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Effect of Pranayama Yoga Breathing Exercises on High School Swimmers

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ABSTRACT

The overall purpose of this study was to determine the effect of regular pranayama yoga breathing on high school swimmers. This study used experimental and survey research methods to collect the data and answer the research question. Experimental data was collected before and after the intervention group went through five weeks of pranayama yoga breathing. Survey data was also collected before and after the intervention. The data collected in this study showed that pranayama yoga breathing is useful in decreasing high school swimmers' race time because the intervention group had a 10.07% decrease, while the control group only had a 6.97% decrease. After analyzing these results, it was concluded that the hypothesis was correct in claiming that regular pranayama yoga breathing would have a positive effect on high school swimmers' race times.

Introduction

Swimmers are constantly training and pushing themselves to shave off just tenths of a second. Consequently, coaches and athletes train together daily, developing new drills and exercises to improve swimmers' performance. For instance, breathing exercises are a common practice when trying to increase underwater efficiency (Ogonowska-Slodownik et al., 2021). A breathing exercise that has not been introduced to the swimming community yet is pranayama yoga breathing. Pranayama, as defined by Karthik et al. (2014), is not just breathing exercises, it is truly "taking control of prana." Prana, which translates to breath in Sanskrit, an ancient Indo-European language, is "the body's vital 'airs,' or energies" (Britannica, 2015, para. 1). Pranayama is one of the five principles of yoga. This principle specifically increases lung capacity, which is done through inspiration and expiration. Through previous studies, Karthik et al. (2014) summarize that pranayama "increases chest wall expansion and almost all lung functions" (p. 4). Numerous studies have been done before on the effects of pranayama yoga breathing, but few focus on the effect in adolescents, and essentially none focus on adolescent athletes.

Pranayama breathing has had an increase in popularity in the medical field as a method of healing for doctors. Many doctors advise their patients with cardiovascular or pulmonary issues to experiment with pranayama to observe how their quality of life is impacted. Numerous researchers have run experiments to evaluate the effectiveness of pranayama in improving pulmonary functions. Donesky-Cuenco et al. (2009) hypothesized that yoga breathing could improve certain pathophysiologic changes in chronic obstructive pulmonary disorder (COPD) patients as well as a decrease in anxiety which leads to a decrease in dyspnea, shortness of breath (p. 226). Previous research had shown pranayama breathing has positive effects on elderly and asthma patients, but research on the effect on COPD patients was limited. Many other articles have been published since then, outlining the effects of pranayama breathing on patients of all kinds of disorders. After reviewing the body of knowledge thoroughly, it can be concluded that pranayama has many positive effects on pulmonary functions in all types of patients and should be further investigated to find the benefits for high school swimmers.

Literature Review

Pranayama Breathing

Essentially, Yoga has been said to originate from India in 5000 BC. Since then it has migrated all around the world and become common practice in some people's lives. Yoga focuses on asana, specific posture, and pranayama, regulated breathing among other aspects. In pranayama, there are four main components of breathing: puraka (inhalation), recaka (exhalation), antah kumbhaka (internal breath retention), and bahih kumbhaka (external breath retention) (Nivethitha, 2016, p. 72). Kumbhaka together can be used as a certain pranayama breathing exercise. This method has shown to have the greatest impact on increasing lung capacity, which is the maximum volume of air in the lungs that can be inhaled.

Effect of Pranayama on Sick Patients

Over the years the body of knowledge around pranayama has grown significantly, but still, there are many gaps to fill. One area that has been thoroughly researched is the effect pranayama breathing has on sick patients. Ranging from COPD to asthma to lung cancer patients, researchers have explored the impact of pranayama. Donesky-Cuenco et al. (2009) stated that "home walking and supervised endurance exercise are strategies that have been shown to reduce dyspnea intensity (DI) and dyspnea-related distress (DD)" (p. 225). This has shown results in the past but patients requested a new method, so doctors evaluated if yoga exercises could be an alternate exercise. After a 12-week program, the results showed there were no significant differences in FEV_1 and FVC between the yoga and control groups. The FEV_1/FVC ratio compares the volume of air patients can force out of their lungs in one second with forced vital capacity, the maximum volume of air a patient can exhale from their lungs after fully inhaling (Leader, 2022). However, the yoga group had a significant increase in the distance traveled for the 6-minute walk (Donesky-Cuenco, 2009, p. 232). The results of this study show that yoga has benefits for COPD patients such as muscle strength, but not precisely lung function.

