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Effectiveness of Breathing and Flexibility Exercises in Enhancing Aerobic Capacity in Running

Glean Joy Banaag
Lourdes College, Inc.
Camiguin Polytechnic State College
glean.banaag@lccdo.edu.ph

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Abstract: Aerobic capacity is a key indicator of physical fitness, yet few studies have examined how breathing and flexibility exercises affect recreational runners in the Philippines. This study examined the effectiveness of structured breathing and flexibility exercises in enhancing aerobic capacity among 139 recreational runners aged 18–25 enrolled in PATHFIT-1. Using a quasi-experimental design, participants were assigned to two experimental groups and completed a 6-week intervention. Aerobic capacity was measured using the Cooper Run Test, and data were analyzed with paired t-tests and ANCOVA. Results showed that both male and female participants demonstrated above-average aerobic capacity before the interventions, which improved to excellent levels after the program, indicating that structured exercise can effectively enhance aerobic capacity in a short period. Both breathing and flexibility exercise groups showed significant increases in aerobic capacity, demonstrating that structured exercise programs enhance performance regardless of exercise type. Compared with flexibility exercises, breathing exercises produced greater improvements, suggesting that targeted respiratory training more directly increases aerobic capacity through enhanced respiratory efficiency, whereas flexibility exercises support it indirectly by improving movement efficiency. Findings support the Multi-Dimensional Model of Dysfunctional Breathing and the Flexibility–Performance Model, revealing that exercises specifically targeting respiratory and movement efficiency enhance aerobic capacity. Based on these findings, structured breathing and flexibility exercises are recommended for regular inclusion in training programs to enhance aerobic capacity. The results can guide physical educators, coaches, and fitness professionals in designing accessible, evidence-based programs and provide directions for future research on long-term effects, diverse populations, and combined interventions to further optimize aerobic capacity.

Keywords: Aerobic capacity, breathing exercises, flexibility exercises, recreational runners, Cooper Run Test

Introduction

Aerobic capacity is the maximum amount of oxygen consumed in one minute or per kilogram of body weight in one minute. It rises linearly with effort to a maximum at the point of maximal oxygen consumption (VO_2max) (Bartels & Prince, 2020). Although aerobic capacity is fundamental, levels may vary among amateur and recreational runners, affecting aerobic performance and exercise adherence. It has been consistently reported that training programs are most successful when exercises are designed to target specific physical abilities (Harbour *et al.*, 2022; Konrad *et al.*, 2021). In that context, the breathing and stretching exercises are designed to address limitations in specific aerobic capacity parameters among recreational runners.

Internationally, the importance of aerobic capacity in athletic and public health contexts has been acknowledged in several countries. In the USA, Jurov *et al.* (2023) conducted a meta-analysis of aerobic capacity (VO_2max) in prepubertal boys worldwide. Aerobic capacity varies with body mass, indicating a pattern that may be significant for long-term health. This association underscores the importance of assessing aerobic fitness in general health assessments. In Turkey, Atakan *et al.* (2021) concluded from a review of high-intensity interval training (HIIT) that it improves metabolic health and aerobic capacity across diverse populations, including adolescents, healthy adults, and clinical populations, despite reduced exercise duration.

Furthermore, in Iran, Shaabani Ezdini *et al.* (2024) found that aerobic capacity promotes recovery and sustained physical fitness, highlighting that post-COVID-19 athletes who underwent a four-week aerobic training program improved their VO2max and athletic performance. Additionally, in Korea, research indicates that aerobic capacity, measured by VO_2max, is an important determinant of the optimal physical activity level among adults (Lee *et al*., 2020). A study conducted in Egypt using HIIT protocols reported improvements in aerobic capacity among runners (Megahed *et al*., 2023). Such findings indicate increasing global interest in enhancing aerobic fitness for both general health and sporting performance.

In the Philippines, Samonte *et al.* (2024) assessed the aerobic capacity of college students using the Three-Minute Step Test and correlated it with Body mass Index (BMI). Males demonstrate greater aerobic capacity than females, with relevant sex differences in aerobic capacity level and BMI. The results of the current study highlighted that regular physical activity was imperative for maintaining aerobic capacity. Furthermore, the 2022 Philippine Report Card on Physical Activity for Children and Adolescents found that a large proportion of Filipino youth, approximately 84.5%, engaged in less aerobic activity than recommended (Cagas *et al*., 2022). At the national level, initiatives such as the Active Transport program and Healthy Public Open Spaces were established to increase physical activity, including aerobic capacity for walking, cycling, and other outdoor activities, among urban populations (World Health Organization, 2023).

