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*Research article*

# The Efficacy of the Nicolescu Protocol in the Treatment of Kyphosis in Adults

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**Abstract:** The effectiveness of a therapeutic method is determined by both the time required to achieve the desired results and its long-term retention. This study aimed to assess the clinical and postural effects of the Nicolescu Protocol in adults with thoracic kyphosis. A longitudinal, prospective case-control design was employed, involving 80 participants (40 women and 40 men, aged 30-40 years) who completed a six-month intervention program consisting of three supervised sessions per week (60-75 minutes). Postural assessment was performed using the Kinetisense 3D system, analyzing sagittal plumb-line deviations before and after the intervention, while statistical analysis was conducted using a paired t-test for dependent samples. The therapeutic strategy focused on correcting neuromuscular imbalances through targeted muscle activation and relaxation techniques, while adhering to fundamental training principles, including intensity, specificity and reversibility. Results demonstrated large and statistically significant reductions across all sagital markers in both sexes (e.g., head, spine, shoulders, pelvis, all $p<0.001$), with very large effect sizes and no significant sex or age related differences. Clinically, participants reported pain resolution, increased joint range of motion and muscular mobility within the first 30 days, absence of regression throughout the intervention period, reductions in body weight and improvements in muscle tone and strength. These findings indicate that the Nicolescu Protocol is an effective physiotherapeutic approach for improving thoracic posture, reducing pain, and enhancing neuromuscular function in adults with kyphotic posture. Further research is recommended to validate these outcomes across broader age ranges and clinical settings.

**Keywords:** Nicolescu Protocol, kyphosis, posture, rehabilitation, physical therapy, neuromuscular imbalances

## 1. Introduction

Modernism in the current era, the lack of physical exercise, and spending leisure time watching television, using computers or phones in poor and prolonged postures—all these are factors that disrupt the posture of the human body, particularly in individuals who have reached maturity.

From the very beginning, the aim of this research has been to design an original program with the objective of correcting kyphotic posture in mature individuals by addressing neuromuscular imbalances.

Currently, there are multiple therapeutic methods, means, and exercises aimed at correcting or, as the case may be, improving kyphosis. What makes the Nicolescu protocol special and effective is the implementation of these methods in a clear and precise order. Clinically, building a battery of tests that provides the highest possible accuracy in identifying neuromuscular imbalances and assessing joint mobility was essential and brought added value to our protocol.

To complement the battery of tests used as the basis for identifying neuromuscular imbalances, we introduced the 3D Kinetisense evaluation system—which will be described in detail in the chapter regarding measurement methods.

Visual postural assessment performed by therapists is widely used in clinical practice, however, its accuracy may be limited by observer subjectivity. When relying on visual evaluation, previous research has reported a measurement error margin of less than 5 mm, highlighting the need for technological assistance to achieve optimal accuracy and objectivity [1]. In recent years, advances in motion analysis technologies, particularly markerless systems, have enabled faster, objective, and more reliable postural assessments without the need for reflective markers. Recent validation studies published between 2024 and 2025 have demonstrated the high accuracy and clinical applicability of these markerless approaches [2,3].

Correct posture represents the absence of musculoskeletal constraints that could disrupt the harmonious alignment between body segments and is therefore fundamental to functional health and pain-free movement. The spinal column, as the central structure of the locomotor system, provides both protection and mobility for the human body [4,5]. Postural deviations developed during childhood and adolescence often persist into adulthood, predisposing individuals to degenerative musculoskeletal changes later in life. Epidemiological data show an alarming increase in postural defects among both young and adult populations, largely due to occupational factors and sedentary behavior [6]. Studies conducted in Europe and the United States reveal that more than 60% of workers perform repetitive tasks or maintain static postures for extended periods, often resulting in pain and functional impairment [7].

Prolonged sitting, in particular, is associated with anterior head posture, thoracic kyphosis, pelvic tilt, and neuromuscular imbalances that compromise both spinal stability and mobility [8,9]. According to biomechanical analyses, these dysfunctions can lead to chronic pain, reduced range of motion, and secondary musculoskeletal adaptations involving the cervical and lumbar regions [10]. While corrective exercise programs are effective during growth phases, there is increasing evidence that targeted interventions can also improve posture and neuromuscular control in adulthood [11–13].