Additionally, Kaminsky et al. (2017), in a more recent study, explored the effect of pranayama breathing on COPD patients but yielded different results. Kaminsky et al. (2017) aimed to focus on simple pranayama to discover if it is a feasible exercise for COPD patients to do at home and improve their condition (para. 4). After running a 12-week study on COPD patients 18 and older, this study concluded that inspiratory capacity, the volume of air forcefully inhaled after casual exhalation, significantly increased in the pranayama group but no change in the control group (para. 23). Kaminsky et al. (2017) concluded that pranayama exercises may be helpful to patients who cannot participate in a formal yoga setting and should be incorporated into the primary care setting.

Similar to COPD, asthma patients have pulmonary issues that could be relieved with pranayama breathing. Agarwal et al. (2017) stated "Nocturnal symptoms score decreased from 1.416 ± 1.619 to 0.067 ± 0.362… All this suggests clinically significant improvement with respect to asthma symptoms" (p. 64). Nocturnal symptoms in asthma patients are chest tightness, wheezing, shortness of breath, etc. which make it hard to sleep at night. Along with nocturnal symptoms decreasing, FEV_1/FVC ratio also significantly increased. Agarwal et al. (2017) claim that pranayama had a significant positive impact on asthma patients. This is another study where the use of pranayama to improve patients' lung function resulted in a positive outcome.

Furthermore, researchers have also observed the effect of pranayama breathing exercises on lung cancer patients. Khan (2017) elaborated further and revealed that the non-small cell lung cancer patients, after going through a pranayama regimen, experienced improvements in FEV_1 measurements (para. 2). Additionally, the study concluded, after analyzing the data, that pranayama can serve to be a helpful exercise when trying to improve lung function in non-small cell cancer patients.

Effect of Pranayama on Healthy Participants

Pranayama has proven to be successful in COPD and lung cancer patients, so consequently there should be benefits for healthy patients as well. Joshi et al. (1992) conducted a study with 75 healthy medical students. The purpose of the study was to "ascertain whether pranayam alone has any effect on the ventilatory lung functions, which depend on compliance of lung and thorax, airway resistance and strength of respiratory muscles" (Joshi et al., 1992, p. 105). This study affirmed the fact that pranayama has a significant impact on lung function. This study focused on healthy participants which other studies did not. After the 6-week study, participants showed a decrease in respiratory rate and a significant increase in respiratory muscle strength. These two factors go hand in hand; a strong musculature of the lungs will result in a slower respiratory rate. Once again, this article has shown pranayama has a positive effect on lung function in participants, this time in healthy participants.

Another article confirms the work of Joshi et al. (1992). This study gave attention to the effect of pranayama on healthy adolescents. Kuppusamy et al. (2017) stated, "Regular practice of prāṇāyāma improves cardiovascular and respiratory functions, improves cognitive function, decreases the effect of stress and strain on the body and hence improves the physical and mental health of an individual" (p. 196). To support this claim the researchers ran a study for 12 weeks with 90 healthy adolescent participants. After the study was concluded, the results showed a significant increase in FEV_1/FVC ratio and FEF, forced expiratory flow. According to Moore (2012), FEF is the flow or speed at which air is expelled from the lung in the middle portion of forced expiration (p. 233). Cohen's D, the effect size of the comparison between two groups, for this experiment was determined to be medium to large (Kuppusamy et al., 2017, p. 198). These results reveal that pranayama could increase lung function in swimmers and further research is needed.