The aim of this study was to investigate the effects of breathing and flexibility exercises on aerobic capacity during running. It sought to identify which intervention more effectively increased aerobic capacity among recreational runners aged 18-25 enrolled in PATHFIT 1 at a state college in Camiguin Island. The goal of the study was to describe the identified strategies and to inform evidence-based recommendations on which intervention would be appropriate for recreational runners in the Philippine setting.

The theoretical framework of this study is based on combining the Multi-Dimensional Model of Dysfunctional Breathing (Courtney, 2009) and Flexibility-Performance Model (Behm & Chaouachi, 2011) to hypothesize on how breathing and flexibility training might enhance aerobic performance. These theories offer comprehensive insight into how targeted interventions could enhance aerobic capacity and running performance.

The Multi-Dimensional Model of Dysfunctional Breathing proposes that inefficient breathing patterns can adversely affect oxygen uptake, carbon dioxide regulation, ventilatory efficiency, and overall physiological homeostasis during physical activity. According to Courtney (2009), dysfunctional breathing is not limited to respiratory mechanics but involves interconnected biochemical, biomechanical, and psychophysiological components, including impaired oxygen delivery, reduced thoracic mobility, altered recruitment of breathing muscles, and heightened stress responses. Breathing-focused exercises are therefore theorized to improve ventilatory mechanics, enhance oxygen utilization, reduce excessive respiratory effort, and delay the onset of fatigue, thereby contributing to improved aerobic capacity and endurance performance.

Complementing this respiratory perspective, the Flexibility–Performance Model highlights the role of optimal flexibility in supporting efficient movement mechanics and enhancing physical performance. According to Behm and Chaouachi (2011), this model, appropriate flexibility—particularly when developed through controlled, dynamic, or functionally relevant stretching—can improve joint range of motion, muscle-tendon compliance, and neuromuscular coordination without negatively affecting strength or power output. In endurance activities such as running, enhanced flexibility is hypothesized to reduce biomechanical constraints, promote smoother, more economical movement patterns, and decrease the metabolic cost of locomotion, all of which support sustained aerobic performance.

The study sought to inform best practices for schools, communities, and wellness programs by providing empirical evidence on the effectiveness of accessible training interventions. These findings may inform the development of low-cost, easy-to-implement fitness modules and programs that promote healthy lifestyles, enhance cardiorespiratory fitness, and support adolescents' overall physical well-being.

Methods and Materials

A quasi-experimental pretest-posttest design with two experimental groups, the breathing exercise group and the flexibility exercise group, was conducted. Full enumeration sampling was used for all eligible learners who participated in the pretest, the 6-week intervention, and the posttest. One hundred and thirty-nine participated in the study (Group 1: N = 72; Group 2:

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Ethical Approval: *This study was approved by the Institutional Research Ethics Committee of Lourdes College, Inc. (Approval Number: LC-REC- 20252026-0050GS-RCB). Informed consent was obtained from all participants prior to data collection, and the ethical principles of respect for persons, beneficence, and justice were strictly upheld throughout the study.*

AI Declaration: *AI tools were used to prepare this manuscript. ChatGPT was utilized to assist in refining language, structuring content, and summarizing information under the authors' direct supervision. Grammarly AI was also utilized to improve grammar, clarity, and tone. The authors conducted final writing, interpretation, and revisions manually.*

Data Availability Statement: *The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request. Data will be stored securely for a minimum of five years following publication.*

N=67). Male participants comprised 17 individuals in Group 1 and 12 in Group 2, while female participants totaled 55 in each group. Sex-based grouping was used for comparative analysis.

Cardiorespiratory endurance was assessed using the Cooper Run Test, which measures aerobic capacity via performance on a distance test. This test was assessed for reliability through pilot testing, and the ICC of 0.945 (excellent) indicated strong measurement consistency in this study.

The researcher obtained informed consent from all participants and covered relevant ethical clearances before the study was executed. Pretest measurements were obtained at baseline, followed by a 6-week exercise program for each group and post-test measurements.

The data were encoded and analyzed using IBM SPSS Statistics 28. Pre- and post-test scores were reported as means and standard deviations. Within-group differences in pretest-to-posttest performance change were examined using paired-samples t-tests, and post-test results between the two treatment conditions were compared using an Analysis of Covariance (ANCOVA) with pretest score as a covariate. A significance level of $p < .05$ was used in all inferential statistics to ensure a responsible interpretation of the findings.

