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Diaphragmatic Breathing for Improving Lumbar Flexibility: An Experimental Study on Final-Year Students at STIKES Bethesda Yakkum Yogyakarta

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Abstract

Introduction: Many final-year students report neuromuscular issues associated with decreased lumbar flexibility. This study examines the effectiveness of diaphragmatic breathing exercises in improving lumbar flexibility and reducing neuromuscular complaints.
Methods: An experimental study with a one-group pretest-posttest design was conducted on 50 final-year students at STIKES Bethesda Yakkum Yogyakarta. Participants were selected based on inclusion criteria and exclusion criteria. The study lasted for two weeks, with two sessions per week. Lumbar flexibility was measured before and after the intervention using the Modified-Modified Schober Test (MMST).
Results: The results showed a significant increase in lumbar flexibility following diaphragmatic breathing exercises, with a p-value of 0.000. The average increase in lumbar flexibility was 1.16 cm (SD = 0.32 cm), indicating that this exercise effectively enhances lumbar flexibility.
Conclusion: Diaphragmatic breathing exercises have a significant impact on improving lumbar flexibility in final-year students. These findings suggest that such exercises can effectively reduce neuromuscular complaints related to lumbar flexibility.

Keywords: diaphragmatic breathing exercises, lumbar flexibility, final-year students

Introduction

Initially, the pattern of diseases was primarily dominated by health issues such as malnutrition or infectious diseases. However, in contemporary times, one of the factors influencing the occurrence of these diseases is a sedentary lifestyle.[1] A sedentary lifestyle is characterized by minimal physical activity, where daily activities primarily involve watching television, playing games for hours, watching video games, and engaging in most tasks while sitting for prolonged periods. Such activities are prevalent among school-aged adolescents.[2]

One of the often-unnoticed impacts of a sedentary lifestyle is neck and back pain, which are neuromuscular disorders with the highest prevalence in the general population. Consequently, neuromuscular disorders have become a significant health concern that can disrupt various aspects of an individual's life, including their work quality.[3]

Other findings also reveal a high prevalence of musculoskeletal disorders caused by prolonged sitting, such as pain in the lower back and neck. Therefore, it is necessary to implement prevention and intervention strategies for disorders in the lower back and neck areas to create a healthier work environment and reduce the risk of persistent and severe complaints.[4] Reported data from America indicates that around 40% of adults experience back pain by 30. A continuously sedentary lifestyle can exacerbate complaints of neck and back pain.[5]

Given the high incidence of back pain among final-year undergraduate students completing their theses, the researcher is interested in conducting physiotherapy training to reduce neuromuscular disorders in these students. Physiotherapy offers numerous modalities to alleviate pain. However, the researcher is particularly interested in investigating the underlying causes of these complaints. Field studies have revealed that many students suffer from decreased lumbar flexibility. Lumbar flexibility is correlated with the occurrence of lower back pain. Therefore, the researcher aims to provide an exercise concept to improve lumbar flexibility.

Prolonged sitting leads to hamstring stiffness, significantly correlating with an increased lumbar lordosis angle. Reduced lumbar lordosis during lumbar movement indicates a lack of lumbar flexibility. Inflexible muscles are unprepared for movement, resulting in pain and stiffness when mobilized. Decreased flexibility can also make everyday movements easier, thereby reducing work quality. Research indicates that a good range of motion (ROM) and strong abdominal muscles in the hip and lower back areas can help prevent or reduce lower back pain (LBP).[6]

In addition to hamstring stiffness and lumbar lordosis, neuromuscular disorders can also be caused by muscle imbalances in other areas. For instance, the erector spinal muscles become tight in back pain caused by spasms in the erector spine. Tight muscles often result from compensation for the weakness of other muscles, such as weak abdominal muscles and gluteal muscles. Consequently, different muscles, like the iliopsoas, compensate by becoming tight.[7]

