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Comparison Between Dynamic Neuromuscular Stabilization Breathing Exercises and Pilates Exercises in Young Overweight Individuals with Activity-Related Breathlessness

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ABSTRACT

Method: The study was conducted on 80 young overweight individuals matching the inclusion criteria from college going students who were given intervention for 3 days a week per 6 weeks. Pre-intervention assessment was done on day 1 and post intervention assessment was done after 6 weeks. Through randomized selection patients were divided into two groups, Group A DNS breathing exercises and Group B Pilates Exercises. Outcome measures: mMRC scale, Harward Step Test, Diaphragm MMT was assessed at baseline and after 6weeks day post-intervention.

Result: Both the Groups DNS breathing exercises and Pilates exercises demonstrated significant improvement in terms of reducing activity related breathlessness. Between-group analyses showed that group A DNS was more effective than group Pilates exercises in improving aerobic capacity, and group B Pilates exercises was more effective than group A DNS breathing exercises in improving Diaphragm muscle strength.

Conclusion: DNS breathing exercises and Pilates exercises demonstrated significant improvement in terms of reducing activity related breathlessness. The group A DNS was more effective than group Pilates exercises in improving aerobic capacity, and group B Pilates exercises was more effective than group A DNS breathing exercises in improving Diaphragm muscle strength.

Keywords: *Activity related breathlessness, Dynamic Neuromuscular Stabilization Breathing Exercises, Pilates Exercises, and Young Overweight individuals*

1. INTRODUCTION

Obesity is a chronic disease defined as an unhealthy accumulation of body fat in the afflicted individual.[1] Generally speaking, body fat percentages of more than 25% for boys and more than 30% for girls are considered substantial. The WHO uses the body mass index as the gold standard for identifying obesity and determining whether a patient is at risk for negative health outcomes.[2] Asian individuals were classified as underweight (<18.5 kg/m2), normal or lean BMI (18.5–22.9 kg/m2), overweight (23.0–24.9 kg/m2), and obese (≥25 kg/m2) based on the latest general standards for India.[3] It is estimated that 1.7 billion individuals worldwide suffer from the obesity and overweight epidemic. Obese people may experience respiratory problems due to structural anomalies affecting the chest wall, lungs, and diaphragm.[4] Central obesity indicators, on the other hand, more accurately depict the distribution of body fat than BMI.[5] Visceral fat deposition, which lowers maximal inspiratory pressures and respiratory muscle strength in obese people, partially mediates the effect of waist size on pulmonary function. Exertional dyspnoea is increasingly prevalent in younger, obese, and otherwise healthy women. Instead, a higher respiratory oxygen cost has a strong correlation with dyspnoea.[6] Weight impacts respiratory parameters because it is linked to a higher risk of small airway dysfunction, expiratory flow limitation, changes in respiratory mechanics, decreased compliance of the chest wall and lungs, decreased breathing control, decreased pulmonary gas exchange, and decreased

exercise capacity.[7] The ACSM advocates at least three times a week, 20–60 minutes of exercise at 60–90% of maximum heart rate reserve or 50–85% of maximum oxygen uptake, to establish and maintain cardio-respiratory fitness.[8] The progressive decline in circulatory efficiency in overweight people would be a sign of the path from childhood obesity to cardiovascular disease.[9] Exercise serves as essential for both treating and preventing obesity, however exertional dyspnoea prevents many obese people from participating in regular exercise. Despite having no comorbidities, exertional dyspnoea may result from a number of obesity-related restrictions.[10] The literature doesn't include a manual diaphragm evaluation scale.[11] The assessment makes it possible to pinpoint areas of the diaphragm with less passive and active excursion as well as those that are less movable and inflexible.[12] A manual diaphragm evaluation is a reliable method for determining the respiratory muscle strength of an asthmatic patient, according to the information previously supplied.[13] Recent improvements in physical performance and fitness include a variety of novel techniques for improving cardiovascular fitness and muscle strength.[14] A thorough corrective program must include both global and local muscle complex synchronization and breathing improvement, which are the goals of DNS breathing exercises.[15] Thoracic kyphosis was straightened and rib cage tension was reduced using DNS deep breathing exercises, both of which are essential for physiological stability. To attain optimal and comprehensive bodily function, DNS integrates breathing techniques, education, postural awareness, and brain stimulation.[16] DNS preserved diaphragmatic breathing and "neutral" spine posture while suitably promoting core muscle sensing and activation. Therefore, this intervention may be a useful strategy to support and enhance lung volume and respiratory function by utilizing appropriate breathing patterns.[17] DNS is established by the simultaneous and synchronized contractions of the diaphragm, pelvic floor muscles, lower back, abdominal muscles, and deep flexors and extensors of the neck and back.[18] Although Pilates mat exercises have grown in popularity over the last 20 years, little is known about the benefits of the practice for inactive people. Pilates mat exercises have been demonstrated to improve a group of dancers' static or postural balance.[19] Pilates is a mind-body training technique that emphasizes core stability, strength, and flexibility along with breathing, posture, and muscular control.[20] The truncal base of support is where Pilates mat exercises start, whether you're supine, side-lying, or prone.[21] Pilates exercises performed on a mat employ gravity and the participant's body weight as resistance. One of the primary lengthening exercises in Pilates. The alignment of each exercise is not largely dictated by the movements of individual muscles.[22]