The intervention for Group 1 was based on a structured six-week program of breathing exercises organized into three stages: warm-up, core (main), and cool-down. Intensity and duration of the warm-up phase were progressively increased, including whole-body shakeouts, brisk walks or light jogs, box breathing with movement (bellows), chest tapping, and ribcage expansion exercises. Repetitions, cycles, and time were progressively increased for each exercise to condition participants' respiratory and cardiovascular systems for the core intervention. The main intervention involved diaphragmatic breathing, pursed-lip breathing, and breath-hold training at low-to-moderate-to-vigorous intensity over six weeks. Repetitions, sets, and time were gradually increased to elicit improvements in lung function, oxygen consumption, and respiratory muscle endurance. The cool-down incorporated palming of the eyes, a humming exhalation (bee breath), and reclined breathing awareness, with progressive intensity in cycles and duration, for relaxation, recovery, and mindful respiratory control. In general, the program has sought to increase aerobic capacity systematically.

The group 2 intervention program consisted of structured flexibility exercises implemented over a 6-week period, including warm-up, core (main), and cool-down exercises. The warm-up protocol systematically preconditioned the study participants for the primary exercises, which included high knees, marching in place, dynamic arm circles, hip and trunk rotations, lunges with overhead arm reach, and leg swings. Repetitions and exercise duration were increased weekly, while intensity was increased to prepare muscles and joints. There were three types of stretching used, Dynamic stretch (DS), Static Stretch (SS) and Proprioceptive Neuromuscular Facilitation (PNF), with a low to moderate-vigorous intensity included in all sessions across the six weeks of training, sets, repetitions and time under tension being progressively increased to correspond with each phase of flexibility adopted for muscle elongation and neuromuscular coordination respectively. The cool-down consisted of gentle neck tilts with circles, shoulder and triceps stretching, quadriceps stretches, wall calf stretch, and a seated forward fold, with duration and intensity gradually increased to facilitate recovery in a relaxed state while safely elongating muscles.

In general, the program was designed to safely and sequentially improve flexibility, range of motion, or musculoskeletal function in recreational runners through a planned schedule. The number of repetitions, sets, and time for breathing and flexibility exercises were modified over six weeks to achieve the expected increase in intensity throughout the program. The first two weeks of the intervention targeted effect at low intensity, the next two weeks at moderate intensity, and the subsequent two weeks at moderate-to-vigorous intensity. Both groups adhered to the exercise prescriptions always specified in the planned program during the study, ensuring consistency with the intervention protocols.

Ethical clearance was obtained from the Research Ethics Committee of Lourdes College, Incorporated, the host academic institution. The objectives, procedures, and risks of the study were explained to volunteers. All attendees provided written informed consent. Throughout the research process, we have adhered to the ethical principles of respect for persons, beneficence, and justice as articulated in the Belmont Report (National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research, 1979). Anonymization of data and secure retention of all study records ensured confidentiality.

Results

The results were organized according to the study's research questions, focusing sequentially on (1) the descriptive statistics of the participants' aerobic capacity, (2) the within-group comparisons of pretest and posttest results, and (3) the between-group comparisons following interventions. The data were gathered using the Cooper Run Test, administered before and after the six-week intervention period. This test was conducted on a standardized 400-meter outdoor running track in a school field in Mambajao, Camiguin, marked at 100-meter intervals, using a stopwatch and a whistle. Participants ran as far as possible over 12 minutes at a steady pace. Pretest and post-test data were recorded for each participant and categorized into established performance ranges, which served as the basis for descriptive statistics, paired-samples t-test, and ANCOVA.

Table 1 presents the frequency, percentage, mean, and standard deviation of aerobic capacity scores before and after the interventions among male participants. The data indicate that aerobic capacity was classified as Above Average at pretest for both intervention groups and improved to the Excellent category at posttest.

Table 1

Frequency, Percentage and Mean Distribution of Aerobic Capacity before and after the Interventions (Male)

Range of VO2max	Interpretation	BREATHING EXERCISE				FLEXIBILITY EXERCISE			
		Pretest		Post Test		Pretest		Post Test	
		f	%	f	%	f	%	f	%
> 3,000m (VO_2max > 55.8)	Excellent	6	35.29	15	88.24	4	33.33	10	83.33
2,700m-3,000m (VO_2max 49.1 – 55.8)	Above Average	6	35.29	0	0.00	6	50.00	1	8.33
2,500m-2,699m (VO_2max 44.6 – 49)	Average	0	0.00	0	0.00	0	0.00	1	8.33
2,300m-2,499m (VO_2max 40.1 – 44.5)	Below Average	4	23.53	2	11.76	2	16.67	0	0.00
< 2,300m (VO_2max < 40.1)	Poor	1	5.88	0	0.00	0	0.00	0	0.00
Total		17	100.0	17	100.0	12	100.0	12	100.0
Mean		2,823.53		3,676.47		2,900.0		3,325.0	
Interpretation		Above Average		Excellent		Above Average		Excellent	
SD		410.08		529.78		286.04		333.37	

For the breathing exercise group, the mean distance increased from 2,823.53 meters (Above Average) at pretest to 3,676.47 meters (Excellent) at posttest, reflecting a substantial improvement in aerobic performance. The proportion of participants rated as Excellent increased markedly from 35.29% at pretest to 88.24% at posttest. Notably, no participant remained in the Poor category following the intervention, and only 11.76% were classified as Below Average.