Pain affects the way in which the nervous system activates musculature, acting as a protective mechanism, thereby explaining the development of postural deficits and demonstrating that these can be influenced through the reorganization of motor control [14]. Studies indicate that patients with low back pain develop pain-induced compensatory strategies, which may persist even after pain has resolved [15,16]. These changes affect the overall behavior of the trunk musculature, with repercussions on both static posture and movement, highlighting the need for neuromuscular reeducation rather than pain reduction alone. Therefore, a sequential and precise intervention is required to address these neuromuscular imbalances.

Recent meta-analyses and randomized controlled trials indicate that comprehensive exercise programs, which address the body globally rather than targeting isolated muscle groups, are significantly more effective in improving thoracic kyphosis. Randomized controlled studies have shown that both isolated and comprehensive exercise interventions can lead to statistically significant improvements in thoracic kyphosis angle; however, global, integrative approaches consistently demonstrate superior clinical outcomes [17]. Moreover, randomized controlled trials in adult populations show that posture-oriented, multicomponent exercise programs, combining spinal strengthening with postural training and movement control, lead to greater reductions in thoracic kyphosis than isolated or local exercise approaches [18].

Recent meta-analyses and clinical studies have highlighted the positive effects of strength and stretching protocols on thoracic kyphosis and lumbar lordosis [19-

20]. Moreover, the traditional view of posture as only a mechanical alignment has been progressively replaced because recent studies suggests that posture is an output of the central nervous systems control process [21-24]. However, despite these findings, few interventions have specifically addressed the sequential correction of neuromuscular imbalances through integrated methods combining muscle relaxation techniques, stretching, and activation. This gap underlies the rationale for the present study.

The aim of this research was to evaluate the effectiveness of a structured intervention—the Nicolescu Protocol—in improving postural alignment and correcting thoracic kyphosis in adults aged 30–40 years. The study hypothesized that addressing neuromuscular imbalances through a specific sequence of interventions would significantly improve sagittal plane alignment and reduce related symptoms.

## 2. Materials and Methods

### 2.1. Study Design and Ethical Approval

This investigation was designed as a longitudinal, prospective, case–control study. The study was carried out in Romania, Alba Iulia, with data collected between March 2019 and November 2024, covering a six year period to evaluate the effectiveness of the Nicolescu Protocol in correcting thoracic kyphotic posture in adults. All participants were informed about the objectives and procedures of the study and provided written informed consent prior to enrollment. The study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Institutional Ethics Committee of "1 December 1918" University of Alba Iulia. The protocol was officially registered with the State Office of Inventions and Trademarks (OSIM) under registration number 196129, in accordance with Law No. 84/1998, in May 2023.

### 2.2. Participants

The selection of subjects for the research on the improvement of kyphotic posture in mature individuals was conducted according to rigorous inclusion and exclusion criteria to ensure the validity and reliability of the study results.

The selection process was random among individuals who presented for evaluation and met the age criteria. All patients who fulfilled the inclusion criteria and did not meet any exclusion criteria were enrolled in the neuromuscular imbalance treatment program. The presence of neuromuscular imbalances and postural deficiencies was confirmed through comprehensive evaluation and testing prior to inclusion.

This careful selection process ensured a homogeneous study group, minimized confounding variables, and increased the internal validity of the research findings.

#### 2.2.1. Eligibility Criteria

Given the random selection, it was uncertain whether all evaluated individuals would be enrolled in the recovery program, so the inclusion and exclusion criteria for this study were carefully defined. Eligible participants were adults aged 30 years or older at the time of assessment. The age threshold was selected in accordance with the World Health Organization's classification, which defines adulthood as beginning at 30 years of age and extending into multiple sub-stages up to 65 years. Additional inclusion criteria included the price of thoracic kyphotic posture deficiency and the physical ability to perform the required exercise-based intervention.

Exclusion criteria were equally important and these included: presence of associated deficiencies; reported fractures of the spine, pelvis, or other joints; prior participation in other physical exercise programs or leisure activities (e.g., swimming or other sports/games); contraindications for intense physical effort (e.g., hypertension, arrhythmias).