Gap in Knowledge

To conclude, pranayama breathing exercises have proven to be useful in increasing lung function in numerous studies, but no study has tried to discover the effect pranayama has on adolescent athletes and more specifically, high school swimmers' race times. This research project aims to do just that. The purpose of this study is to discover a method to help swimmers gain an advantage in the pool. The goal is to find the effect of kumbhaka pranayama breathing exercises on high swimmers' race times. This leads to the research question: to what extent does performing kumbhaka pranayama breathing exercises using an app, Pranayama 2, for 20 minutes a day, five days a week for five weeks, affect race times in high school swimmers? If the research study results in findings that support the hypothesis that if high school swimmers regularly perform pranayama breathing exercises then their race times will decrease because of an increase in lung function, then this will significantly impact the swimming community. Swimmers are always looking for a new way to gain an advantage in a race. Pranayama breathing exercises may be the perfect leg up.

Methods

This study investigated the effect of pranayama yoga breathing on high school swimmers' race times using a mixed methods approach. A mixed methods approach was used for this experiment because it resulted in data that depicted pranayama breathing's effects. While the quantitative data was the race times for the swimmers, the qualitative data explained how the swimmers felt in the water. The swim times that were collected are numeric values and therefore were categorized as quantitative data. Qualitative data was collected through a survey that asked questions about their breathing before and after going through the study. The participants answered with their feelings and explanations as to how they thought the intervention affected them. The conclusion about the effect of pranayama breathing exercises on high school swimmers was strengthened by correlating findings between the quantitative and

qualitative data. Bhimani et al. (2011) used a mixed methods approach in their study. This study investigated the effects of pranayama on stress and cardiovascular levels in medical students. Both quantitative and qualitative data were used in this study to see the full picture of the effects of pranayama.

To collect relevant data, experimental and survey research methods were used in this study. Experimental research data collected the quantitative data and survey research acted as the qualitative data. Experimental research was ideal for this study because investigating the effects of pranayama breathing requires an intervention, the implementation of a change to determine how that variable affects the participants (Agarwal et al., 2017). The intervention is the pranayama breathing exercises. The implementation of this intervention directly showed the effect of pranayama breathing. This study also uses survey research to gather data that experimental data can not gather. For instance, experimental data does not gather how the swimmers feel before and after the intervention. The survey research helps wholly see the effects of pranayama breathing on high school swimmers' race times. Akshayaa et al. (2019) used survey research in their study to find the effect of yoga on health status and physical fitness. This survey was distributed across Chennai to 101 yoga practitioners. This survey asked questions about practicing yoga and the health of these yoga practitioners. After analyzing the results, it showed that the majority of participants were practicing yoga for stress reduction and fitness enhancement. Similar to this study, Akshayaa's study asked questions that gathered more information about what the participants thought about the breathing exercises. After reviewing all kinds of research methods, it was found that experimental and survey research would best answer the research question presented.

Subject Selection

This research study used a purposeful sampling procedure. All of the participants met the criteria of being high school swimmers. The research study solely focused on the effect of pranayama breathing exercises on high school swimmers which is the specific gap in the body of knowledge, so the only logical sampling procedure would be purposeful sampling. The subjects were selected from a Delaware high school varsity swim team and a local club swim team with swimmers in grades nine through twelve. The swimmers were asked if they wanted to participate in the study. If they said yes, they would be given further information about the study. Ashfaque et al. (2013) used similar procedures to gather their subjects by utilizing the hospital's adult chronic asthma patients. Only the patients who met the criteria for this study were allowed to participate.

Validity

External validity was maintained throughout the research study by performing the study in a real-life setting. Using a real-life setting was important because, in swimming, the environment always affects the swimming performance. For pranayama yoga breathing to be applied to real-life competitive swimming for training purposes, the results needed to be collected in a real-life setting. Content validity was also ensured throughout the study because the questions being asked, along with the before and after recorded times of the swimmers, directly correlated with the research question. The research question addressed the correlation between pranayama breathing and high school swimmers' race times, and the data collected is the high school swimmers' race times before and after the intervention. The survey also answers how the participants felt before and after the intervention. In this research study, internal validity was ensured by triangulation, collecting data from different sources. This research study collects data from two different sources, the race times, quantitative data, and the survey, qualitative data. Internal validity was also ensured by assigning the intervention group uniform instructions with exact instructions on how to use the breathing app. Establishing a control group to compare data points with the intervention group also helped maintain internal validity in this study.