2. METHODOLOGY

A prospective Interventional Comparative Study done on subjects of all genders with activity related breathlessness of age group 18-25 years at D.Y.Patil College of Physiotherapy, Kadamwadi Kolhapur for a duration 12 months using Consecutive Sampling method paired t test used for data analysis. **Sampling Design:** Simple Random Sampling **Sampling technique:** Subjects were randomly allocated. **Sample Size**: The sample size is 80 (40 in each group) subjects fulfilling

Inclusion Criteria and Exclusion Criteria were taken into consideration**. Inclusion Criteria**- Age 18-25 Years, participants of all genders, young Overweight Individuals i.e. BMI between (23-24.9 kg/m^2) according to the Asian Body mass index Classification, participants who are willing to participate, non-exercising overweight individuals **Exclusion Criteria-** Hypertension with medications, recent surgeries, hypothyroidism, diabetes mellitus, smokers, females with PCOD/ Irregular Periods, asthmatic Individuals, post COVID- 19 infection individuals, interstitial Lung Disease, congenital Heart Defects like atrial septal defect (ASD), tetralogy of fallot, participants who consume Alcohol, Inability to comply with the study procedure **MATERIALS USED:** Chair, steeper, pen, stopwatch, Spighnamanometer, stachurmeter, pulse oximeter, weighing macine. **TOOLS:** Informed consent, data collection sheet, mMMRc scale, diaphragm MMT scale.

3. METHODOLOGY

Ethical clearance was obtained from the institutional ethical committee of D.Y Patil Education Society, Kolhapur. All the participants were screened according to inclusion and exclusion criteria before their enrolment into the study and detailed demographic data of each individual was noted. The study's purpose was explained and written informed consent was obtained from all the participants. Then the participants were divided into two groups: Group A and Group B. Group A was given Dynamic Neuromuscular Stabilization Breathing Exercises. Group B was given Pilates exercises. Outcome measures were evaluated pre and post intervention with the following scales Modified Medical Research Council (mMRC Scale), Manual Muscle Testing (Diaphragm), and Harvard step test. The warm-up exercises (5 minutes), DNS exercises with respiratory correction (40 minutes), and cool-down exercises (5 minutes). The 40 minutes are divided into four 10-minute sections that cover the main movements. The exercise protocol for Group A and Group B was for 3 times per week for 6 weeks. Pilates group Warm-up exercises was given for 5 minutes pre-intervention, cool down exercises for 5 minutes post-intervention, and 40 minutes of exercise time divided by 5 minutes for exercise. Both exercises were for a total of 50 minutes. Both groups were taught their exercises and exercise sessions were conducted in the investigator's observation at D.Y.Patil College of Physiotherapy Yoga Lab. The exercise protocol was for 6 weeks. Post-intervention values were taken after the completion of the 6-week protocol.

4. RESULTS

By using Shapiro test, it is found that pre and post values of group A and Group B does not follow Normality (0.0003)

therefore, Wilcoxon Signed-Ranks Test is used.