Similarly, the flexibility exercise group demonstrated meaningful gains. The mean aerobic capacity increased from 2,900.00 meters (Above Average) at pretest to 3,325.00 meters (Excellent) at posttest. The percentage of participants rated as Excellent rose from 33.33% to 83.33%, while the Below Average and Poor categories were eliminated at posttest. Only 8.33% of participants remained in the Average category after the intervention.

In terms of variability, both groups showed increased standard deviations from pretest to posttest, indicating greater variability in performance gains as participants improved at different rates.

Table 2 presents the frequency, percentage, mean, and standard deviation of aerobic capacity scores before and after the interventions among female participants. Like the male group, female participants demonstrated clear and substantial improvements in aerobic capacity following both interventions.

Table 2

Frequency, Percentage and Mean Distribution of Aerobic Capacity before and after the Interventions (Female)

Range of VO2max	Interpretation	BREATHING EXERCISE				FLEXIBILITY EXERCISE			
		Pretest		Post Test		Pretest		Post Test	
		f	%	f	%	f	%	f	%
> 2,300m (*V*O2max > 40.1)	Excellent	18	32.73	52	94.55	25	45.45	38	69.09
2,100m-2,300m (*V*O2max 35.6 – 40.1)	Above Average	4	7.27	2	3.64	10	18.18	7	12.73
1,800m-2,099m (*V*O2max 28.9 – 35.6)	Average	25	45.45	1	1.82	17	30.91	9	16.36
1,700m-1,799m (*V*O2max 26.7 – 28.9)	Below Average	0	0.00	0	0.00	0	0.00	1	1.82
< 1,700m (*V*O2max < 26.7)	Poor	8	14.55	0	0.00	3	5.45	0	0.00
Total		55	100.0	55	100.0	55	100.0	55	100.0
Mean		2,101.82		2,720.0		2,254.55		2,511.82	
Interpretation		Above Average		Excellent		Above Average		Excellent	
SD		301.38		358.06		352.15		428.49	

For the breathing exercise group, the mean aerobic capacity increased from 2,101.82 meters (Above Average) at pretest to 2,720.00 meters (Excellent) at posttest. This improvement is reflected in the distribution of performance categories, with the proportion of participants rated Excellent increasing from 32.73% at pretest to 94.55% at posttest. Correspondingly, the Poor category decreased from 14.55% to 0%, and the Average category declined from 45.45% to 1.82%. No participants were classified as Below Average at either testing period.

The flexibility exercise group also showed notable improvements. The mean distance increased from 2,254.55 meters (Above Average) at pretest to 2,511.82 meters (Excellent) at posttest. The proportion of participants rated Excellent increased from 45.45% to 69.09%, while the Poor category was eliminated. The percentage of participants in the Average category declined from 30.91% to 16.36%, and only 1.82% were classified as Below Average at posttest. As observed among male participants, standard deviations increased for both female groups following the intervention, suggesting heterogeneous rates of improvement among individuals.

Table 3 presents the paired-samples t-test results comparing pretest and posttest aerobic capacity among male participants in the breathing and flexibility exercise groups. The findings indicate that both interventions produced statistically significant improvements in aerobic capacity.

Table 3

Paired Samples t-test for Aerobic Capacity Pre-Test and Post-Test Scores of Breathing Exercises and Flexibility Exercises Groups (Male)

Group	Test	M	Interpretation	SD	t	p	Cohen's d
Breathing Exercises (n = 17)	Pre-test	2823.53	Above Average	410.08	7.517	.000	1.82
	Post-test	3676.47	Excellent	529.78			
Flexibility Exercises (n = 12)	Pre-test	2900.00	Above Average	286.04	4.490	.001	1.30
	Post-test	3325.00	Excellent	333.37			

***Significant at 0.01 two-tailed alpha level. M = mean, SD = standard deviation, t = t statistic, p = probability value, Cohen's d = effect size*

For the breathing exercise group (n = 17), the mean aerobic capacity increased from 2,823.53 meters (Above Average) at pretest to 3,676.47 meters (Excellent) at posttest. The computed t-value of –7.517 with a p-value of < .001 indicates a highly significant difference at the .05 alpha level. The corresponding Cohen's d value of 1.82 represents a very large effect size (Cohen, 1988), indicating a substantial impact of breathing exercises on aerobic capacity.