Procedure

To begin, the pre-survey was emailed to the 30 participants who volunteered to participate in the study. Once the participants answered the pre-survey (see Appendix A) that asked questions about demographics and prior knowledge about pranayama breathing, the participants were randomly divided into the control and intervention groups. Then, to collect race times the participants swam a set of four 50s (50 yards) on the minute. Each 50 time was recorded and then averaged for the overall 50 race time. This was the pre-intervention quantitative data.

The intervention group was then sent another email disclosing how to use the app, Pranayama 2 (see Appendix C), and which mode they should use. The control group was instructed to continue their normal training schedule. On the app, the participants were instructed to use the box breathing mode for 20 rounds. Box breathing is another term used for kumbhaka pranayama breathing. The app then walked the participants through how long they were supposed to inhale, hold their breath, and exhale. The participants were instructed to do 20 minutes of breathing exercises five days a week, for five weeks. Once the five weeks were over, participants took the post-survey (see Appendix B) and answered almost identical sets of questions to the pre-survey to collect comparable data. Then the post-intervention race times were also collected in the same fashion as the pre-intervention race times. Once all of the results were recorded, they were inserted into a spreadsheet sheet to analyze.

Limitations

Some limitations throughout this research study were time restraints, human variability, and the honor code. The time restraint forced the study to take course over five weeks when the study would have benefitted from six or more weeks. Another limitation was human variability because the swimmers may have given different amounts of effort in the pre and post-swim tests. This would mean if there was a decrease in the time it could have just been that the swimmer swam faster or slower in the swim tests. Lastly, the honor code also plays a role in this study. Swimmers may not have performed pranayama breathing exercises for the amount of time assigned to them. The study instructed them to do the breathing exercises for a certain time, but the swimmers may not have done that. If the swimmers lied about how long they did the breathing exercises, then the validity of the results would be compromised.

Analysis

To analyze the results collected in the study, statistical analysis was used. The average race times for the control and intervention groups were compared side by side to determine what kind of effect pranayama breathing had on the high school swimmers' race times. The survey also took into consideration the swimmers' breathlessness level from pre to post-test. If the intervention group had a greater decrease in time and breathlessness level than the control group, then this would indicate that the breathing exercises had a positive impact on the race times.

Results

The overall research question around which the study revolved was to find if there was a correlation between high school swimmers' race times and them performing pranayama breathing exercises five days a week for five weeks on an app. The participants were split into two groups: control and intervention. The intervention group used the breathing app while the control group continued with their normal training routine. Quantitative and qualitative data were collected to determine if pranayama breathing exercises affected the race times. Quantitative data was collected by recording the average time it took the swimmer to swim four 50s, before and after the intervention. In the control group, there were 15 swimmers, whose average change in time from pre to post was 2.43 sec (see Figure 1). In the intervention group, with 15 swimmers as well, the average change in 50 time was 3.65 sec (see Figure 2).