Group A Age, height, weight, BMI with values represent mean age 21.65 ±1.46, mean Height 164.1 ± 8.7, mean Weight 63.95 ±8.057, mean BMI 23.85 ± 0.630**.**

Group A Gender Distribution among participant with 21 and 19 Male and Female Respectively.

Harvard Step test		
	Pre Values	Post Values
Quartile_1	53	86.75
Median	58	89
Quartile_3	63	96
IQR	10	9.25
P-Value	9.09E-13	

Table no.1 Represent Group A Harvard step test within group comparison, pre intervention mean was 63 and Post intervention 96 with P-value of less than 0.005 (9.09 $E^{\times 13}$)

mMRC Scale		
	Pre Values	Post Values
Quartile_1	1	0
Median	1	0
Quartile_3	2	1
IQR	1	1
P-Value	2.07E-09	

Table no.2 Represent Group A mMRC scale within group comparison pre intervention values was 2 and post intervention value was 1 with P-value of less than 0.005 (2.07 $E^{\times 9}$).

MMT	**Diaphragm**	
	Pre Values	**Post Values**
Quartile_1	3	4
Median	3	4
Quartile_3	3	4
IQR	0	0
P-Value	1.82E-12	

Table no. 3 Represent Group A MMT Diaphragm within group comparison pre intervention values was 3 and post intervention value was 4 with P-value of less than 0.005 (1.82$E^{\times 12}$).

Group B Age, height, weight, BMI with values represent mean age 21.45 ± 1.63, mean Height 160.7 ± 5.94, mean Weight 61.17 ±4.99, mean BMI 23.77 ± 0.53.

Group B Gender Distribution among participant with 16 and 24 Male and Female Respectively.

Harvard Step test		
	Pre Values	Post Values
Mean	60.2	86.68
Std. Dev.	7.57	7.84
P-Value	1.36E-27	

Table no.4 Represent Group B Harvard step test within group comparison, mean and standard deviation, pre intervention mean was 60.2 ± 7.57 and Post intervention 86.68 ±7.84 with P-value of less than 0.005 (1.36 $E^{\times 27}$).

mMRC Scale		
	Pre Values	Post Values
Quartile_1	1	0
Median	2	0
Quartile_3	2	1
IQR	1	1
P-Value	2.73E-08	

Table no.5 Represent Group B mMRC scale within group comparison pre intervention values was 2 and post intervention value was 1 with P-value of less than 0.005 (2.07 $E^{\times 8}$).

MMT Diaphragm		
	Pre Values	Post Values
Quartile_1	3	4
Median	3	4
Quartile_3	3.25	4.25
IQR	0.25	0.25
P-Value	4.61E-09	

Table no. 6 Represent Group B MMT Diaphragm within group comparison pre intervention values was 3.25 and post intervention value was 4.25 with P-value of less than 0.005 (4.61$E^{\times 9}$).

Harvard Step Test		
	DNS Post Values	Pilates Post Values
Quartile_1	86.75	81.75
Median	89	86.5
Quartile_3	96	93.25

IQR	9.25	11.5
P-Value	1.03E-02	

Table no.7 Represents Group- Wise Comparison for Harvard step test Group A (DNS) post values were 96 and Group B (Pilates) post values were 93.25 with P-value of less than 0.005 ($1.03E^{\times 2}$).

mMRC Scale		
	DNS Post Values	Pilates Post Values
Quartile_1	0	0
Median	0	0
Quartile_3	1	1
IQR	1	1
P-Value	0.414	

Table no.8 Represents Group- Wise Comparison for mMRC scale Group A (DNS) post values were 1 and Group B (Pilates) post values were 1with P-value of less than 0.005 (0.414).

MMT Diaphragm		
	DNS Post Values	Pilates Post Values
Quartile_1	4	4
Median	4	4
Quartile_3	4	4.25
IQR	0	0.25
P-Value	0.199	

Table no. 9 Represents Group- Wise Comparison for MMT Diaphragm Group A (DNS) post values were 4 and Group B (Pilates) post values were 4.25 with P-value of less than 0.005 (0.199).

