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Response of Pulmonary Functions to Deep Breathing Exercise in Twin Pregnancy

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Abstract:
Purpose: to investigate the impact of deep breathing exercises on pulmonary functions in twin pregnant women during the third trimester.
Methods: A randomized controlled study was conducted at Soaad Kafafy University Hospital between October 2022 and June 2023. Sixty twin pregnant women, aged 25 to 35 years, in the third trimester of their pregnancies, were randomly assigned to two equal groups. Pulmonary function tests were conducted at the 27th and 36th weeks of gestation to establish baseline values. The study group engaged in deep breathing exercises, involving both diaphragmatic and costal breathing, three times daily for 15 repetitions over 9 weeks.
Results: Pre-treatment values of Forced Vital Capacity, Forced Expiratory Volume in the first second, and Peak Expiratory Flow showed no significant differences between the study and control groups ($p > 0.05$). Post-treatment outcomes in the study group demonstrated a noteworthy improvement in all variables compared to pre-treatment values ($p < 0.05$). Conversely, the control group showed no significant difference between the pre- and post-study outcomes. A comparative analysis of post-study results revealed a substantial increase favoring the study group ($p < 0.05$).
Conclusion: Diaphragmatic and costal breathing proved to be effective in augmenting pulmonary functions in twin pregnant women. These findings underscore the benefits of incorporating respiratory exercises into prenatal care for twin pregnancies.
Key words: Twin pregnancy, pulmonary function test, breathing exercise.

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1.Introduction:

Pregnancy is a transformative journey for the human body, encompassing a multitude of changes that extend beyond the visible aspects. Among the intricate adaptations occurring in various organ systems, the respiratory system stands out as a remarkable example of selective adjustment during maternal adaptation to pregnancy. This adaptation involves profound anatomical, physiological, and biochemical modifications in response to the escalating demands imposed by the growing fetus (1).

The respiratory system's response to pregnancy-related changes is evident through alterations in maternal pulmonary functions. Factors such as the progressive enlargement of the uterus, increased levels of progesterone, and augmented blood flow and volume contribute to these changes. Interestingly, these adaptations are predominantly mediated by progesterone rather than estrogen, emphasizing its pivotal role in increasing respiratory oxygen consumption (2).

In the intricate web of maternal physiology, hormonal changes and mechanical impediments induced by the growing fetus are responsible for shifts in pulmonary function. Elevated levels of estrogen, for instance, lead to mucosal changes in the upper airway, causing nasal obstruction, particularly in the third trimester (3).

On the contrary, the expanded subcostal angle and heightened transverse diameter of the chest counteract the effects of the enlarging uterus and elevated diaphragm. This ensures that, despite modifications in pulmonary function, it sustains an uncompromised state during pregnancy (4).

To assess these changes systematically, pulmonary function tests (PFTs) offer a valuable tool (5). Researchers have extensively studied PFTs during normal pregnancy, consistently noting a significant decrease in various parameters throughout all trimesters (6,7,8,9). The underlying mechanisms behind these alterations, potentially related to decreased respiratory muscle power, warrant further exploration (10).

Spirometry, a frequently utilized examination for assessing lung function, offers essential insights into lung volumes and capacities. Essential metrics such as forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1), Peak Expiratory Flow (PEF), and the FEV_1/FVC ratio provide valuable insights into respiratory health during pregnancy (11).

Diaphragmatic breathing as a technique focuses on reducing the respiratory rate (RR) to improve the efficiency of alveolar ventilation. It involves recruiting the abdominal muscles to facilitate the optimal use of the diaphragm to its best advantage on its length tension curve. After respiratory muscle training, there is an improvement in mechanics of ventilatory functions (12,13,14,15).

The incidence of twin pregnancies has steadily risen over the past 30 years, attributed to advances in reproductive medicine and a higher proportion of older pregnant mothers naturally having a higher incidence of multiple gestations. Twin pregnancies, constituting 1% of all pregnancies in an unmedical population, account for at least 10% of prenatal mortality. Considered high-risk pregnancies, different aspects of risk, including the mode of delivery, remain subjects of controversy and discussion among obstetricians (16).