From an ergonomic perspective, prolonged sitting leads to excessive loading and tissue damage in the lumbar vertebrae, muscle tension, and ligament strain in the spine. Extended periods of sitting can cause blood vessel constriction, resulting in reduced oxygen and nutrient supply to tissues, leading to lactic acid build-up and pain. Other research also confirms that long periods of sitting without regular muscle contractions can increase back muscle stiffness, potentially exacerbating lower back pain.[8] Based on research conducted from 1990 to 2019, there has been a global increase of 50% in the prevalence of lower back pain.[9] In Indonesia, based on data from the Central Statistics Agency (Badan Pusat Statistik) 2018, approximately 26.7% of the population aged 15 years and older reported experiencing lower back pain.[10] This study uses a sample of university students because they fall within the productive-age population aged 15 years and above. In the Special Region of Yogyakarta Province, the productive-age population (aged 15-64 years) totals 2.52 million people, comprising 68.78% of the total population. Meanwhile, the number of active students in Yogyakarta is 266,491.[11]

Previous research on improving lumbar flexibility has been conducted using the Dynamic Neuromuscular Stabilization (DNS) approach. The results indicated that DNS enhances lumbar flexibility in female batik artisans after four weeks of DNS compared to a static stretching group. DNS is an approach that optimizes movement patterns based on the scientific principles of developmental kinesiology (DK), reflecting the developmental patterns observed in infants aged 3 to 12 months.[12] The DNS concept revolves around activating all stabilizers proportionally to ensure optimal movement patterns for functional activities or further skill execution. According to developmental kinesiology (DK), the diaphragm initially functions as a stabilizer in early life. Therefore, the DNS concept focuses on activating the diaphragm to achieve stability, primarily through diaphragmatic breathing techniques.[13]

Previous research utilizing diaphragmatic breathing exercises investigated Dynamic Neuromuscular Stabilization (DNS) movements based on developmental kinesiology (DK). The study compared these exercises with static stretching and found significant results.[13] However, this study focuses on one of DNS's simplest components, diaphragmatic breathing. It is used to enhance lumbar flexibility, hoping that increased flexibility will address neuromuscular neck and lower back issues among final-year university students who often engage in prolonged sitting. Reduced lumbar flexibility contributes to these issues. Therefore, increasing the range of motion (ROM) in the lumbar area through exercises that engage the back and abdominal muscles is crucial. Breathing exercises can effectively enhance both areas. Hence, the researcher aims to prove that diaphragmatic breathing exercises can improve lumbar flexibility.

Given that all students have complained of lower back or neck pain, and considering the typical routine of final-year students, simple exercises like diaphragmatic breathing are necessary to address these complaints. Hence, the researcher undertakes this study to investigate the effects of diaphragmatic breathing in alleviating these issues among students. The specific objective of this study is to examine whether diaphragmatic breathing exercises can improve lumbar flexibility and subsequently reduce neuromuscular complaints in final-year students. This study hypothesizes that diaphragmatic breathing exercises will significantly improve lumbar flexibility and reduce neuromuscular complaints in final-year students.

Method

This study employed a pre-post test design conducted at STIKES Bethesda Yakkum Yogyakarta. Pre-test data were collected on October 31, 2023, and post-test data were gathered on November 7, 2024. The research began with a field study to assess which students from various cohorts and classes experienced neuromuscular disorders related to lower back or neck pain most frequently. Subsequently, final-year female students who had previously experienced neck or lower back pain were recruited as participants, encompassing the entire final-year student body as the research sample.

The study commenced with data collection from sedentary lifestyle seventh-semester STIKES Bethesda students. Female students willing to participate in the study provided informed consent before completing a questionnaire detailing personal information and daily activities. Following questionnaire completion, participants underwent pre-test data collection using the Modified-Modified Schober Test (MMST) to measure lumbar flexibility.

Participants then engaged in Diaphragmatic Breathing exercises, initially guided by a physiotherapist for 45 minutes. Subsequently, participants performed these exercises independently for one week. After this period, a second 45-minute session was conducted with the physiotherapist, followed by post-test data collection using MMST to assess the effects of the intervention.

The study used a pre-post test design to experiment with a single group by comparing pre and post-variables, specifically lumbar flexibility. The sample consisted of 50 female students from the final semester of the Nursing undergraduate program at STIKES Bethesda Yakkum. A total sampling method encompassed all eligible population members based on inclusion and exclusion criteria. Inclusion criteria included being female, enrolled at STIKES Bethesda Yakkum Yogyakarta, experiencing neuromuscular disorders, and being a final-year student. Exclusion criteria included respiratory illness, heart disease, and concentration disorders. Initially, 57 participants were enrolled, but five were absent during the final data collection, resulting in a final sample size 50.