5. DISCUSSION

A study by Mohammad-Rashimi N (2020) found that 26 male students, aged 19 to 23, had bad posture and were sedentary. Maximal voluntary ventilation (MVV), forced expiratory volume in one second (FEV1), forced vital capacity (FVC), and the FEV1/FVC ratio were all measured during the first pulmonary function pretest. This study investigated how dynamic neuromuscular stabilization breathing exercises affected the respiratory function of inactive students with bad posture. When compared to the baseline, the study's results after six weeks showed significant ($p<0.001$) improvements in MVV, FEV1, FVC, and the FEV1/FVC ratio, indicating that DNS breathing exercises are a useful strategy to enhance respiratory health.[16] The Efficacy of Dynamic Neuromuscular Stabilization Breathing Exercises on Chest Mobility, Trunk Muscles, and Thoracic Kyphosis: A Randomized Controlled 6-Week Trial was conducted by Nasser Mohammad Rahimi et al. (2020) with 52 participants ages 19–23. This study examined how DNS breathing exercises affected a group of inactive students with poor posture in terms of trunk extensor endurance, thoracic kyphosis, and upper and lower chest wall mobility (UCM and LCM). They came to the conclusion that DNS breathing exercises, which emphasize breathing techniques and the integrated spinal stabilizing system, are a useful protocol to greatly enhance trunk muscle endurance, thoracic kyphosis, and UCM and LCM. It has been suggested that DNS breathing exercises be implemented in order to enhance posture and chest mobility and to promote physiological stability for students' general health and performance.[17] In present study the Age of the participants is

varied from 18 to 25 years with an average of 21.75 in Group and 21.45 in Group B. An additional research study by Eda Akbas et al. (2018) A total of 51 sedentary females between the ages of 18 and 25 were randomized to either the Control Group (n = 26) or the Pilates Exercise Group (n = 25). For a period of six weeks, the Pilates Exercise Group engaged in a Pilates mat exercise regimen, while the Control Group didn't participate in any regular physical activity. At baseline and six weeks later, the subjects' anthropometric characteristics, anxiety, depression, fatigue, and quality of life were evaluated. According to the research results of this study, a 6-week Pilates mat workout program that is done twice a week for a total of 12 sessions benefits young women's physical and mental health in terms of body mass, slimness, anxiety, depression, weariness, and quality of life. Future research with a longer duration and a larger sample size is still necessary to elucidate the potential mechanisms of action of Pilates exercises and the data supporting this topic.[26]

Present study includes healthy individuals with activity related breathlessness like stair climbing. In one study only male students who were sedentary and had bad posture were the subject of a study by Mohammad-Rashimi N et al. (2020).[16] An additional study was carried out to assess how the Pilates mat workout regimen affected the young women's physical and mental health in terms of their anthropometric characteristics, emotional state, level of exhaustion, and other aspects of their quality of life. Only sedentary female individuals were included in the study by Eda Akbas et al. (2018).[26] In present study due to random allocation method and due to small sample size there were more female subjects than male .Group A had 40 subjects where 21 males and 19 female subjects were present, similarly Group B had 40 subjects where16 males and 24 females subjects. The mean age was 21yrs in both the groups. In present study Mean BMI in Group A was 23.8 and for Group B was 23.7. Contrasting with The BMI of the individuals in the study conducted by Muhammad-Rashimi N (2020) ranged from 19 to 25 kg/m2. Sedentary students with poor posture were the subjects of this study to examine the effects of dynamic neuromuscular stabilization breathing exercises on their respiratory function.[16] According to a 2009 study by Cheryl M. Salome et al., obesity impairs lung function and may exacerbate the effects of pre-existing airway illness. Even in the absence of a particular respiratory ailment, it can potentially impair respiratory health.[25] In present study Dynamic Neuromuscular Stabilization Breathing Exercises showed significant difference posttest. DNS breathing exercises were useful in improving aerobic fitness in young overweight individuals with activity related breathlessness. In regard to these modifications in neuromuscular coordination, the diaphragm muscle, a primary respiratory muscle that provides stability, and other breathing muscles are more active and wanted. Strengthening the muscles involved in exhalation will increase and enhance maximum expiratory pressure, achieving this goal. Additionally, these problems may be lessened in the second stage by enhancing the coordination of the breathing muscles and the alignment of the chest and spine. The natural, neutral posture of the spine facilitates the function of numerous muscles, including the external oblique, pelvic floor, transverse abdominal, and intercostal muscles.[16] The current study showed how Pilates exercises were helpful in reducing dyspnea associated with activities like stair climbing. An increase in aerobic capacity may result from better respiratory awareness and coordinated muscular control.[26] Pilates exercises after the Diaphragm MMT test revealed a significant advancement. By increasing abdominal and lower back strength, posterior trunk flexibility, and abdominal muscular endurance, the study by Betul Sekendiz et al. (2006) stated. Inactive older females' quality of life was enhanced by contemporary Pilates mat exercises.[20] The present study shows that DNS Breathing exercises were more effective than Pilates Exercises in improving aerobic fitness with Harvard step test (p value- 1.03). Pilates Exercises were more effective in improving diaphragm muscle strength with Diaphragm MMT (p value- 0.199). Both DNS Breathing exercises and Pilates exercises were improved activity related breathlessness with mMRC scale (p value- 0.414). Evaluation of Obesity-Related Breathlessness Using the Baseline Dyspnea Index and the Modified Medical Research Council Scale. Their objective was to compare the two dyspnea scales for obese people and analyze the results using metrics that measure obesity, such as waist circumference, six-minute walk distance, and rate of perceived exertion. and to see whether these two scales are related in any way. A cross-sectional evaluation study was created, with obese people who appeared to be in good health. mMRC and BDI have been utilized in a random order to evaluate dyspnea. A 6-minute walk test was used to measure the waist-to-hip ratio. To ascertain the association between mMRC and obesity, a non-parametric correlation test was employed. According to the study's findings, dyspnea in obese people can be evaluated using the Baseline Dyspnea Index and the Modified Medical Research Council Scale. Because the Baseline Dyspnea Index and the Modified Medical Research Council Scale have a modest relationship, they may be utilized as needed.[11]