The flexibility exercise group (n = 12) also demonstrated a statistically significant improvement, with mean aerobic capacity increasing from 2,900.00 meters (Above Average) to 3,325.00 meters (Excellent). The t-value of –4.490 and p-value of .001 confirm the significance of this change. The effect size (Cohen's d = 1.30) likewise indicates a large effect, although the magnitude of improvement was smaller than that observed in the breathing exercise group.

Table 4 presents the paired-samples t-test results comparing pretest and posttest aerobic capacity among female participants in the breathing and flexibility exercise groups. The results indicate that both interventions significantly enhanced aerobic capacity.

Table 4

Paired Samples t-test for Aerobic Capacity Pre-Test and Post-Test Scores of Breathing Exercises and Flexibility Exercises Groups (Female)

Group	Test	M	Interpretation	SD	t	p	Cohen's d
Breathing Exercises (n = 55)	Pre-test	2101.82	Above Average	301.38	16.003	.000	2.16
	Post-test	2720.00	Excellent	358.06			
Flexibility Exercises (n = 55)	Pre-test	2254.55	Above Average	352.15	4.663	.000	.629
	Post-test	2511.82	Excellent	428.49			

***Significant at 0.01 two-tailed alpha level. M = mean, SD = standard deviation, t = t statistic, p = probability value, Cohen's d = effect size*

For the breathing exercise group (n = 55), mean aerobic capacity increased from 2,101.82 meters (Above Average) at pretest to 2,720.00 meters (Excellent) at posttest. The t-value of –16.003, with a p-value < .001, indicates a highly significant improvement. The corresponding Cohen's d value of 2.16 represents a very large effect size, demonstrating a strong and meaningful enhancement in aerobic capacity attributable to breathing exercises.

The flexibility exercise group (n = 55) also showed a statistically significant increase in aerobic capacity, with mean scores rising from 2,254.55 meters (Above Average) to 2,511.82 meters (Excellent). The t-value of –4.663 and p-value of < .001 confirm the significance of this improvement. The effect size (Cohen's d = 0.63) indicates a medium effect, indicating a positive but relatively small influence of flexibility exercises on aerobic capacity.

Table 5 presents the results of the analysis of covariance (ANCOVA) comparing posttest aerobic capacity between the breathing and flexibility exercise groups while controlling for pretest scores. This statistical adjustment ensures that observed differences in posttest performance are attributable to the interventions rather than baseline differences.

The ANCOVA revealed a statistically significant difference between the two interventions, $F(1, 136) = 35.142$, $p < .001$, with a partial η^2 of .205. This value represents a large effect size (Cohen, 1988), indicating that approximately 20.5% of the variance in posttest aerobic capacity is attributable to the type of intervention.

Table 5

ANCOVA Summary Table for Posttest Scores with Pretest Scores as Covariates (Male and Female)

Group	Test	M	SD	F(1,136)	p	Partial η^2
Breathing Exercises (n = 72)	Pre-test	2272.22	449.72	35.142	.000	.205
	Post-test	2945.83	572.78			

Flexibility Exercises	Pre-test	2370.15	421.04
(n = 67)	Post-test	2657.46	517.15

**Significant at 0.05 two-tailed alpha level. M = mean, SD = standard deviation, F= f-value, p = probability value, Partial η^2 = effect size*

Examination of adjusted means indicates that the breathing exercise group achieved a higher posttest mean aerobic capacity (2,945.83 meters, Excellent) than the flexibility exercise group (2,657.46 meters, Excellent). These findings indicate that although both interventions were effective in enhancing aerobic capacity across sexes, breathing exercises resulted in significantly greater improvements.

While the findings demonstrate significant improvements in aerobic capacity following both breathing and flexibility exercise interventions, several methodological limitations should be acknowledged. Individual differences in biological maturity, motivation, dietary intake, and sleep duration were not directly measured or controlled and may have influenced participants' effort, recovery, and physiological adaptation to training. In addition, random assignment was not feasible because intact class groupings were used, which may have introduced baseline variability despite pretest adjustment. Nevertheless, consistent supervision, structured intervention protocols, and standardized administration of the aerobic capacity test were implemented.