Although a larger number of participants were initially enrolled in the study, the analysis was restricted to the data obtained from those who completed the entire six-month intervention program. In the final phase of the study, the sample consisted of 80 participants, evenly distributed by gender (40 women and 40 men).

### 2.3. Assessment Tools and Measurement Procedures

In addition to the somatic assessment, the researcher also benefited from the Kinetisense 3D postural analysis system (https://www.kinetisense.com/), which is a patented platform for evaluating human body posture based on photo–video analysis. To minimize measurement errors, all Kinetisense assessments were performed according to the manufacturer's technical specifications. The 3D sensor was positioned 3.5–4.5 feet above ground level, and participants were assessed at a standardized distance of 6–8 feet from the device, with an unobstructed field of view. Clothing was standardized (tight-fitting, light-colored garments), and accessories that could interfere with motion detection were removed. Lighting conditions were controlled to avoid direct exposure of the sensor to sunlight or strong LED sources. All assessments were conducted in a stable indoor environment, ensuring optimal tracking accuracy.This is a comprehensive body analysis system that provides data for each segment (head, neck, spine, hip, knee, ankle), evaluating from the frontal, sagittal, and transverse planes.

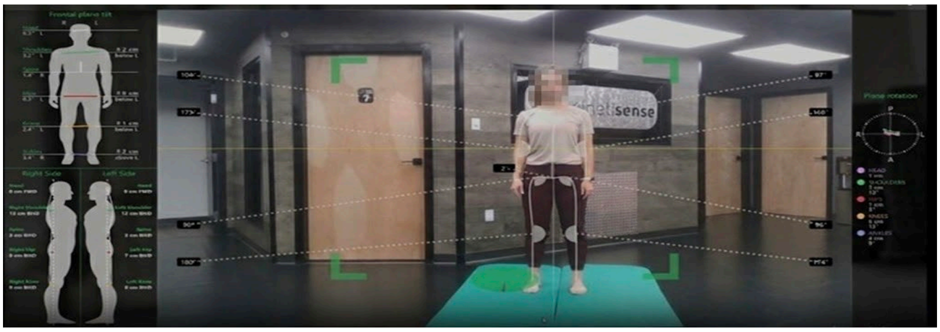


Figure 1 - Postural analysis system – KINETISENSE (https://www.kinetisense.com/)

The system can measure and assess both joint range of motion and the biomechanics of physical exercise execution. Kinetisense evaluates joint amplitude based on AMA guidelines, while postural assessment is based on plumb line analysis.

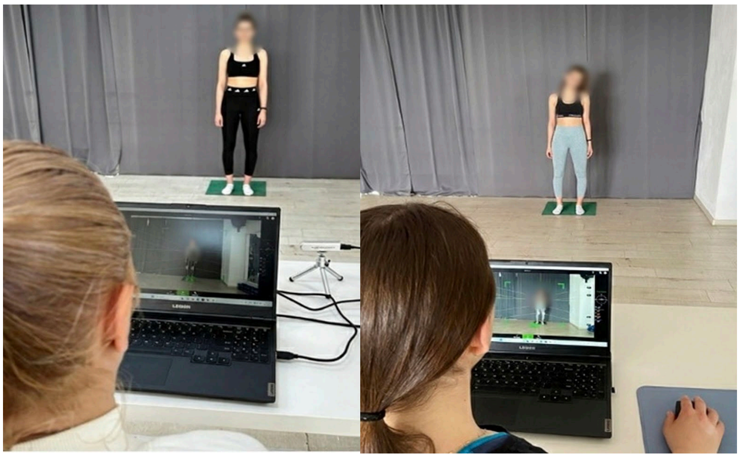


Figure 2 – Assessment of posture and range of motion (from the author's personal archive)

The postural analysis system—used for the evaluation and identification of spinal and body segment deficiencies—performs a non-invasive assessment without radiation, using a system based on a camera with 3D sensors connected to specialized software capable of specific measurements. This unit is used both for determining deviations from correct posture and for monitoring the rehabilitation program. In the this study, from the multitude of data provided by the Kinetisense postural evaluation system, only the data directly relevant to the analysis of kyphotic posture were selected, namely: head, spine, shoulders, and pelvis. The measurements performed were as follows: distance from the plumb line to the tragus, distance from the plumb line to the spinous process of the C7/T1 vertebra, distance from the plumb line to the acromion, and distance from the plumb line to the greater trochanter. The values are expressed in centimeters for the sagittal plane assessment. Subjects were evaluated with their eyes open, each test being recorded for 20 seconds.