Measurement tools included the Modified-Modified Schober Test (MMST) for assessing lumbar flexion, requiring a measuring tape or Medline. The questionnaire tool was validated using SPSS software before data collection. The MMST validity test resulted in moderate validity (r=0.67), while interclass reliability (r=0.91) and intraclass reliability (r=0.95) tests indicated excellent reliability.

Participants received two joint training sessions and were instructed to continue exercises independently at home for one week. A WhatsApp group was used to monitor adherence and provide reminders and support. The correct diaphragmatic breathing technique involves activating all muscles to expand like a tube while breathing comfortably.

Participants were instructed to place fingertips on the lower abdomen and upper chest to ensure proper breathing through nasal inhalation and exhalation.

Figure 1. The instructor provided example of diaphragmatic breathing

Figure 2. The instructor guided the research participants in performing diaphragmatic breathing

Correct breathing patterns involve proper muscle activation, observable through trunk movements. During inhalation, activation can be observed from the lower abdomen, moving from the diaphragm to the pelvic floor, through the middle-lower thoracic region between the diaphragm and thoracic vertebra 5, up to the upper thoracic region from T5 to the lower cervical spine. Differences in movement between the lower and upper ribs during inhalation can be observed from the horizontal characteristics of thoracic expansion in all directions: cross-sectional (lateral-lateral), anterior-posterior (front to back), and cranio-caudal (cervical).

Functional mechanisms accompany these thoracic movements: the upper rib movement (from the first to the seventh rib) with the sternum on both anterior and posterior sides (sternocostal mechanism), and the lower ribs moving with the diaphragm in cross-sectional and vertical alignment (costodiaphragmatic mechanism).

Ethical clearance for this study was obtained from STIKES Bethesda Yakkum Yogyakarta with clearance number No.043/KEPK.02.01/VI/2023, ensuring compliance with research ethics principles. The ethical clearance process was initiated in January–February. Field studies were conducted from March to September 2023, followed by research activities in October–November 2023 and subsequent report preparation.

The study commenced with normality and homogeneity tests, followed by paired t-tests to compare pre and post-test data. To minimize potential biases, measurements were conducted by six research assistants who also served as guides for the diaphragmatic breathing exercises. Participants were instructed on correct diaphragmatic breathing techniques, ensuring proper muscle activation and expansion during inhalation while seated. They verified their breathing by placing fingertips on the lower abdomen and upper chest, ensuring nasal inhalation and exhalation.

The sample size was determined based on total sampling of eligible participants. This ensured that all final-year female students experiencing neuromuscular disorders were included, comprehensively representing the target population. Any missing data were addressed by contacting participants who were absent during data collection and encouraging their participation in follow-up sessions to ensure completeness of the dataset. While the primary analysis focused on the entire sample, subgroup analyses were performed to examine potential differences in outcomes based on factors such as the severity of neuromuscular complaints and adherence to exercise protocols. Interaction effects between variables (e.g., daily activity levels and lumbar flexibility improvements) were also explored to understand the intervention's impact better.

Results

The sample comprised the entire population of STIKES Bethesda Yakkum Yogyakarta senior nursing students. The total population meeting the inclusion and exclusion criteria was 57 individuals, all providing informed consent. Initial data indicated that participants' ages ranged from 20 to 22 years. However, during the diaphragmatic breathing exercise training and final data collection, seven individuals did not participate, resulting in a final sample size of 50 participants for this study.

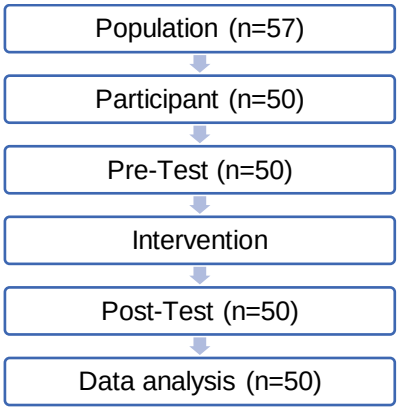

Figure 1. Research Process Flowchart

The study included the entire population of senior nursing students at STIKES Bethesda Yakkum Yogyakarta, who met the inclusion and exclusion criteria. Initially, 57 participants provided informed consent. However, during the diaphragmatic breathing exercise training and final data collection, seven individuals did not participate, resulting in a final sample size of 50 participants.