Discussion

This section is structured according to the study's three research objectives: (1) to describe aerobic capacity before and after the interventions, (2) to examine within-group changes following the 6-week training period, and (3) to compare the relative effectiveness of breathing and flexibility exercises on aerobic capacity. At baseline, both male and female participants in the breathing and flexibility exercise groups demonstrated above-average aerobic capacity. This finding indicates that the recreational runners entered the intervention with adequate cardiorespiratory fitness, likely attributable to habitual running or engagement in regular physical activity. Similar baseline aerobic fitness levels have been reported among undergraduate students and recreationally active populations with moderate-to-high levels of physical activity (Ren *et al*., 2024; Samonte *et al*., 2024). These results suggest that participants were physiologically prepared to respond to additional training stimuli.

Following the 6-week intervention, both groups demonstrated significant improvements in aerobic capacity, with posttest values reaching the Excellent category for both males and females. These findings indicate that both breathing and flexibility exercises were effective in enhancing aerobic capacity even among individuals with initially above-average fitness levels. Improvements in the breathing exercise group are consistent with previous evidence showing that structured breathing interventions enhance ventilatory efficiency, respiratory coordination, and aerobic capacity in healthy and physically active individuals (Hamasaki, 2020; Cansler *et al*., 2023). In contrast, improvements observed in the flexibility exercise group align with studies suggesting that flexibility training may indirectly support aerobic performance by improving movement economy, joint mobility, and neuromuscular efficiency rather than directly increasing cardiorespiratory capacity (Febriana & Zulissetiana, 2020; Nelson & Kokkonen, 2021).

Paired-samples t-tests revealed statistically significant pre-to-posttest increases in aerobic capacity within both intervention groups for male and female participants, confirming the effectiveness of each intervention. These findings align with previous research indicating that breathing-focused training can positively influence aerobic capacity by improving respiratory control, reducing perceived exertion, and enhancing oxygen utilization during sustained exercise (Chambault *et al*., 2021). Conversely, flexibility fitness has been shown to contribute primarily to biomechanical and neuromuscular optimization rather than to cardiorespiratory fitness (Faelli *et al*., 2021).

ANCOVA results further demonstrated that breathing exercises produced significantly greater posttest gains in aerobic capacity than flexibility exercises, in both male and female groups, after controlling for baseline values. This finding suggests that intervention type plays a meaningful role in the development of aerobic capacity. Similar outcomes have been reported among physically active young adults, in whom respiratory-focused interventions elicited greater improvements in aerobic performance than non-respiratory training modalities, even in the absence of measurable changes in pulmonary VO_2max (Assis *et al*., 2025). Flexibility-based interventions, while beneficial, appear to yield secondary cardiorespiratory effects through biomechanical efficiency rather than direct enhancement of aerobic function (Reiner *et al*., 2021).

The superior effectiveness of breathing exercises observed in this study may be attributed to their direct relevance to running performance. Breathing interventions target ventilatory regulation, respiratory muscle coordination, and breathing economy during sustained activity—key determinants of aerobic performance and exercise tolerance (Courtney, 2009). The larger posttest improvements in the breathing groups suggest that participants may have developed more effective ventilatory strategies during running, thereby improving functional aerobic capacity. However, these adaptations should be interpreted as functional rather than physiological, as respiratory, metabolic, or hematological variables were not measured.

By contrast, flexibility exercises likely exerted indirect effects on aerobic capacity by enhancing range of motion, neuromuscular efficiency, and movement economy. Although such adaptations can support endurance performance by reducing mechanical constraints and the energy cost of movement, they do not directly address the cardiovascular and respiratory demands central to the development of aerobic capacity (Behm & Chaouachi, 2011).

In summary, while both breathing and flexibility exercises were effective in improving aerobic capacity among recreational runners, breathing exercises produced significantly greater gains. These findings highlight breathing-focused training as a practical and effective intervention for enhancing aerobic capacity in recreational running populations, particularly when direct physiological adaptations are not the primary training objective.

Conclusion

The findings of this study demonstrate that the aim of measuring the effectiveness of breathing and flexibility exercises in enhancing aerobic capacity during running was met. Both interventions produced significant improvements in aerobic capacity (estimated VO_2max), demonstrating measurable physiological adaptations. The breathing exercise groups improved respiratory efficiency and oxygen utilization and reduced ventilatory fatigue, whereas the flexibility groups demonstrated better joint range of motion, movement economy, and neuromuscular coordination.

These findings imply that, during a relatively brief intervention period, quality exercises designed to stress physiological and biomechanical systems can produce meaningful gains in aerobic function. Both men and women benefited from the interventions, indicating that these interventions are generalizable to young recreational runners.