2.4. Intervention Protocol

The Nicolescu Protocol was developed to identify and correct neuromuscular imbalances through sequential interventions that respect the law of reciprocal innervation.

The central nervous system is responsible for initiating, controlling, and monitoring movement. The first step of the CNS is identifying the muscles that need to be activated for a specific movement, and then it generates electrical impulses to develop the optimal level of force required for that movement.

Neuromuscular balance occurs when, over time, agonist and antagonist muscles are engaged in relatively equal proportions, indicating that they function in harmony.

Neuromuscular imbalance is described as a situation in which antagonist muscles do not work in harmony, producing unequal forces and creating different tensions at the joint they control.

This imbalance typically arises over time due to repetitive movements or prolonged postural habits, where agonist muscles become overused and antagonist muscles become underactive. To describe this relationship, the terms "shortened muscles" and "lengthened muscles" are commonly used. An overused muscle may develop painful spots (myofascial trigger points) that cause tension and pain either in the same muscle, its tendon, the joint, or the antagonist muscle. Another scenario involves an overused muscle creating tension in other muscles within the same kinetic chain.

The neuromuscular imbalances can lead to secondary effects such as:

- Postural deficiencies or misalignments;
- Pain in the musculoskeletal system (muscle, tendon, joint pain, or radiating pain caused by nerve compression);
- Injuries such as muscle strains, tendon or ligament damage, or vertebral disc lesions;

Correcting neuromuscular imbalances involves reversing the process: relaxing or releasing tension in the overused muscle followed by activating the antagonist muscle.

Although we now have a wide range of therapeutic tools and methods for muscle relaxation and activation, the so-called Nicolescu Protocol is composed of well-known techniques. Its originality lies in the selection and sequence of methods, which has proven to enhance the effectiveness of anatomical correction—even in older adults.

The intervention program known as the "Nicolescu Protocol" consists of three phases:

Phase 1 – Evaluation and identification of neuromuscular imbalances;

Phase 2 – Treatment of imbalances aimed at improving kyphotic posture;

Phase 3 – Consolidation or stabilization of the results obtained during treatment.

The evaluation phase focuses on identifying neuromuscular imbalances, while the treatment phase addresses these dysfunctions through targeted physical exercises to improve the kyphotic posture. The consolidation phase aims to maintain and further enhance the results over time. A key innovative aspect of the Nicolescu Protocol is the strategic integration of physical exercise at precisely defined stages of intervention, optimising efficiency and improving outcomes in the correction of kyphotic posture in mature individuals. Given the wide availability of therapeutic tools and methods for muscle relaxation and activation, the effectiveness of an intervention is determined by both the speed at witch the desired results are achieved and the long-term retention of these outcomes.

2.5. Statistical Analysis

The research is a longitudinal, prospective, interventional case-control study. Data were analyzed using SPSS 25.0 (IBM Corp., USA). Descriptive statistics (mean, standard deviation, variance coefficient) and paired-sample t-tests were used to compare pre- and post-intervention results. Statistical significance was set at $p < 0.05$. Effect sizes were calculated according to Cohen's d classification.

To evaluate the effectiveness of the recovery protocol designed to correct kyphotic posture in mature individuals, the study employed the paired t-test (dependent t-test). This statistical method is suitable for comparing pre- and post-intervention values within the same group of subjects, enabling the assessment of the significance of changes between initial and final measurements. The paired t-test was applied to each evaluated body segment (head, spine, shoulders, pelvis), separately for both female and male groups. A significance threshold of $p < 0.001$ was adopted, indicating statistically significant differences between initial and final values and thereby confirming the protocol's effectiveness. The obtained t-values exceeded the critical threshold, demonstrating that the observed postural improvements were consistent and statistically robust.