The participants were all female students aged between 20 and 22 years. Before the intervention, data on lumbar flexibility were collected using the Modified-Modified Schober Test (MMST). The following table provides detailed characteristics of the study participants, including their age and baseline lumbar flexibility. Table 1 summarizes the characteristics of the study participants, including their age and baseline lumbar flexibility measured using the Modified-Modified Schober Test (MMST).

Table 1. Participant Characteristics

Characteristic	Value
Age Range	20-22 years
Gender	Female
Baseline Lumbar Flexibility (Mean ± SD)	4.87 ± 1.56 cm

Based on Table 1, the study involved a final sample of 50 female senior nursing students from STIKES Bethesda Yakkum Yogyakarta. The participants' ages ranged from 20 to 22 years. Baseline lumbar flexibility, measured by the Modified-Modified Schober Test (MMST), had a mean value of 4.87 cm with a standard deviation of 1.56 cm. This demographic information helps contextualize the study population, clarifying the participants' age range and baseline lumbar flexibility before the intervention. Table 2 shows the difference in test results using MMST.

Table 2. The Difference Test Results Using MMST

Measurement	Pre-Test Mean (± SD)	Post-Test Mean (± SD)	p-value
MMST	4.87 ± 1.56 cm	6.03 ± 1.63 cm	0.000

Table 2 presents the difference test results using the Modified-Modified Schober Test (MMST), with a significance value (p-value) of 0.000. A low p-value ($p < 0.05$) indicates a significant difference in lumbar flexion curvature before and after the diaphragmatic breathing exercise intervention. This outcome suggests that diaphragmatic breathing exercises effectively improve lumbar flexibility among the sampled senior nursing students.

No missing data were reported for this study's primary variables of interest. All 50 participants provided complete data for both pre-test and post-test measurements. No adjustments for potential confounders were made as the study design inherently controlled for variability by using a within-subject comparison. The results were based on paired t-tests comparing pre and post-intervention measurements. No subgroup or sensitivity analyses were conducted in this study. Future studies may consider exploring these aspects to provide further insights into the intervention's effectiveness across different participant characteristics or conditions.

Discussion

This study demonstrates that diaphragmatic breathing exercises can enhance lumbar flexibility. Diaphragmatic exercise, as explained in the introduction, represents a fundamental aspect of the Dynamic Neuromuscular Stabilization (DNS) approach to improve body stability. The finding of enhanced flexibility through simple exercises contrasts with previous studies, indicating that maintaining lumbar flexibility can be achieved without complex routines solely through breath training. Consequently, addressing neuromuscular disturbances resulting from decreased lumbar flexibility through diaphragmatic breathing exercises represents a significant advancement.[14]

Increased flexibility, as evidenced by improved Range of Motion (ROM), is a crucial indicator of the effectiveness of these exercises. ROM enhancement can be attributed to soft tissue improvements in the targeted area.[14]

Neuromuscular disturbances in the lumbar region often stem from stability issues primarily caused by muscle imbalances. As previously mentioned, when there is pain in the lower back, it is likely due to weakness in the abdominal muscles.[5] Other studies also explain that spinal stabilization involves the abdominal, diaphragm, pelvic floor, and back muscles. Enhancing the activity and coordination of these muscles is essential to alleviate excessive load and prevent back pain, which can be achieved through correct breathing patterns.[12] Diaphragmatic breathing activates the diaphragm, abdominal muscles, and pelvic floor and moderates the activity of the back muscles, leading to improved neuromuscular function.

Diaphragmatic breathing using ribcage activation induces intra-abdominal pressure (IAP) during exercise, decreasing spinal pressure. This activation minimizes muscle tension, allowing for greater flexion and extension movements. The principle of stabilizing the body by establishing correct posture is crucial here. This approach also aids in reducing pain by enhancing dynamic muscle function, which contracts to compress the intra-distal area. Reducing the workload on the lumbar muscles increases oxygen supply, subsequently reducing pain.[13]

The training regimen implemented in this study consisted of 45-minute sessions of diaphragmatic breathing. During diaphragmatic breathing, previously weak muscles such as the pelvic floor, diaphragm, and multifidus muscles are interconnected. Activation of these muscles inhibits those previously overworked, such as the erector spinae in the back, allowing them to relax and facilitating increased lumbar flexibility.