In twin pregnancies, the maternal and fetal demands for oxygen are elevated. A previous study hypothesized that respiratory changes would be more pronounced compared to singleton pregnancies. Additionally, the larger uterus in twin pregnancies might result in greater cephalad displacement of the diaphragm and increased laxity of rib ligaments, both potentially affecting lung volumes (17).

In addition to understanding the general changes in respiratory function during pregnancy, this article delves into the specific context of twin pregnancies. With the incidence of twin pregnancies steadily rising, there is a growing need to unravel the nuances of respiratory adaptations in this unique scenario. Previous hypotheses suggesting more pronounced respiratory changes in twin pregnancies compared to singleton pregnancies underscore the importance of dedicated research in this area (18).

Despite the wealth of information on alterations in pulmonary function during pregnancy, a notable gap in knowledge persists concerning twin pregnancies (17). This article seeks to bridge the gap by presenting a comprehensive review of existing literature and emphasizing the need for further research. By shedding light on the intricacies of respiratory changes in twin pregnancies, this study contributes to a deeper understanding of the complexities involved in high-risk pregnancies.

2.Patients and Methods:

2.1. Study participants and recruitment criteria:

Inclusive criteria of this research involved 60 twin pregnant women in their third trimester (27^{th} week gestation), aged 25 to 35 years, with a BMI ≥ 30 Kg/m^2. The participants were recruited from Soaad Kafafy University Hospital. Exclusion criteria included any pulmonary illnesses prior to pregnancy, any physical or mental disorders, gestational diabetes, or gestational hypertension.

Local ethical clearance (ref. P.T.REC/012/004052) was obtained from the ethical committee at Faculty of Physical Therapy, Cairo University with a clinical trial registration number) NCT 06031220). Informed consent was obtained

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from each participant, and the study duration lasted for 9 months, from October 2022 to June 2023.

2.2. Study Design:

Participants were randomly assigned to two equal groups (control and study) using the closed envelope method. Both groups underwent a pulmonary function test during the 27th and 36th weeks of gestation to measure FEV_1, FVC, and PEF. Over a span of 9 weeks, the study group engaged in deep breathing exercises, including diaphragmatic and costal breathing, three times a day, with 15 repetitions each.

2.3. Methods:

Pulmonary Function Test (Spirometry). A spirometer was used to measure FVC, FEV_1, and PEF during the spirometry test. Both groups used it before starting the study at the 27th week of gestation and again after 9 weeks at the 36th week of gestation. The participants were instructed to take the deepest inhalation (inspiration) and then exhale rapidly (exhalation) into the sensor as forcefully and as long as possible to assess FVC, FEV_1, and PEF. Soft nose clips were used to prevent nasal air escape, and filter mouthpieces were employed for hygiene.

Breathing Exercise. Costal and diaphragmatic breathing exercises were administered to women in the study group three times a day. Each exercise consisted of 15 repetitions, with 20 seconds of rest between every five repetitions, for a duration of nine weeks.

Costal Breathing. Women are positioned in a relaxed, comfortable long sitting position, with small cushions placed under their necks to support their body curvature. The therapist's hands are positioned around the lower costal region, with her fingers forming a fan shape over the intercostal space. The woman inhaled deeply through her nose, expanding her ribcage, and exhaled gently through her mouth.

Diaphragmatic Breathing. Women are positioned in a relaxed, comfortable long sitting position, with small cushions placed under their necks to support their body curvature. The therapist placed her inner palm horizontally over her upper chest and her inner hand horizontally above her belly. The woman inhaled deeply through her nose, allowing her abdomen to expand like a balloon, and exhaled gently through her mouth.

2.4. Outcome measures:

All women underwent the Futured Discovery spirometry pulmonary function test, which examined the respiratory cycle's FEV_1, FVC, and PEF.

3. Data Analysis:

Statistical analysis was performed using SPSS version 28, with a significance level set at $p < 0.05$. Descriptive analysis included the mean and standard deviation. Inferential statistical analysis involved paired t-tests for within-group differences and unpaired t-tests for between-group differences.

4. Results:

This investigation enrolled pregnant women aged 25 to 35 years, with a mean age of 28.45 ± 4.5 for Group A (study group) and 29.57 ± 4.2 for Group B (control group). Remarkably, no appreciable difference in age distribution emerged between the two groups ($t = 0.29$, $p = 0.78$).