Figure 1
Pre and Post Times and Change in Time for Control Group

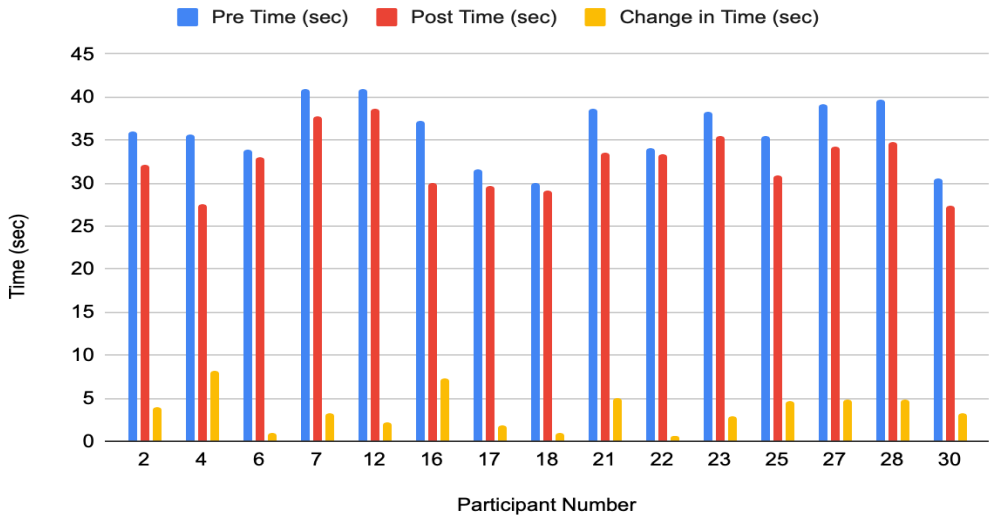

Figure 2
Pre and Post Times and Change in Time for Intervention Group

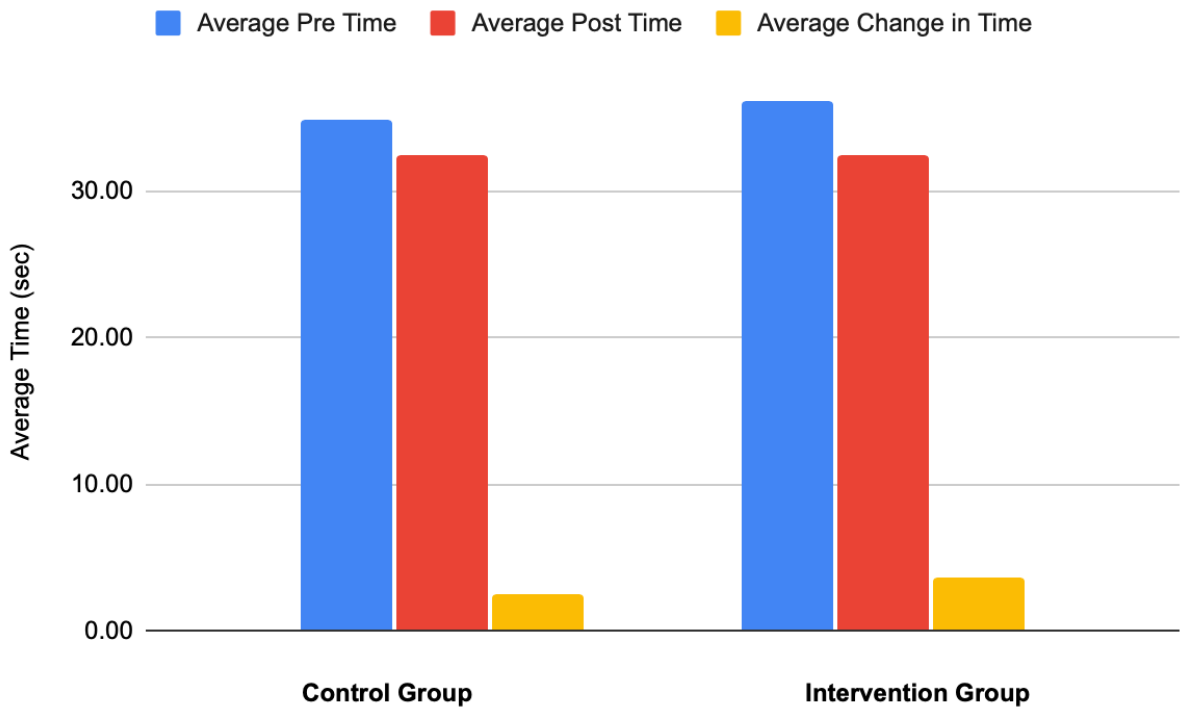

Figure 3
Average Pre and Post Race Times and Change in Time for Control and Intervention Group

After reviewing figure three, it can be seen that the average pre-time for the 15 control swimmers was 34.88 seconds, while the post time was 32.45. The results show a 2.43 second difference. On the other hand, the intervention group's average pre-time was 36.14, and post-time was 32.50. The average change in time for the intervention group was 3.65. The results show a 1.22 second greater decrease in the intervention group than the control group. To present the results in terms of percentages, the control group had a 6.97% decrease and the intervention group had a 10.07% decrease.

There are some outliers within the sample. Participant 13, in the control group, had a negative change in time, meaning they increased their 50 time between the pre and post-test. Their change in time was -0.39 sec. On the other hand, Participant four, in the intervention group, had the highest drop in time at 8.11 sec. The outliers will affect the average times for their groups.

