

Effect of Breathing Exercises on Lung Capacity in Obese and Non-Obese Young Adults: An Experimental Study

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Abstract: ***Background:** Obesity is associated with reduced lung volumes, altered breathing mechanics and diminished ventilatory reserve. Breathing exercises are a simple, low-cost physiotherapy intervention, but evidence on their effect in obese young adults, relative to non-obese peers, is limited. **Objective:** To evaluate the effect of a two-week breathing-exercise programme on chest expansion, spirometric volumes and breath-hold time in obese and non-obese young adults, and to compare the magnitude of response between the groups. **Methods:** In this experimental pre-post study conducted in the Department of Physiotherapy, SVIMS, 29 adults aged 18–25 years (18 obese, 11 non-obese) performed diaphragmatic, pursed-lip and segmental breathing exercises for two weeks. Axillary and xiphoid chest expansion (inch tape), inspiratory and expiratory spirometric volumes (cc) and breath-hold time (s) were measured before and after the programme. Within-group changes were analysed with paired t-tests, between-group differences with Welch's t-tests, and effect sizes with Cohen's d/dz ($\alpha = 0.05$). **Results:** Both groups improved significantly in inspiratory volume (obese +25.8%, non-obese +23.9%; both $p < 0.001$), expiratory volume (+16.3%, +11.0%; both $p < 0.001$) and breath-hold time (+12.9%, +9.6%; $p < 0.001$ and $p = 0.003$), with large effect sizes (dz 1.16–4.01). Chest expansion did not change significantly in either group. At baseline, breath-hold time was lower in the obese group (33.7 ± 3.9 s vs 44.5 ± 3.1 s; $p < 0.001$). Change scores did not differ significantly between groups for any parameter (all $p > 0.05$). **Conclusion:** A two-week breathing-exercise programme improved spirometric volumes and breath-hold time in both obese and non-obese young adults, with comparable gains in the two groups. Controlled trials with longer follow-up are needed to confirm these findings.*

Keywords: obesity; breathing exercises; diaphragmatic breathing; lung volumes; chest expansion; breath-hold time; physiotherapy; young adults

1. Introduction

Obesity is a chronic, complex disease defined by excess adiposity that can impair health [1]. According to the World Health Organization (WHO), one in eight people worldwide was living with obesity in 2022 [1], and global prevalence has risen sharply over the past three decades in both adults and younger age groups [2]. Obesity is a major non-communicable disease risk factor and is linked to cardiovascular disease, type 2 diabetes, certain cancers, sleep apnoea, depression, and musculoskeletal and skin disorders [1,7]. It shortens life expectancy, and the sustained expansion of adipose tissue creates a chronic state of low-grade systemic inflammation that underpins many of these comorbidities [6,7].

By WHO criteria, overweight is defined as a body mass index (BMI) ≥ 25 kg/m² and obesity as BMI ≥ 30 kg/m², further divided into Class I (30.0–34.9), Class II (35.0–39.9) and Class III (≥ 40 kg/m²) [1]. Lower thresholds are recommended for Asian populations because of higher body fat at a given BMI [4,5]. More recently, a Lancet Commission proposed distinguishing preclinical obesity (excess adiposity without organ dysfunction) from clinical obesity, and recommended combining BMI with waist circumference or direct body-composition measures [3].

Obesity affects the respiratory system through both mechanical and neural pathways. Excess fat over the chest wall and abdomen reduces chest-wall compliance, lowers

functional residual capacity and expiratory reserve volume, and can impose a restrictive pattern on spirometry, with forced vital capacity, forced expiratory volume in one second and peak expiratory flow tending to fall as BMI rises [8–13]. Obese individuals typically breathe faster and more shallowly, and neural respiratory drive is increased to overcome the added elastic load [13,14]. The diaphragm must generate greater force for a smaller excursion, and dyspnoea is far more common in obese than in non-obese people [8,14,15]. A reduced ability to expand the rib cage may further alter proprioceptive input from the thoracic wall and reduce the efficiency of diaphragmatic activation, a mechanism proposed to contribute to progressive respiratory muscle weakness; this hypothesis remains largely theoretical [8,13].

Breathing exercises, including diaphragmatic breathing, pursed-lip breathing and segmental (localised) expansion breathing, are widely used in physiotherapy to improve ventilation, chest-wall mobility and breath control [16,17]. Their effects have been examined in healthy young adults [18], but data comparing the response of obese and non-obese young adults to the same programme are scarce. If obesity blunts the response to breathing training, obese individuals might need modified or more intensive programmes; if the response is similar, simple breathing exercises could be recommended irrespective of body weight.