All participants were twin pregnant women in the 27th week of gestation, with a Body Mass Index (BMI) ≥ 30. The mean BMI for Group A and Group B were (31.75 ± 1.6) and (32.05 ± 1.3) respectively, with no significant difference in BMI identified between the two groups ($t = 0.98$, $p = 0.33$).

From a statistical perspective, the pre-study values of Forced Vital Capacity (FVC), Forced Expiratory Volume in 1 second (FEV_1), and Peak Expiratory Flow (PEF) measured as a percentage of predicted exhibited no noticeable differences between the two groups ($p > 0.05$). This confirms the homogeneity of the sample before any therapeutic intervention. In the study group (Group A), post-treatment results showed a significant deviation from pre-treatment values for the measured variables, while no significance was observed between pre- and post-study results in the control group (Group B).

Furthermore, a comparative analysis of post-study results between both groups exhibited a noteworthy increase ($p < 0.05$) in favor of the study group.

The collected data underwent meticulous analysis and synthesis, and the findings are summarized as follows:

4.1 Comparison Between Forced Vital Capacity (FVC) of Study and Control Groups Before and After Treatment:

Before the intervention, an unpaired t-test indicated no discernible difference in FVC measured as a percentage of predicted ($p = 0.33$), with mean values for Group A and Group B at 69.32 ± 1.8 and 68.75 ± 2.1, respectively.

The paired t-test revealed a substantial increase in FVC in Group A after breathing exercises compared to before treatment, with mean values of 76.45 ± 2.2 and 69.32 ± 1.8, respectively ($p < 0.01$), equating to a percentage improvement of ↑10.33%.

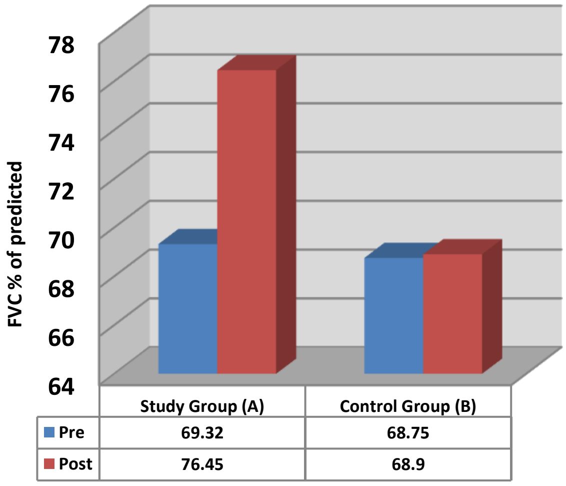
Conversely, in the control group (B), no significant difference was observed in FVC pre- and post-study ($p = 0.46$), with mean values of 68.75 ± 2.1 and 68.9 ± 2.0, respectively, resulting in a percentage improvement of ↑0.22% (**Table 1 and Graph 1**).

The unpaired t-test for post-study FVC mean values between the groups showed a significant difference ($p < 0.01$).

(Table 1): Comparison Between Mean (±SD) of FVC of Study and Control Groups Before and After Treatment.

Forced Vital Capacity (FVC)	Group A (n=30) Mean ± SD	Group B (n=30) Mean ± SD	Comparison (between groups) t	P
Pre-treatment	69.32 ± 1.8	68.75 ± 2.1	0.98	0.33 *
Post-treatment	76.45 ± 2.2	68.9 ± 2.0	6.38	< 0.01**
% of improvement	↑10.33%	↑ 0.22 %		
Comparison (within group) pre/post **t**	5.21	0.75		
P	< 0.01**	0.46 *		

**** Significant** *** Not Significant**



(Graph 1): Mean Values of FVC Pre- and Post-Treatment in both the Study and Control Groups

4.2 Comparison Between Forced Expiratory Volume in the 1st Second (FEV_1) of the Study and Control Groups Before and After Treatment

Before the intervention, an unpaired t-test demonstrated no detectable difference in FEV1 measured as a percentage of predicted (p=0.23), with mean values for Group A & Group B at 63.45 ± 1.8 and 64.32 ± 2.1, respectively.

The paired t-test showcased a substantial increase in FEV1 in Group A after breathing exercises compared to pre-treatment values, with mean values of 72.15 ± 2.2 and 63.45 ± 1.8, respectively (p < 0.01), resulting in a percentage improvement of ↑13.7%.