Qualitative data was collected through a pre and post-survey, distributed through Google Forms. In the surveys, the participants were asked to rate the level of breathlessness during practice and after a race on a Likert scale. Likert scales are commonly used in survey research to evaluate the emotions and behaviors of participants in response to a questionnaire. Their responses were collected and presented below (see Figures 4 and 5). The qualitative data indicated the swimmers felt no change in breathlessness level pre and post-intervention.

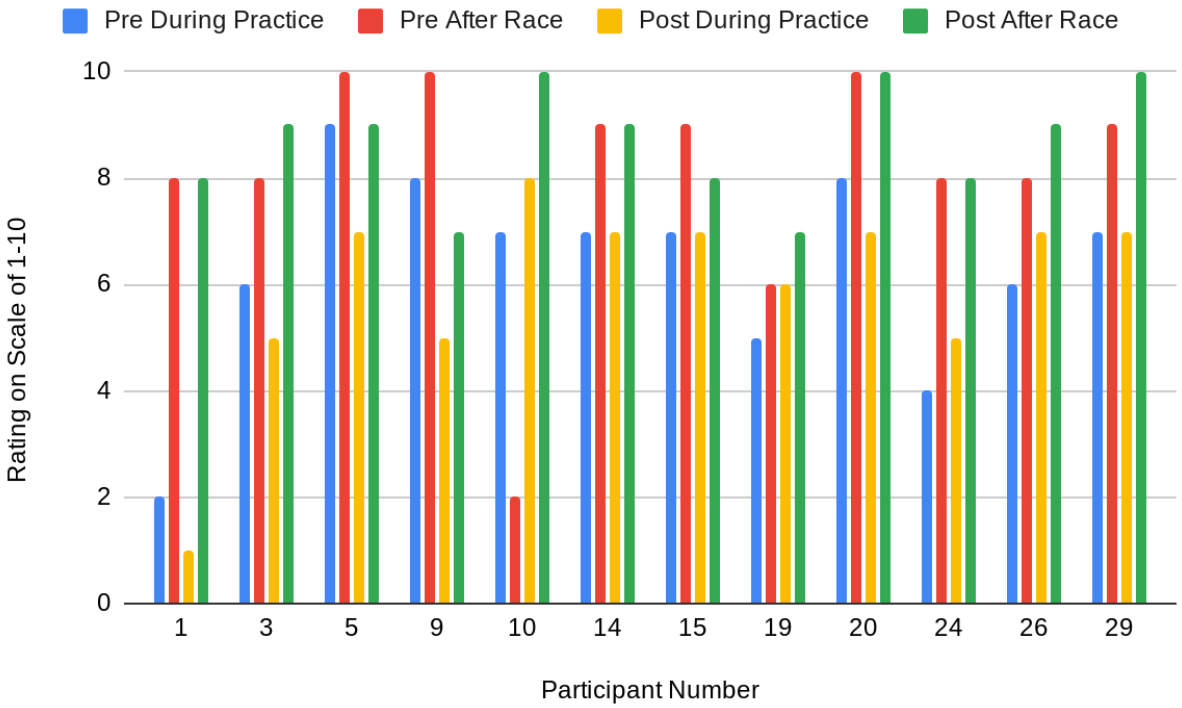

Figure 4
Likert Scale Results of Breathlessness Level Pre and Post Survey for Control Group