This training aimed to mitigate the effects of excessive strain and prevent back, neck, and shoulder pain associated with a sedentary lifestyle. This required enhancing the activity and coordination of these muscles through proper breathing patterns. Participants were instructed to focus on contracting the respiratory muscles—especially the diaphragm, pelvic floor, and transversus abdominis—which regulate intra-abdominal pressure (IAP) and provide anterior stability to the lumbopelvic posture. Movements were performed slowly and smoothly, using controlled muscle

contractions tailored to the exercise needs. Participants were guided to breathe normally (without profound breaths or breath-holding), emphasizing movement quality and body awareness during daily exercise.

The research aimed to observe improvements in lumbar flexibility among participants, and the findings indicated an increase in lumbar flexibility after applying diaphragmatic breathing. Potential biases in this study could arise from participants engaging in other forms of exercise or activities that could affect lumbar flexibility during the one-week interval between pre-test and post-test measurements. Additionally, variables such as varying physical conditions during data collection (e.g., menstrual discomfort) might influence results. To mitigate these factors, participants were provided with correct diaphragmatic breathing demonstration videos, educated on setting reminders to perform exercises, and ensured to be in good health during data collection (e.g., absence of abdominal pain affecting MMST calculations).

This study demonstrates the significant improvement in lumbar flexibility achieved through diaphragmatic breathing exercises. The findings highlight a notable range of motion (ROM) increase, indicative of enhanced flexibility primarily attributed to improved soft tissue quality within the targeted area. This contrasts with previous studies, underscoring the efficacy of more straightforward exercise routines focused solely on breath training to maintain lumbar flexibility.

Addressing neuromuscular disturbances associated with decreased lumbar flexibility, this study aligns with the Dynamic Neuromuscular Stabilization (DNS) approach, emphasizing diaphragmatic exercises as fundamental for enhancing body stability. Diaphragmatic breathing stabilizes the spine by activating the diaphragm, abdominal muscles, and pelvic floor while moderating back muscle activity. It reduces intra-abdominal pressure (IAP), minimizing spinal stress and muscle tension. This mechanism supports greater flexion and extension movements, improving dynamic muscle function and reducing pain.

However, the study acknowledges several limitations that could affect its outcomes. Participants' engagement in other physical activities during the one-week interval between pre-test and post-test measurements and variations in physical conditions during data collection may introduce potential biases. Although efforts were made to mitigate these factors through participant education and health monitoring, the small sample size—comprising exclusively female students aged 20-22—limits the generalizability of the findings. Future research should include broader demographic representation and larger sample sizes to enhance external validity.

In conclusion, while this study provides valuable insights into the benefits of diaphragmatic breathing for enhancing lumbar flexibility and stabilizing neuromuscular function, further investigation is warranted. Future studies should explore long-term effects and consider additional controls to strengthen the evidence base and broaden applicability across diverse populations.

Conclusion

This study concludes that diaphragmatic breathing exercises, conducted over one week among 50 senior nursing students at STIKES Bethesda Yakkum Yogyakarta, effectively improved lumbar flexibility by 1.16 cm as measured by MMST. The findings underscore the efficacy of this simple intervention in enhancing musculoskeletal health, particularly among sedentary individuals experiencing lower back issues. The implications are significant, highlighting diaphragmatic breathing as a viable strategy to improve postural stability and mitigate lower back discomfort. Future research should explore variations in study variables, including diverse age groups and male populations, to enhance generalizability and deepen our understanding of the broader benefits of diaphragmatic breathing across demographics. The use of MMST proved valuable in objectively measuring lumbar flexibility, suggesting its utility in both research and clinical settings for assessing such interventions. Educating participants on correctly executing diaphragmatic breathing exercises, supported by video examples and reminders, ensured consistency and minimized potential confounders during data collection. Overall, this study contributes valuable insights into the therapeutic potential of diaphragmatic breathing and sets a foundation for further exploration in related fields.

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