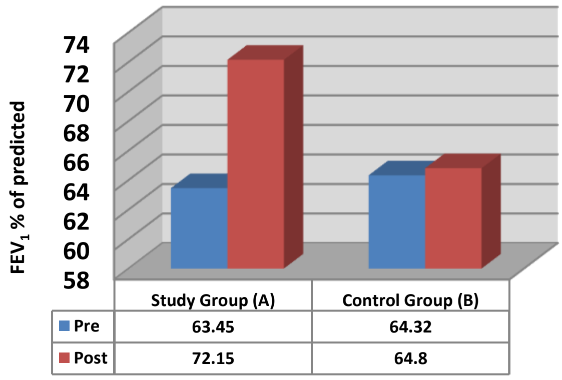
Conversely, in the control group (B), no significant difference was observed in FEV1 pre- and post-study (p=0.33), with mean values of 64.32 ± 2.1 and 64.8 ± 2.0, respectively, resulting in a percentage improvement of ↑0.75% (**Table 2 and Graph 2**).

The unpaired t-test for post-study FEV1 mean values between the groups showed a significant difference (p < 0.01).

(Table 2): Comparison Between Mean (±SD) of FEV_1 of Study and Control Groups Before & After Treatment.

Forced Expiratory volume in the 1st second (FEV_1)	Group A (n=30) Mean ± SD	Group B (n=30) Mean ± SD	Comparison (between groups) t	P
Pre-treatment	63.45 ± 1.8	64.32 ± 2.1	1.22	0.23*
Post-treatment	72.15 ± 2.2	64.8 ± 2.0	9.36	< 0.01**
% of improvement	↑ 13.7 %	↑ 0.75 %		
Comparison (within group) pre/post **t**	8.76	0.98		
P	< 0.01**	0.33*		

**** Significant** *** Not Significant**



(Graph 2): Mean Values of FEV_1 Pre- and Post-Treatment in both Study and Control Groups

4.3 Comparison Between Peak Expiratory Flow (PEF) of Study and Control Groups Before & After Treatment

Before the intervention, an unpaired t-test revealed no significant difference in PEF measured as a percentage of predicted (p=0.39), with mean values for Group A & Group B at 31.75 ± 2.0 and 32.15 ± 1.5, respectively.

The paired t-test demonstrated a highly significant increase in PEF in Group A after breathing exercises compared to pre-treatment values, with mean values of 40.2 ± 2.3 and 31.75 ± 2.0, respectively (p < 0.01), resulting in a percentage improvement of ↑26.6%.

Conversely, in the control group (B), no significant difference was observed in PEF pre- and post-study (p = 0.46), with mean values of 32.15 ± 1.5 and 32.0 ± 1.8, respectively, yielding a percentage improvement of ↓0.47% (**Table 3 and Graph 3**).

The unpaired t-test for post-study PEF mean values between the groups showed a detectable difference (p < 0.01).

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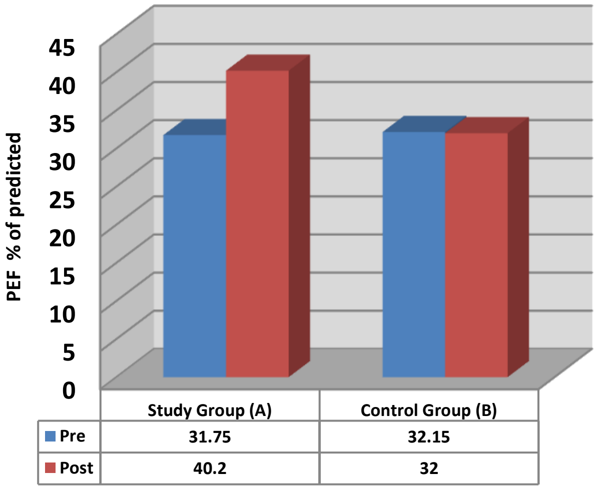
(Table 3): Comparison Between Mean (±SD) of PEF of Study and Control Groups Before & After Treatment:

Peak Expiratory Flow (PEF)	Group A (n=30) Mean ± SD	Group B (n=30) Mean ± SD	Comparison (between groups)	
			t	P
Pre-treatment	31.75 ± 2.0	32.15 ± 1.5	0.87	0.39*
Post-treatment	40.2 ± 2.3	32.0 ± 1.8	10.17	< 0.01**
% of improvement	↑ 26.6 %	↓ 0.47 %		
Comparison (within group) pre/post t	9.22	0.75		
P	< 0.01**	0.46*		