The present study therefore aimed to (i) assess the effect of a two-week breathing-exercise programme on chest expansion,

spirometric volumes and breath-hold time in obese and non-obese young adults, and (ii) compare baseline function and the magnitude of change between the two groups.

2. Materials and Methods

2.1 Study design and setting

This was an experimental pre-post study conducted in the Department of Physiotherapy, SVIMS, over a two-week intervention period. All participants gave written informed consent, and the study followed the principles of the Declaration of Helsinki.

2.2 Participants

Participants were young adults aged 18–25 years of either sex, recruited according to predefined criteria. A total of 30 participants were planned, and data from 29 (18 obese, 11 non-obese) were analysed. Obese participants were required to have a BMI of 30.0–39.9 kg/m² (WHO Class I–II) and non-obese participants a BMI of 18.5–24.9 kg/m². Participants also had to be willing to provide written informed consent and able to understand and correctly perform the breathing technique and attend for the whole study period.

Exclusion criteria were: diagnosed cardiopulmonary disease (e.g., asthma, chronic obstructive pulmonary disease, obstructive sleep apnoea, cardiac disease); current or recent smoking or tobacco use; recent thoracic, abdominal or spinal surgery or chest-wall deformity; pregnancy; uncontrolled hypertension or diabetes mellitus or any condition making participation unsafe; and identifiable secondary (endocrine) causes of obesity.

2.3 Assessments

Age, sex, height, weight and BMI (kg/m²) were recorded for every participant using a demographic proforma, stadiometer and weighing scale. All outcome measures were recorded before and after the two-week programme.

- **Chest expansion.** Chest circumference was measured with an inch tape at the axillary and xiphoid levels at full inspiration and full expiration; chest expansion was the difference between the two readings (cm). Cloth-tape measurement of thoracic excursion has acceptable reliability [19].
- **Spirometric volumes.** Inspiratory and expiratory volumes were recorded with a spirometer and expressed in cubic centimetres (cc) with Incentive spirometer.
- **Breath-hold time.** Maximum voluntary breath-hold after full inspiration was timed with a stopwatch (s). Breath-hold duration reflects ventilatory reserve, chemosensitivity and voluntary breath control [20].

2.4 Intervention

Participants were taught diaphragmatic breathing, pursed-lip breathing and segmental breathing using a standard instruction sheet. They sat comfortably with the back straight, inhaled slowly and deeply through the nose, and rested for a few normal breaths between attempts. Participants were told to stop and inform the supervising investigator if they felt dizzy, light-headed or had chest discomfort. The programme lasted two weeks [2 sessions per day and more than 12 sessions per week, 10 repetitions/sets, 10 mins of session duration, and it is supervised.

2.5 Statistical analysis

Data are presented as mean $\pm$ standard deviation (SD) and range. Baseline characteristics were compared with independent-samples t-tests. Pre- versus post-intervention scores within each group were compared with paired-samples t-tests. Obese and non-obese groups were compared at baseline, post-intervention and on change scores (Δ = post – pre) using Welch's independent-samples t-test, which does not assume equal variances [22]. Effect sizes were expressed as Cohen's d (independent comparisons) and dz (paired comparisons) [23,24]. Statistical significance was set at $p < 0.05$ (two-tailed). SPSS 2.0 software is used.

3. Results

3.1 Baseline characteristics

Eighteen obese and eleven non-obese young adults were analysed. The groups were comparable in age ($t = 1.05$, $p = 0.306$) and height ($t = 1.02$, $p = 0.316$), while weight and BMI differed significantly by design (BMI: $t = 6.93$, $p < 0.001$) (Table 1). Group- 1 has 6 male, 12 female and Group -2 has 11 female.

Table 1: Baseline characteristics of participants (mean $\pm$ SD)

Group	n	Age (years)	Height (cm)	Weight (kg)	BMI (kg/m ²)
Obese	18	22.4 $\pm$ 1.4	161.3 $\pm$ 7.4	73.1 $\pm$ 11.4	27.9 $\pm$ 2.4
Non-obese	11	22.9 $\pm$ 1.2	158.8 $\pm$ 5.5	56.5 $\pm$ 5.4	22.7 $\pm$ 1.6

BMI, body mass index.

3.2 Descriptive statistics

Pre- and post-intervention values of all respiratory parameters are given in Table 2.