Also, to evaluate the effectiveness of the Nicolescu Protocol, we used analysis of variance (ANOVA) to compare the results obtained by the experimental group with those of the control group. Differences between the means of the final measurements (or initial–final differences) were analyzed for the main postural variables (head, spine, shoulders, pelvis). The results showed statistically significant differences between the two groups ($p < 0.05$), further confirming the effectiveness of the applied protocol.

2.6. Data Availability

All datasets generated during the current study are available from the corresponding author upon reasonable request. The Nicolescu Protocol and all associated materials are protected by copyright and may be shared for academic replication purposes only.

## 3. Results

3.1. General Findings

This study evaluated the effects of an experimental intervention on sagittal plane parameters measured at the head, spine, shoulders, and pelvis, with a comparative analysis between female and male groups. Statistical analysis included the calculation of means, standard deviations, minimum and maximum values, and coefficients of variation for each anatomical segment. The significance of differences between groups was assessed using the independent samples t-test, with Levene's test applied to verify the equality of variances.

The results are presented both in tabular and graphical formats, providing a comprehensive overview of the post-intervention values and the evolution of the measured parameters. These findings contribute to a better understanding of the impact of the experimental program on postural characteristics and highlight potential gender-related differences in response to the intervention.

## 3.2. Sagittal Plane Measurements

### 3.2.1. Head Alignment

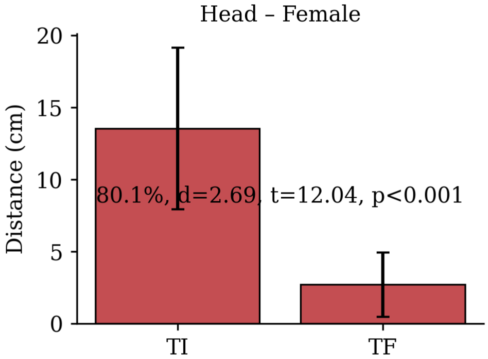
Table 1 **Head** (Distance from Plumb Line to Tragus) Female Group

| Statistical Indicator | IT | FT |
|---|---|---|
| Mean | 13.55 | 2.70 |
| Standard deviation | 5.61 | 2.23 |
| Minimum | 3 | 0 |
| Maximum | 26 | 9 |
| Range | 23 | 9 |
| Coef of Variation | 41.4% | 82.5% |

| Statistical Indicator | | |
|---|---|---|
| Difference in Means (FT - IT) | -10.85 | 80.1% |
| Dependent t-test | Critical t | df |
| | 2.09 | 19 |
| | t | p |
| | 12.04 | <0.001 |
| Effect size | | 2.69 |

*IT = Initial Testing; FT = Final Testing.*

Figure 3. Head alignment in the sagittal plane – female group.




The analysis of the values measured at the head level, in the sagittal plane, revealed a significant decrease in the distance from the vertical reference line (plumb line). The initial mean was 13.55 cm, while at the end of the protocol it reached 2.70 cm, representing a reduction of 10.85 cm (80.1%). The paired t-test confirmed the statistical significance of this decrease (t=12.04, p<0.001, t critical=2.09, df=19), indicating substantial progress in correcting head protraction.

Head alignment improved markedly from IT to FT, reflected by a large reduction in the mean value. This indicates a substantial decrease in sagittal head deviation. The change is statistically significant ($p < 0.001$) and associated with a very large effect size (Cohen's d = 2.69), supporting a clinically meaningful correction of head posture.

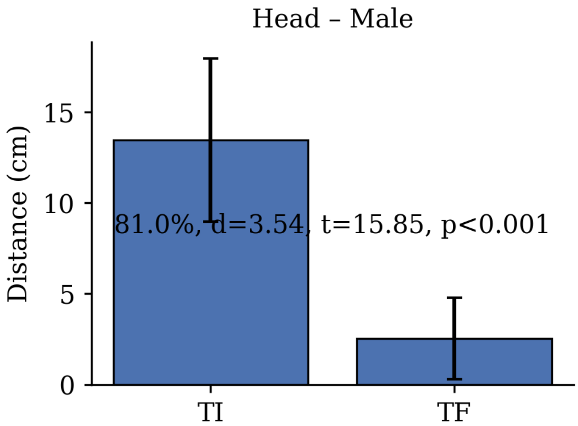
Table 2 **Head** (Distance from Plumb Line to Tragus) Male Group

