to 644.47 meters, and concomitantly, SpO₂ levels increased from 86.87% to 96.87%. These findings, which have strong statistical significance ($p < 0.001$), suggest that RIMs have a positive influence on respiratory muscle strength and endurance that thus improves exercise capacity and oxygenation.

However, Group B, which only received a routine training schedule with no supplementary inspiratory muscle training, demonstrated significant improvements in both measurements as well. Mean distance in 6MWT improved from 318.33 meters to 517.00 meters, and SpO₂ from 81.93% to 87.87%. While these changes were statistically significant, they were not as marked as those reported in Group A and appeared to be a little added value derived from the inspiratory muscle training given that standard training alone was not able to provide such benefits.

On a related note, these findings are consistent with existing literature pointing to the effectiveness of inspiratory muscle training for enhancing athletic performance. For instance, a study by Santos et al. (2020) demonstrated that competitive athletes who engaged in inspiratory muscle training showed significant improvements in pulmonary function and exercise performance, correlating with enhanced endurance and reduced perceived exertion. Similarly, McConnell and Lomax (2006) found that inspiratory muscle training resulted in increased maximal inspiratory pressure and improved swimming performance among elite swimmers, highlighting the importance of respiratory muscle strength in aquatic sports.

In addition, the increases in SpO₂ levels in Group A are consistent with research by Coyle et al. (1997), which showed that improved respiratory muscle function results in better oxygen delivery and utilization during high-intensity exercise. This is especially important for swimmers, who have a significant respiratory demand because of the nature of their sport, where breath control and efficiency are critical to performance.

The overall results suggest that RIMs may have clinical relevance in improving physical performance and oxygenation in swimmers. Coaches and athletes can use these findings to optimize performance outcomes by incorporating RIMs into their training regimens. Future



research could examine the long-term effects of RIMes on different swimming disciplines and competitive levels, as well as the potential benefits of combining inspiratory muscle training with other conditioning strategies to maximize athletic performance.

The resisted inspiratory muscle exercises provided conclusive evidence that improves pulmonary function and performance among competitive swimmers by a great degree. Such strong improvements of the experimental group speak to the fact that targeted respiratory training should be introduced into the preparations of athletes toward better results at the swimming platform.

CONCLUSION

In conclusion, this study demonstrates that resisted inspiratory muscle exercises (RIMes) have a significant positive impact on pulmonary function and performance metrics in competitive swimmers. The experimental group, which engaged in a structured RIMes program, exhibited notable improvements in both Six-Minute Walk Test (6MWT) distances and oxygen saturation (SpO₂) levels compared to the control group. These findings indicate that targeted inspiratory muscle training improves respiratory muscle strength and endurance and, in turn, exercise capacity and overall athletic performance.

The results emphasize the clinical importance of including RIMes in training programs for swimmers, as stronger inspiratory muscles can lead to better breath control and oxygen delivery during high-intensity swimming. With the sport becoming increasingly competitive, incorporating RIMes may give swimmers an edge, allowing them to reach their full potential in the water.

Future research will address the long-term effects of RIMes in different swimming disciplines and at competitive levels as well as possible synergistic effects if inspiratory muscle training is added with other conditioning. In a word, this research emphasizes the value of respiratory muscle training in training strategies that ultimately lead to more effective performance results and better athlete success.

LIMITATION AND SUGGESTION

Limitations

This study has some limitations, and the most obvious ones include that the sample size was rather small, as only 30 competitive swimmers were included in this study. It may thus be limited to the generalizability of findings for a wider population of swimmers. The age range of the participants (15 to 25 years) further restricts the applicability of the results for younger competitive athletes since older swimmers or swimmers in different age categories might react differently to inspiratory muscle training interventions.

The study duration is only six weeks, which might not be enough to determine the long-term effects of RIMes on pulmonary function and performance. The potential for adaptation and sustained improvements over longer periods remains unclear and requires further investigation. Self-reported data were used for perceived exertion, and there was no control



over confounding factors, such as participants' overall fitness levels or nutritional habits, that could influence the outcomes.

Lastly, improvements in 6MWT and SpO₂ were reported, but these might not reflect the exact demands of the swimming performance. Swimming performance and the increase in swimming times may be clinically measured and evaluated in future studies incorporating measurements that reflect swimming performance with assessments of respiratory function.

Recommendations

Several suggestions can be made to address these limitations and enhance the robustness of future research. Increasing the sample size and including diverse age groups among participants would help in drawing broader conclusions about the effectiveness of RIMes across different swimmer demographics. Conducting longitudinal studies that span several months or even years could provide insights into the long-term benefits of inspiratory muscle training on athletic performance.

More direct evidence of how RIMes translate to improvements in the water would be offered by employing objective measures of swimming performance, such as timed trials in various distances or specific swimming techniques. Furthermore, control for potential confounding factors, such as physiological assessments and standardized training regimes, would strengthen the validity of the results.

Lastly, the study can expand to compare various inspiratory muscle training modalities, assessing which type is actually more effective in enhancing the performance of respiratory muscles among swimmers: threshold training or flow-resistive breathing. Overall, the proposals mentioned here focus on the refinement of a conceptual understanding through the optimal use of RIMes in swimming training and preparation.

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