Table 2: Descriptive statistics of respiratory parameters before and after the intervention

Parameter	Group	Pre (mean $\pm$ SD)	Pre range	Post (mean $\pm$ SD)	Post range
Axillary expansion (cm)	Obese	4.3 $\pm$ 2.0	1–9	3.9 $\pm$ 1.7	1.5–6
	Non-obese	2.7 $\pm$ 1.5	0.5–5	3.1 $\pm$ 1.0	2–5
Xiphoid expansion (cm)	Obese	2.8 $\pm$ 1.3	1–5	2.9 $\pm$ 1.2	1–5
	Non-obese	2.5 $\pm$ 1.2	1–5	3.2 $\pm$ 1.4	1–6
Inspiratory volume (cc)	Obese	733.3 $\pm$ 157.2	500–900	922.2 $\pm$ 143.7	700–1100
	Non-obese	800.0 $\pm$ 134.2	600–900	990.9 $\pm$ 113.6	800–1100
Expiratory volume (cc)	Obese	922.2 $\pm$ 143.7	700–1100	1072.2 $\pm$ 95.8	900–1200

	Non-obese	990.9 ± 113.6	800–1100	1100.0 ± 89.4	900–1200
Breath-hold time (s)	Obese	33.7 ± 3.9	28–41	38.0 ± 3.3	31–43
	Non-obese	44.5 ± 3.1	39–50	48.8 ± 4.6	40–55

SD, standard deviation

3.3 Within-group changes

In both groups, inspiratory volume, expiratory volume and breath-hold time increased significantly after two weeks of breathing exercises (Table 3, Figure 1). In the obese group, inspiratory volume rose by 188.9 cc (+25.8%; $t = 17.00$, $p < 0.001$, $dz = 4.01$), expiratory volume by 150.0 cc (+16.3%; $p < 0.001$, $dz = 2.43$) and breath-hold time by 4.3 s (+12.9%; $p < 0.001$, $dz = 1.80$). In the non-obese group, the corresponding gains were 190.9 cc (+23.9%; $p < 0.001$, $dz = 3.54$), 109.1 cc (+11.0%; $p < 0.001$, $dz = 2.02$) and 4.3 s (+9.6%; $p = 0.003$, $dz = 1.16$). Neither axillary nor xiphoid chest expansion changed significantly in either group (all $p > 0.05$).

Table 3: Paired t-test of pre- versus post-intervention values within each group

Parameter	Group	Pre	Post	Δ	% Δ	t	p	dz
Axillary expansion	Obese	4.3	3.9	-0.33	-7.8	1.44	0.169	0.34
	Non-obese	2.7	3.1	0.41	15.3	1.03	0.328	0.31
Xiphoid expansion	Obese	2.8	2.9	0.06	2	0.44	0.668	0.1
	Non-obese	2.5	3.2	0.68	27.3	1.78	0.105	0.54
Inspiratory volume	Obese	733.3	922.2	188.89	25.8	17	<0.001	4.01
	Non-obese	800	990.9	190.91	23.9	11.74	<0.001	3.54
Expiratory volume	Obese	922.2	1072.2	150	16.3	10.29	<0.001	2.43
	Non-obese	990.9	1100	109.09	11	6.71	<0.001	2.02
Breath-hold time	Obese	33.7	38	4.33	12.9	7.66	<0.001	1.8
	Non-obese	44.5	48.8	4.27	9.6	3.84	0.003	1.16

Chest expansion in cm, spirometric volumes in cc, breath-hold time in s. Δ , mean change; % Δ , percentage change; dz, Cohen's dz. $p < 0.05$ considered significant.

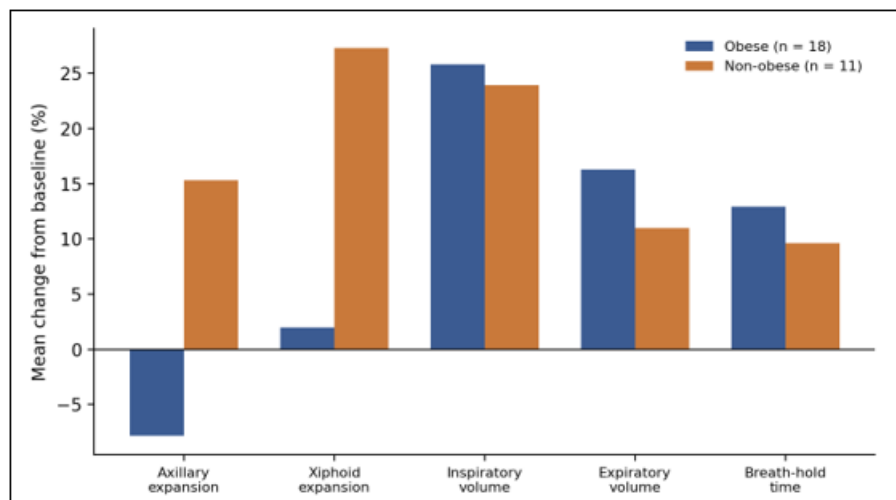


Figure 1: Mean percentage change from baseline for each respiratory parameter in obese and non-obese groups