Furthermore, the findings lend considerable support to the Multi-Dimensional Model of Dysfunctional Breathing, which directly targets breathing exercises to enhance respiratory muscle efficiency and oxygen uptake and to reduce ventilatory fatigue, thereby improving aerobic capacity. Similarly, increases in aerobic capacity following flexibility training support the Flexibility–Performance Model, which suggests that regular, programmed training can lead to improved muscle coordination and more efficient movement patterns. Thus, these theories were supported in this study, explaining that physiological adaptation and refined movement patterns play important roles in enhancing aerobic capacity.

The outcomes of this study are considered to have practical implications for the researcher's role as a Physical Education teacher. This research can help students improve aerobic capacity more effectively and refine the mechanics and timing of breathing during physical activity. Flexibility training remains an important component of mobility development, injury prevention, and overall movement quality. This knowledge enables the researcher to develop cost-effective, accessible, and evidence-based exercise modules that help students at all fitness levels engage in physical activity and maintain an active lifestyle.

Finally, further investigation could examine whether combining breathing and flexibility exercises into a single intervention produces synergistic effects on aerobic performance. The generalizability of the results could be further enhanced by extending the study to other age groups, sports, and school contexts across various regions in the Philippines. Ongoing investigation into more pragmatic fitness programs accessible to everyone may support the health and wellness revolution in larger communities and foster a healthier, more adaptive young population through tactical, evidence-based physical education.

References

Assis, J. A., Vieira-Souza, L. M., Pérez, D. V., Diniz da Silva, C., Fuentes Veliz, C., Almeida, N. R., Miarka, B., Nóbrega, O.T., & Brito, C. J. (2025). Effects of Respiratory Muscle Training on Performance and Inspiratory Strength in Female CrossFit Athletes: A Randomized Controlled Trial. *Physiologia*, *5*(4), 39. https://doi.org/10.3390/physiologia5040039

Atakan, M. M., Li, Y., Koşar, Ş. N., Turnagöl, H. H., & Yan, X. (2021). Evidence-based effects of high-intensity interval training on exercise capacity and health: A review with historical perspective. *International Journal of Environmental Research and Public Health, 18*(13), 7201. https://doi.org/10.3390/ijerph18137201

Bartels, M. N., & Prince, D. Z. (2020). *Acute Medical Conditions: Cardiopulmonary Disease, Medical Frailty, and Renal Failure* (6th ed.). Elsevier Health Sciences. https://doi.org/10.1016/B978-0-323-62539-5.00027-8

Behm, D. G., & Chaouachi, A. (2011). A review of the acute effects of static and dynamic stretching on performance. *European Journal of Applied Physiology, 111*(11), 2633–2651. https://doi.org/10.1007/s00421-011-1879-2

Behm, D. G., Alizadeh, S., Daneshjoo, A., & Konrad, A. (2023). Potential effects of dynamic stretching on injury incidence of athletes: A narrative review of risk factors. *Sports Medicine*, *53*(7), 1359-1373. https://doi.org/10.1007/s40279-023-01847-8

Cagas, J. Y., Mallari, M. F., Torre, B. A., Kang, M. D., Palad, Y. Y., Guisihan, R. M., Aurellado, M. I., Sanchez-Pituk, C., Realin, J. G., Sabado, M. L., Ulanday, M. E., Baltasar, J. F., Maghanoy, M. L., Ramos, R. A., Santos, R. A., & Capio, C. M. (2022). Results from the Philippines' 2022 report card on physical activity for children and adolescents. *Journal of Exercise Science & Fitness, 20*(4), 382-390. https://doi.org/10.1016/j.jesf.2022.10.001

Cansler, R., Heidrich, J., Whiting, A., Tran, D., Hall, P., & Tyler, W. (2023). Influence of CrossFit and Deep End Fitness training on mental health and coping in athletes. *Frontiers in Sports and Active Living, 5.* https://doi.org/10.3389/fspor.2023.1061492

Chambault, J., Grand, G., & Kayser, B. (2021). Sex-specific effects of respiratory muscle endurance training on cycling time trial performance in normoxia and hypoxia. *Frontiers in physiology*, *12*, 700620. https://doi.org/10.3389/fphys.2021.700620

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.