*** Not Significant** **** Significant**



(Graph 3): ***Mean Values of PEF Pre- and Post-Treatment in both Study and Control Groups:***

5. Discussion:

The significant improvement in pulmonary functions observed among the study group indicates that the incorporation of deep breathing exercises, conducted from the 27th to the 36th week of gestation positively enhanced respiratory parameters in twin pregnant women during the third trimester. This finding aligns with the existing literature on the benefits of breathing exercises on diaphragmatic excursion and lung volumes.

A study comparing the effects of diaphragmatic breathing exercises versus inspiratory muscle training on dyspnea and expiratory reserve volume (ERV) in pregnant women. The researcher concluded that inspiratory muscle rehabilitation improved respiratory functions in terms of decreasing dyspnea, fatigue and enhancement of ERV in pregnancy during third trimester. Meanwhile, significant improvement was also observed in the group that practiced diaphragmatic breathing (19). However, it is noteworthy that our study specifically targeted twin pregnancies and measurements of more pulmonary functions including (FVC, FEV_1 & PEF) adding valuable insights to the limited research available in this particular population.

Diaphragmatic breathing has been proven to lower the respiratory rate and enhance blood gases exchange (20). Furthermore, its impact on dyspnea and exercise tolerance in patients with chronic obstructive pulmonary disease demonstrated improved ventilatory functions, including a significant decrease in respiratory rate, an increase in minute ventilation, extension of expiratory time, enhanced tidal volume, and elevated oxygen saturation (21).

Consistent with our findings, a randomized controlled trial showed improvement in blood oxygenation in pregnant women in response to breathing exercises combined with aerobic training (22). This aligns with our results, which revealed a significant improvement in lung function after diaphragmatic and costal deep breathing retraining in the third trimester of twin pregnancy.

The choice of diaphragmatic breathing particularly enhances oxygen saturation and the FEV_1/FVC ratio. It is noteworthy that this study was conducted on patients with chronic obstructive pulmonary disease (23). Another randomized controlled trial proved that this type of breathing greatly improved abdominal motion and diaphragmatic mobility during natural breathing, positively impacting the functional capacity of participants (24).

A systematically reviewed study examined the impact of various skilled breathing interventions and relaxation techniques on the maternal and neonatal outcomes. Antenatal education classes, including breathing techniques, showed a positive influence on women during labor (25). Nevertheless, none of the studies included in their systematic review measured pulmonary function in response to deep breathing techniques, especially in the context of twin pregnancies. Our study, therefore, uniquely contributes to the understanding of the respiratory benefits associated with deep breathing exercises in this particular population.

Strengths, Limitations and Recommendations:

This research stands as the inaugural randomized controlled trial investigating the effects of deep breathing exercises on pulmonary function, specifically focusing on FVC, FEV_1, and PEF, during the third trimester in twin pregnant women.

However, it is imperative to acknowledge certain limitations within the study. The relatively modest sample size, coupled with the exclusive focus on twin pregnancies, raises concerns regarding the generalizability of the findings. To establish the robustness of the results, it is recommended that the study be replicated on a larger scale across diverse national and international settings.

Further research, considering the nuances of different pregnancy populations, will contribute to refining and optimizing respiratory interventions during pregnancy. Additionally, long-term follow-up assessments, especially after delivery, are necessary to determine the sustainability of the observed improvements.

Conclusion:

In conclusion, our study provides valuable insights into the positive impact of deep breathing exercises, specifically diaphragmatic and costal breathing, on pulmonary functions (FVC, FEV_1, PEF) in twin pregnant women during the third trimester. This discovery augments the expanding body of literature advocating for the incorporation of structured breathing exercises into prenatal care.

Authors' Contribution:

The authors played a pivotal role in the inception of the study, overseeing the conceptualization, data collection, statistical analysis, and the initial drafting, as well as subsequent editing of the article.

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Disclosure Statement:

None of the authors involved in this research have any financial interests or have received financial benefits stemming from this study.

Conflicts of Interest:

The authors explicitly declare the absence of any conflicts of interest pertaining to this research.

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