3.4 Between-group comparison

At baseline, breath-hold time was markedly lower in the obese group ($t = 8.38$, $p < 0.001$) and axillary chest expansion was significantly greater ($t = 2.38$, $p = 0.025$); spirometric volumes and xiphoid expansion did not differ (Table 4). After the intervention, the groups still differed in breath-hold time ($p < 0.001$) but not in the other parameters. Importantly, the magnitude of change did not differ between groups for any parameter (all $p > 0.05$), indicating a similar response to the programme irrespective of obesity status.

Table 4: Welch's t-test comparing obese and non-obese groups at baseline, post-intervention and for change scores (Δ)

Parameter	t (pre)	p (pre)	t (post)	p (post)	t (Δ)	p (Δ)
Axillary expansion	2.38	0.025	1.6	0.121	1.61	0.126
Xiphoid expansion	0.64	0.529	0.63	0.539	1.55	0.146
Inspiratory volume	1.22	0.236	1.43	0.166	0.1	0.919
Expiratory volume	1.43	0.166	0.79	0.438	1.87	0.073
Breath-hold time	8.38	<0.001	6.83	<0.001	0.05	0.962

$\Delta = \text{post} - \text{pre}$. $p < 0.05$ considered significant.

4. Discussion

In this study, two weeks of diaphragmatic, pursed-lip and segmental breathing exercises produced large and statistically significant improvements in spirometric volumes and breath-hold time in both obese and non-obese young adults, and the size of improvement was similar in the two groups. Chest expansion measured by tape did not change significantly in either group.

The lower baseline breath-hold time in the obese group agrees with the reduced ventilatory reserve, increased respiratory load and higher neural respiratory drive described in obesity [8,13,14,20]. Spirometric volumes did not differ significantly between groups at baseline, which may reflect our young, otherwise healthy participants without overt respiratory disease, in whom the mechanical effects of adiposity are less pronounced than in older or more severely obese cohorts [9–12]. Contrary to the expectation that a thicker chest wall would reduce excursion, axillary expansion was greater in the obese group at baseline. This may reflect measurement error introduced by soft-tissue thickness when using a tape, which is a recognised limitation of circumferential measures [19]; direct imaging or optoelectronic plethysmography would be needed to test this.

Improvement in lung volumes and breath-hold time after breathing training is biologically plausible. Diaphragmatic breathing encourages greater diaphragmatic excursion and slower, deeper breaths, and pursed-lip breathing prolongs expiration, raises airway pressure and slows respiratory rate [16,17]. Together with improved voluntary control of breathing, these mechanisms may raise achievable inspiratory and expiratory volumes and breath-hold tolerance. Similar programmes of a few weeks have been used in healthy young adults [18]. In obese individuals, the additional mechanical load on the diaphragm and chest wall [8,14,15] might have been expected to blunt the response, but our data suggest that training can yield comparable gains despite a lower starting breath-hold time.

The absence of a significant change in chest expansion suggests that two weeks may be too short to alter thoracic mobility, in contrast to the volume and breath-hold measures, which are more sensitive to short-term improvements in breathing pattern and voluntary control. Small subgroup sizes and the variability of tape measurements may also have limited power for these outcomes, particularly for xiphoid expansion in the non-obese group ($dz = 0.54$; $p = 0.105$).

From a clinical standpoint, the findings support including simple, low-cost breathing exercises in physiotherapy and health-promotion programmes for overweight and obese young adults, who are at risk of later respiratory and cardiometabolic complications [1,7,8]. Because such exercises are safe and require no equipment, they could complement, but not replace, weight-management strategies.

4.1 Limitations

This study has several limitations. First, the sample was small (18 obese and 11 non-obese participants), limiting power, especially for between-group comparisons. Second, there was

no control group receiving no intervention, so the improvements cannot be attributed to the exercises alone; practice and learning effects on spirometric and breath-hold tests are likely contributors. Third, the intervention lasted only two weeks and no follow-up was performed, so durability is unknown and structural changes in the chest wall may not have had time to develop. Fourth, outcomes were assessed with an inch tape, spirometer volumes and a stopwatch; assessors were not blinded. Fifth, groups differed in size, and sex distribution was not analysed. Finally, the single-centre design and narrow age band (18–25 years) limit generalisability. Future randomised controlled trials with larger samples, longer follow-up, standardised diagnostic spirometry [21], respiratory muscle strength testing and objective adherence monitoring are recommended.