6. CONCLUSION

The study demonstrated that both the exercises are equally effective. The Dynamic Neuromuscular Stabilization Breathing Exercises are effective in improving aerobic capacity. The Pilates exercises are effective in improving in diaphragm muscle strength. Dynamic Neuromuscular Stabilization Breathing Exercises and Pilates Exercises both are equally effective in improving activity related breathlessness.

CONFLICT OF INTEREST

There is no declared potential conflict of interest by the author.

REFERENCES

[1] Shoukri A. Effects of obesity on respiratory mechanics at rest and during exercise. Egyptian Journal of Bronchology. 2015 Dec;9:224-6.

[2] Amin F, Fatima SS, Islam N, Gilani AH. Prevalence of obesity and overweight, its clinical markers and associated factors in a high risk South-Asian population. BMC obesity. 2015 Dec;2:1-1.

[3] Aziz N, Kallur SD, Nirmalan PK. Implications of the revised consensus body mass indices for Asian Indians on clinical obstetric practice. Journal of clinical and diagnostic research: JCDR. 2014 May;8(5):OC01.

[4] Magnani KL, Cataneo AJ. Respiratory muscle strength in obese individuals and influence of upper-body fat distribution. Sao Paulo Medical Journal. 2007;125:215-9.

[5] Huxley R, Mendis S, Zheleznyakov E, Reddy S, Chan J. Body mass index, waist circumference and waist: hip ratio as predictors of cardiovascular risk—a review of the literature. European journal of clinical nutrition. 2010 Jan;64(1):16-22.

[6] Babb TG, Ranasinghe KG, Comeau LA, Semon TL, Schwartz B. Dyspnea on exertion in obese women: association with an increased oxygen cost of breathing. American journal of respiratory and critical care medicine. 2008 Jul 15;178(2):116-23.

[7] Ekström MP, Blomberg A, Bergström G, Brandberg J, Caidahl K, Engström G, Engvall J, Eriksson M, Gränsbo K, Hansen T, Jernberg T. The association of body mass index, weight gain and central obesity with activity-related breathlessness: the Swedish Cardiopulmonary Bioimage Study. Thorax. 2019 Oct 1;74(10):958-64.

[8] Bhatti U, Laghari ZA, Syed BM. Effect of Body Mass Index on respiratory parameters: A cross-sectional analytical Study. Pakistan Journal of Medical Sciences. 2019 Nov;35(6):1724.