| Statistical Indicator | IT | FT |
|---|---|---|
| Mean | 13.45 | 2.55 |
| Standard deviation | 4.49 | 2.24 |
| Minimum | 4.0 | 0.0 |
| Maximum | 22.0 | 8.0 |
| Range | 18.0 | 8.0 |
| Coef. Of Variation | 33.4% | 87.7% |

| Statistical Indicator | | |
|---|---|---|
| Difference in Means (FT - IT) | -10.90 | 81.0% |
| Dependent t-test | Critical t | df |
| | 2.09 | 19 |
| | t | p |
| | 15.85 | <0.001 |
| Effect size | | 3.54 |

*IT = Initial Testing; FT = Final Testing.*

Figure 4. Head alignment




In the sagittal plane, the mean values measured at the head decreased by 10.90 cm (81%), from 13.45 cm at the initial assessment to 2.55 cm at the final assessment.

This decrease is statistically significant; the results of the paired t-test show a significance threshold of $p < 0.001 < 0.05$ for $t = 15.85 > 2.09$ (critical t), with $df = 19$.

The male group showed a similarly pronounced improvement in head alignment, with a large decrease in the mean value from TI to TF. The result is statistically significant ($p < 0.001$) with an extremely large effect size (Cohen's $d = 3.54$), suggesting a strong and consistent intervention effect on sagittal head posture.

3.2.2. Thoracic Spine Alignment

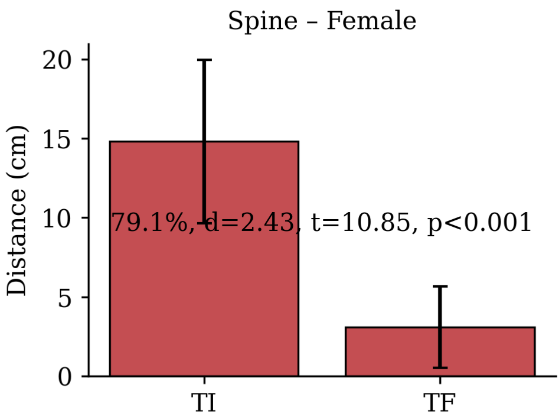
Table 3 **SPINE** - Female gender group

| Statistical Indicator | IT | FT |
|---|---|---|
| Mean | 14.80 | 3.10 |
| Standard deviation | 5.16 | 2.57 |
| Minimum | 5.0 | 0.0 |
| Maximum | 25.0 | 10.0 |
| Range | 20.0 | 10.0 |
| Coef. Of Variation | 34.8% | 83.0% |

| Statistical Indicator | | |
|---|---|---|
| Difference in means (FT - IT) | -11.70 | 79.1% |
| Dependent t-test | Critical t | df |
| | 2.09 | 19 |
| | t | p |
| | 10.85 | <0.001 |
| Efect size | | 2.43 |

*IT = Initial Testing; FT = Final Testing.*

Figure 5. Spine alignment in the sagittal plane – female group



The mean value of spinal measurements in the sagittal plane decreased by 11.70 cm (79.1%), from 14.80 cm at the initial assessment to 3.10 cm at the final assessment. This reduction was statistically significant, as confirmed by the paired t-test ($t = 10.85$, $p < 0.001$, $df = 19$).

Spinal alignment improved significantly, as indicated by a substantial reduction in the mean value from TI to TF. This suggests a meaningful decrease in sagittal spinal deviation. The improvement is statistically significant ($p < 0.001$) and shows a very large effect (Cohen's $d = 2.43$), indicating clinical relevance.