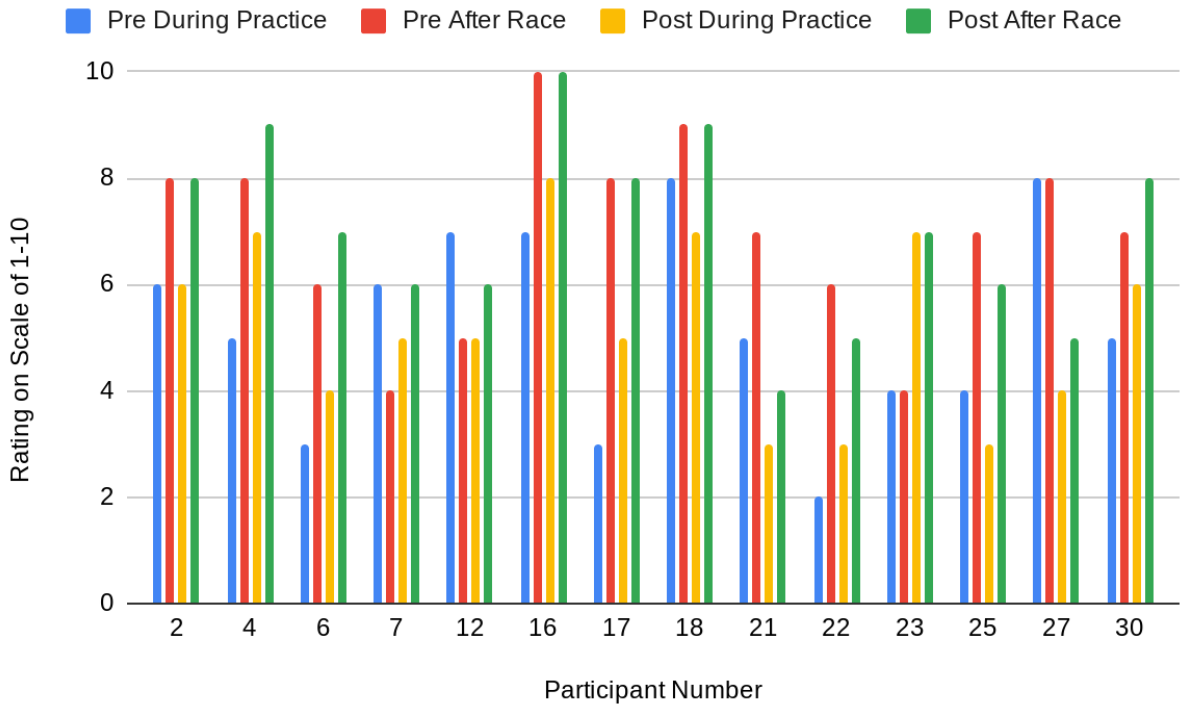

Figure 5
Likert Scale Results of Breathlessness Level Pre and Post Survey for Intervention Group

The qualitative data presented above in figures four and five show the participants' responses to the Likert scale questions. In the control group pre-survey, the average rating for breathlessness during practice was six while after a race was eight. The post-survey showed an average rating for during practice was six while after a race was nine. For the control group, it was observed that there was no change in breathlessness during practice, but there was a change of one for after a race. In the intervention group pre and post-survey, the average breathlessness level during practice was five, and after a race was seven. The data presented shows no difference between pre and post-intervention. Even though the quantitative data collected shows pranayama breathing has a positive effect on race times, the swimmers did not notice a difference in their lung quality.

Discussion

In the field of pulmonary rehabilitation, a common form of treatment is pranayama yoga breathing. This form of treatment has been tested on different types of unhealthy pulmonary patients. Few studies have been done on the effect pranayama yoga breathing has on adolescents and even fewer on adolescent athletes. This study worked to fill the research gap of discovering the effect of pranayama yoga breathing on high school swimmers. To discover this relationship, a mixed methods approach was used, and to collect that data experimental and survey research methods were used. The data collected in this study showed the intervention group had a greater decrease in time than the control group. The survey research data showed that the swimmers did not believe the pranayama affected them even though the experimental data showed a positive effect.

Significance of Results

During the experiment, since the intervention group had a 10.07% decrease in time compared to the control group's 6.97% decrease, it suggests that regular pranayama yoga breathing has a positive effect on high school swimmers' race times. In terms of seconds, the intervention group had an average of 3.65 second decrease, and the control group had an average decrease of 2.43 seconds. The fact that the intervention group had a greater decrease in time shows a positive correlation between pranayama yoga breathing exercises and the swimmers' race times. Qualitative data was collected to measure the internal response the body had to the breathing exercises.