5. Conclusion

A two-week breathing-exercise programme significantly improved inspiratory and expiratory spirometric volumes and breath-hold time in both obese and non-obese young adults, and the magnitude of improvement was similar between groups. Chest expansion did not change significantly over this period. Larger controlled studies with longer follow-up are needed to confirm these results and establish the optimal dose of breathing exercises in obesity.

References

- [1] World Health Organization. Obesity and overweight [fact sheet]. Geneva: WHO; 2025. Available from: <https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight>
- [2] NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in underweight and obesity from 1990 to 2022: a pooled analysis of 3663 population-representative studies with 222 million children, adolescents, and adults. *Lancet*. 2024;403(10431):1027–1050.
- [3] Rubino F, Cummings DE, Eckel RH, Cohen RV, Wilding JPH, Brown WA, et al. Definition and diagnostic criteria of clinical obesity. *Lancet Diabetes Endocrinol*. 2025;13(3):221–262.
- [4] WHO Expert Consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet*. 2004;363(9403):157–163.
- [5] Misra A, Chowbey P, Makkar BM, Vikram NK, Wasir JS, Chadha D, et al. Consensus statement for diagnosis of obesity, abdominal obesity and the metabolic syndrome for Asian Indians and recommendations for physical activity, medical and surgical management. *J Assoc Physicians India*. 2009;57:163–170.
- [6] Hotamisligil GS. Inflammation and metabolic disorders. *Nature*. 2006;444(7121):860–867.
- [7] Fontaine KR, Redden DT, Wang C, Westfall AO, Allison DB. Years of life lost due to obesity. *JAMA*. 2003;289(2):187–193.
- [8] Koenig SM. Pulmonary complications of obesity. *Am J Med Sci*. 2001;321(4):249–279.
- [9] Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. *J Appl Physiol*. 2010;108(1):206–211.

- [10] Jones RL, Nzekwu MM. The effects of body mass index on lung volumes. *Chest*. 2006;130(3):827–833.
- [11] Parameswaran K, Todd DC, Soth M. Altered respiratory physiology in obesity. *Can Respir J*. 2006;13(4):203–210.
- [12] Melo LC, Silva MA, Calles AC. Obesity and lung function: a systematic review. *Einstein (Sao Paulo)*. 2014;12(1):120–125.
- [13] Littleton SW. Impact of obesity on respiratory function. *Respirology*. 2012;17(1):43–49.
- [14] Steier J, Jolley CJ, Seymour J, Roughton M, Polkey MI, Moxham J. Neural respiratory drive in obesity. *Thorax*. 2009;64(8):719–725.
- [15] Bernhardt V, Babb TG. Exertional dyspnoea in obesity. *Eur Respir Rev*. 2016;25(142):487–495.
- [16] Hamasaki H. Effects of diaphragmatic breathing on health: a narrative review. *Medicines (Basel)*. 2020;7(10):65.
- [17] Nield MA, Soo Hoo GW, Roper JM, Santiago S. Efficacy of pursed-lips breathing: a breathing pattern retraining strategy for dyspnea reduction. *J Cardiopulm Rehabil Prev*. 2007;27(4):237–244.
- [18] Han JW, Kim YM. Effect of breathing exercises combined with dynamic upper extremity exercises on the pulmonary function of young adults. *J Back Musculoskelet Rehabil*. 2018;31(2):405–409.
- [19] Bockenbauer SE, Chen H, Julliard KN, Weedon J. Measuring thoracic excursion: reliability of the cloth tape measure technique. *J Am Osteopath Assoc*. 2007;107(5):191–196.
- [20] Parkes MJ. Breath-holding and its breakpoint. *Exp Physiol*. 2006;91(1):1–15.
- [21] Graham BL, Steenbruggen I, Miller MR, Barjaktarevic IZ, Cooper BG, Hall GL, et al. Standardization of spirometry 2019 update. An official ATS/ERS technical statement. *Am J Respir Crit Care Med*. 2019;200(8):e70–e88.
- [22] Ruxton GD. The unequal variance t-test is an underused alternative to Student's t-test and the Mann–Whitney U test. *Behav Ecol*. 2006;17(4):688–690.
- [23] Lakens D. Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Front Psychol*. 2013; 4: 863.
- [24] Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale (NJ): Lawrence Erlbaum Associates; 1988.