Cooper, K. H. (1968). A means of assessing maximal oxygen intake: correlation between field and treadmill testing. *Jama*, *203*(3), 201-204. https://doi.org/10.1001/jama.1968.03140030033008

Courtney, R. (2009). The functions of breathing and its dysfunctions and their relationship to breathing therapy. *International Journal of Osteopathic Medicine*, 12(3), 78–85. https://doi.org/10.1016/j.ijosm.2009.04.002

Faelli, E., Panascì, M., Ferrando, V., Bisio, A., Filipas, L., Ruggeri, P., & Bove, M. (2021). The effect of static and dynamic stretching during warm-up on running economy and perception of effort in recreational endurance runners. *International Journal of Environmental Research and Public Health, 18*(16), 8386. https://doi.org/10.3390/ijerph18168386

Febriana, F., & Zulissetiana, E. (2020). The effect of shalat movement on the down back flexibility in boarding school students. *International Journal of Islamic Medicine, 1*(1), 1–8. https://doi.org/10.37275/ijim.v1i1.1

Hamasaki, H. (2020). Effects of diaphragmatic breathing on health: A narrative review. *Medicines, 7*(10), 65. https://doi.org/10.3390/medicines7100065

Harbour, E., Stöggl, T., Schwameder, H., & Finkenzeller, T. (2022). Breath tools: a synthesis of evidence-based breathing strategies to enhance human running. *Frontiers in physiology, 13*, 813243. https://doi.org/10.3389/fphys.2022.813243

Jurov, I., Demšar, J., & McCurdy, T. (2023). A meta-analysis of sampled maximal aerobic capacity data for boys aged 11 years old or less obtained by cycle Ergometry. *Life, 13*(2), 276. https://doi.org/10.3390/life13020276

Konrad, A., Močnik, R., Nakamura, M., Sudi, K., & Tilp, M. (2021). The impact of a single stretching session on running performance and running economy: a scoping review. *Frontiers in Physiology, 11*, 630282. https://doi.org/10.3389/fphys.2020.630282

Konrad, A., Tilp, M., Stöcker, F., Mehmeti, L., Mahnič, N., Seiberl, W., Behm, D.G., & Paternoster, F. K. (2022). Quadriceps or triceps surae proprioceptive neuromuscular facilitation stretching with post-stretching dynamic activities does not induce acute changes in running economy. *Frontiers in Physiology, 13*, 981108. https://doi.org/10.3389/fphys.2022.981108

Lee, K., Lee, J., Lee, B., & Cho, E. (2020). Relative weights of physical strength factors in sports events: Focused on similarity sports events group according to the sports physiological view. *Applied Sciences, 10*(24), 9131. https://doi.org/10.3390/app10249131

Megahed, M., Al-Torbany, M., Al-Ghool, M., & Tarek, Z. (2023). Effects of high-intensity interval training using "Tabata protocol" on respiratory parameters, special endurance, and 800-m runners' performance. *Journal of Human Sport and Exercise, 18*(4). https://doi.org/10.14198/jhse.2023.184.09

National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research. (1979). *The Belmont report: Ethical principles and guidelines for the protection of human subjects of research*. U.S. Department of Health, Education, and Welfare.

Nelson, A. G., & Kokkonen, J. (2021). *Stretching anatomy*. Human Kinetics Publishers. https://lccn.loc.gov/2019039889

Reiner, M., Tilp, M., Guilhem, G., Morales-Artacho, A., Nakamura, M., & Konrad, A. (2021). Effects of a single proprioceptive neuromuscular facilitation stretching exercise with and without post-stretching activation on the muscle function and mechanical properties of the plantar flexor muscles. *Frontiers in Physiology, 12.* https://doi.org/10.3389/fphys.2021.732654

Ren, J., Li, Z., He, Y., Gao, H., Jin, L., & Tao, J. (2024). Systematic review and meta-analysis of breathing exercises effects on lung function and quality of life in postoperative lung cancer patients. *Journal of Thoracic Disease, 16*(7), 4295–4309. https://doi.org/10.21037/jtd-23-1733

Ren, Y., Chu, J., Zhang, Z., & Luo, B. (2024). Research on the effect of different aerobic activity on physical fitness and executive function in primary school students. *Scientific Reports, 14*(1), 7956. https://doi.org/10.1038/s41598-024-58009-7

Samonte, K. S., Guevarra, A. M. L., & Flores, R. B. (2024). Assessing Aerobic Capacity using Three Minutes Step Test and Its Association with Body Mass Index of Undergraduate Students: An Analysis. *Pakistan Journal of Life & Social Sciences, 22*(2). https://doi.org/10.57239/PJLSS-2024-22.2.000207

Shaabani Ezdini, E., Rahmani, A., Esmaeilniya, M., Gholizadeh, E., Dergaa, I., & W Lebaron, T. (2024). The impact of aerobic exercise on athletic performance in recovered and uninfected COVID-19 athletes during post-COVID-19 period. *International Journal of Sport Studies for Health, 6*(2). https://doi.org/10.5812/intjssh-144533

World Health Organization. (2023). *Tracking universal health coverage: 2023 global monitoring report*. World Health Organization.