[9] Weyer C, Linkeschowa R, Heise T, Giesen HT, Spraul M. Implications of the traditional and the new ACSM physical activity recommendations on weight reduction in dietary treated obese subjects. International journal of obesity. 1998 Nov;22(11):1071-8.

[10] Bagade AH, Bhonde MS, Nikam L. Cardiac response to exercise determined by physical fitness index in young obese and normal-weight medical students. Indian Journal of Basic and Applied Medical Research. 2015;4(2):389-93.

[11] Bernhardt V, Babb TG. Exertional dyspnoea in obesity. European respiratory review. 2016 Dec 1;25(142):487-95.

[12] Bordoni B, Marelli F, Morabito B, Sacconi B. Proposal for a New Manual Evaluation Scale for the Diaphragm Muscle: Manual Evaluation of the Diaphragm Scale–MED Scale. Int J Complement Altern Med. 2017;7(6):1-7.

[13] Bordoni B, Morabito B. The diaphragm muscle manual evaluation scale. Cureus. 2019 Apr;11(4).

[14] Serrano-Villar Y, Rodríguez-Grande EI, Segura MS. Manual Testing of Respiratory Muscles in Adults with Asthma: A Intra and Interrater Reliability and Validity Study.

[15] Jay K, Frisch D, Hansen K, Zebis MK, Andersen CH, Mortensen OS, Andersen LL. Kettlebell training for musculoskeletal and cardiovascular health: a randomized controlled trial. Scandinavian journal of work, environment & health. 2011 May 1:196-203.

[16] Mohammad-Rahimi N, Mahdavinezhad R, Attarzadeh-Hosseini SR, Negahban H. Effect of dynamic neuromuscular stabilization breathing exercises on respiratory function of sedentary students with poor posture. Health Education and Health Promotion. 2020 Mar 10;8(1):19-24.

[17] Mohammad Rahimi N, Mahdavinejad R, Attarzadeh Hosseini SR, Negahban H. Efficacy of dynamic neuromuscular stabilization breathing exercises on chest mobility, trunk muscles, and thoracic kyphosis: a randomized controlled 6-Week trial. Iranian Rehabilitation Journal. 2020 Sep 10;18(3):329-36.

[18] Ghavipanje V, Rahimi NM, Akhlaghi F. Six weeks effects of dynamic neuromuscular stabilization (DNS) training in obese postpartum women with low back pain: A randomized controlled trial. Biological Research for Nursing. 2022 Jan;24(1):106-14.

[19] Madle K, Svoboda P, Stribrny M, Novak J, Kolar P, Busch A, Kobesova A, Bitnar P. Abdominal wall tension increases using Dynamic Neuromuscular Stabilization principles in different postural positions. Musculoskeletal Science and Practice. 2022 Dec 1;62:102655.

[20] Sekendiz B, Altun Ö, Korkusuz F, Akın S. Effects of Pilates exercise on trunk strength, endurance and flexibility in sedentary adult females. Journal of bodywork and movement therapies. 2007 Oct 1;11(4):318-26.

[21] Wells C, Kolt GS, Bialocerkowski A. Defining Pilates exercise: a systematic review. Complementary therapies

in medicine. 2012 Aug 1;20(4):253-62.

[22] Aladro-Gonzalvo AR, Machado-Díaz M, Moncada-Jiménez J, Hernández-Elizondo J, Araya-Vargas G. The effect of Pilates exercises on body composition: a systematic review. Journal of bodywork and movement therapies. 2012 Jan 1;16(1):109-14.

[23] Segal NA, Hein J, Basford JR. The effects of Pilates training on flexibility and body composition: an observational study. Archives of physical medicine and rehabilitation. 2004 Dec 1;85(12):1977-81.

[24] Kulkarni M, Saini S, Palekar T, Hamdulay N. Effects of pilates on core muscle strength and endurance in post 6 months delivered women. Proteus J. 2020;11(8):136-51.

[25] Salome CM, King GG, Berend N. Physiology of obesity and effects on lung function. Journal of applied physiology. 2010 Jan;108(1):206-11.

[26] Akbaş E, Ünver B. A six-week Pilates exercise protocol for improving physical and mental health-related parameters. Malaysian Journal of Movement, Health & Exercise. 2018 Jul 1;7(2):65-79.