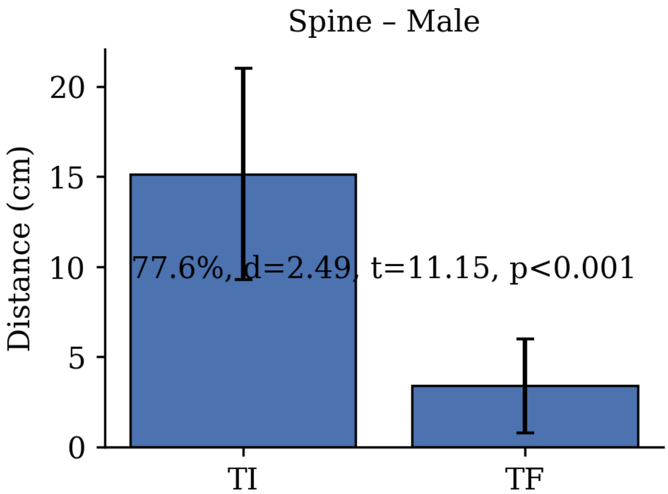
Table 4 **SPINE** - Male gender group

| Statistical Indicator | IT | FT |
|---|---|---|
| Mean | 15.15 | 3.40 |
| Standard deviation | 5.87 | 2.60 |
| Minimum | 4.0 | 0.0 |
| Maximum | 28.0 | 8.0 |
| Range | 24.0 | 8.0 |
| Coef. Of Variation | 38.7% | 76.6% |

| Statistical Indicator | | |
|---|---|---|
| Difference in means (FT - IT) | -11.75 | 77.6% |
| Two-tailed paired t-test | Critical t | df |
| | 2.09 | 19 |
| | t | p |
| | 11.15 | <0.001 |
| Effect size | | 2.49 |

*IT = Initial Testing; FT = Final Testing.*

Figure 6. Spine alignment in the sagittal plane – male group




The average of the measurements taken at the level of the spine, in the sagittal plane, decreased by 11.75 cm (77.6%), from 15.15 at the initial test to 3.40 at the final test. The results of the dependent t-test show a statistically significant decrease, $p<0.001<0.05$ for $t=11.15>2.09$ (critical t) and $df=19$.

A significant improvement in sagittal spinal alignment is observed in males, with a marked reduction from TI to TF. The change is statistically significant ($p < 0.001$) and the very large effect size (Cohen's $d = 2.49$) supports a robust therapeutic impact on spinal posture.

### 3.2.3. Shoulder Alignment

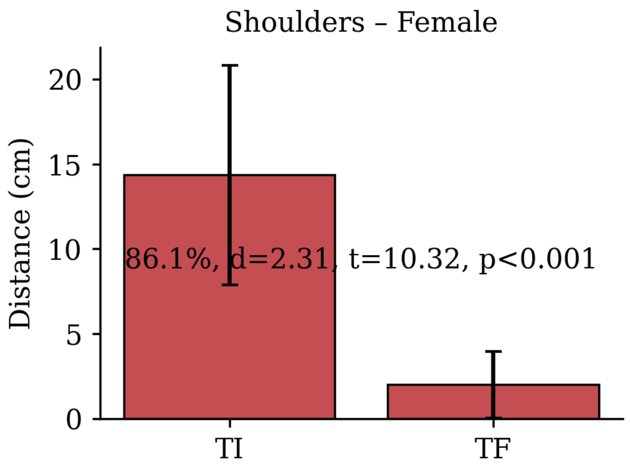
Table 5 SHOULDERS Female gender group

| Statistical indicator | IT | FT |
|---|---|---|
| Mean | 14.35 | 2.00 |
| Standard deviation | 6.47 | 1.95 |
| Minimum | 4.0 | 0.0 |
| Maximum | 24.0 | 8.0 |
| Range | 20.0 | 8.0 |
| Coef. Of Variation | 45.1% | 97.3% |

| Statistical indicator | | |
|---|---|---|
| Difference in means (FT - IT) | -12.35 | 86.1% |
| | Critical t | df |
| Two-tailed paired t-test | 2.09 | 19 |
| | t | p |
| | 10.32 | <0.001 |
| Size efect | | 2.31 |

*IT = Initial Testing; FT = Final Testing.*

Figure 7. Shoulders alignment in the sagittal plane – female group




The mean of the degrees measured at the shoulders in the sagittal plane, in the female baseline group, decreased by 12.35 cm (86.1%), from 14.35 at the initial assessment to 2.00 cm at the final assessment. The paired-samples t-test indicates a statistically significant decrease, with a significance level of $p < 0.001 < 0.05$, for $t = 10.32 > 2.09$ (critical t) and df = 19.