Two sources that support the results collected in this research study are written by Joshi et al. (1992) and Kuppusamy et al. (2017). Joshi's study presented results that indicated an improvement in ventilatory function after six weeks of pranayama yoga breathing. The data showed a significant increase in FVC and FEV_1 measurements. Joshi's study presented the question of collecting FVC and FEV_1 measurements to determine the effect of pranayama yoga breathing, but after careful consideration, it was determined that it would not be feasible, with the equipment available, for this study to collect these measurements. Although different forms of data were presented, both Joshi's study and this study determined pranayama yoga breathing had a positive effect on the participants. Another source with data that supports the qualitative data collected in this study is Kuppusamy et al. (2017). Kuppusamy's study presented the results which concluded pranayama yoga breathing improved lung functions in healthy adolescents. Both Kuppusamy et al. (2017) and this study used healthy adolescent participants, which led to similar results, confirming that pranayama yoga breathing does have a positive effect on the participants.

Implications and Alternative Explanations

The implications that arose are related to the pulmonary and swimming fields. For the pulmonary field, another form of pulmonary rehabilitation was confirmed through this study. On the other hand, the swimming field can take advantage of this study as well. As seen in the results, there was a greater decrease in race time for the intervention group than the control group, therefore revealing regular pranayama breathing exercises has a positive impact on high

school swimmers. As pranayama breathing can affect performance enhancement, coaches may incorporate it into practice.

The important alternative explanation to the results is regular practice. As the season progresses, swimmers improve their skills and movement in the water with practice. With the normal season, the swimmer may become faster naturally. This could explain the greater decrease in times for the intervention group. Another alternative explanation is swimmers may have given different amounts of effort in the pre and post-swim tests. This would mean if there was a decrease in the time it could have just been that the swimmer ended up swimming at different speeds in the pre and post-test. These alternate explanations could also be the reason for the outliers in this study that strayed significantly from the other participants.

Limitations and Further Research Suggestions

Some limitations to this research study are time restraints and the honor code. The time restraint forced the study to take over five weeks when the study would have benefitted from six or more weeks. Numerous studies in the body of knowledge take place over six or more weeks, so to collect the best results, six or more weeks should be allotted for this study. Lastly, the honor code also plays a role in this study. Swimmers may not have performed the pranayama breathing exercises for the amount of time assigned to them. The study instructed the swimmers to do the breathing exercises for twenty minutes a day, five days a week, for five weeks, but the swimmers may not have followed that. This study depended on believing the participants' word that they did the breathing exercises.

Some suggestions for further research are to be allotted more time to run the study. Also to more closely monitor each participant's pranayama breathing activity. If the participants' activity is monitored, then it will decrease the variability in results for the data collected. The study could implement mandatory progress checks, which will ensure the participants perform the breathing exercises. Another suggestion is to include more participants to get a better understanding of the effect pranayama breathing has on high school swimmers. This study utilized thirty high school swimmers from the same high school. In future studies, branching out to other high schools to recruit participants may be helpful to gain better knowledge of the effect of pranayama. Lastly, in a future study, the researcher could focus on lung function measurements such as forced expiratory volume and forced volume capacity. These measurements would show the researcher the physiological effects pranayama yoga breathing has on high school swimmers. This is an important aspect to explore in this field because there is still so much to discover about the effect pranayama yoga breathing can have on lung function, not just athletic performance. Discovering the effect of pranayama breathing on other types of athletes such as runners could be another future research study.

Conclusion

This study presented results that indicated regular pranayama yoga breathing has a positive impact on high school swimmers' race times. The quantitative data showed when the intervention group performed pranayama yoga breathing for five weeks, those swimmers had a greater decrease in race time than the control group. However, when inspecting the qualitative data, it showed the swimmers felt no difference in their breathlessness level between pre and post-intervention. Although it may be believed that the swimmers naturally improve throughout the season, this study combated that argument by comparing the intervention data to the control data. By doing this, it can be seen that the pranayama yoga breathing affected swimmers' race times because the intervention group had a greater decrease in time than the control group. This study closed the gap in the body of knowledge by discovering the effect pranayama yoga breathing had on high school swimmers. Previous studies found the effect breathing exercises had on sick participants as well as healthy participants, but few focused on athletes and none focused on high school swimmers. This study can be further improved by future research by taking into account the limitations that affected this study. Further

research may support data collected in this study to go onto help swimmers improve their lung function and consequently, their race times.

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