Shoulder alignment shows one of the largest proportional improvements, with a strong reduction from TI to TF. This indicates a substantial decrease in anterior shoulder deviation. The result is statistically significant ($p < 0.001$) and the effect size is very large (Cohen's d = 2.31), supporting a clinically important change.

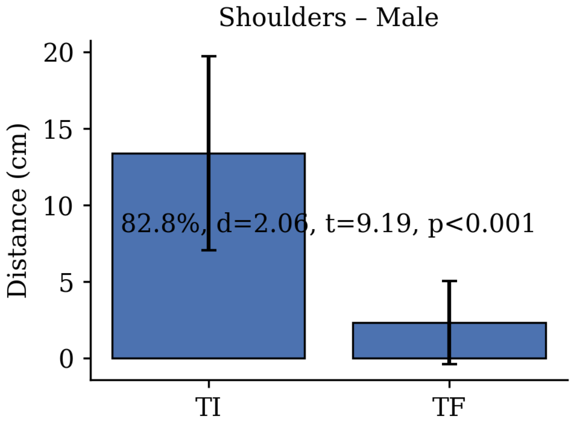
Table 6 SHOULDERS Male gender group

| Statistical indicator | IT | FT |
|---|---|---|
| Mean | 13.40 | 2.30 |
| Standard deviation | 6.35 | 2.72 |
| Minimum | 5.0 | 0.0 |
| Maximum | 25.0 | 10.0 |
| Range | 20.0 | 10.0 |
| Coef of Variation | 47.4% | 118.1% |

| Indicatori statistici | | |
|---|---|---|
| Diferență medii (FT - IT) | -11.10 | 82.8% |
| | Critical t | df |
| Two-tailed paired t-test | 2.09 | 19 |
| | t | p |
| | 9.19 | <0.001 |
| Size efect | | 2.06 |

*IT = Initial Testing; FT = Final Testing.*

Figure 8. Shoulders alignment in the sagittal plane – male group




The average value of the measurements taken at the shoulders in the male baseline group, in the sagittal plane, decreased by 11.10 cm (82.8%), from 13.40 cm at the initial assessment to 2.30 cm at the final assessment.

The paired t-test indicates a statistically significant decrease, p<0.001<0.05 for t=9.19>2.09 (critical t), with df=19.

Male participants demonstrate a significant reduction in sagittal shoulder deviation from TI to TF. Despite high dispersion indicated by the variability measures in the source tables, the paired comparison remains statistically significant (p < 0.001) and the effect size is large (Cohen's d = 2.06), indicating meaningful improvement.

### 3.2.4. Pelvis Alignment

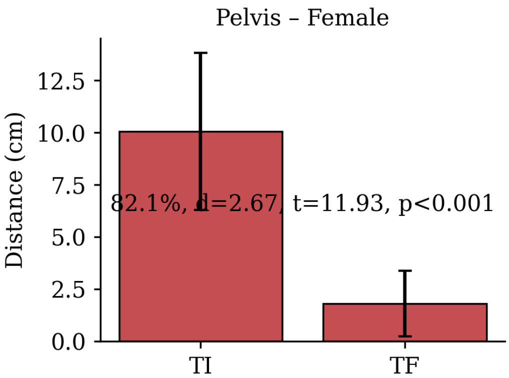
Tabel 7 Pelvis Female Group

| Statistical Indicators | IT | FT |
|---|---|---|
| Mean | 10.05 | 1.80 |
| Standard deviation | 3.76 | 1.58 |
| Minimum | 4.0 | 0.0 |
| Maximum | 17.0 | 5.0 |
| Range | 13.0 | 5.0 |
| Coef. Of Variation | 37.4% | 87.6% |

| Statistical Indicators | | |
|---|---|---|
| Difference in mean (FT - IT) | -8.25 | 82.1% |
| | Critical t | df |
| Two-tailed paired t-test | 2.09 | 19 |
| | t | p |
| | 11.93 | <0.001 |
| Effect size | | 2.67 |

*IT = Initial Testing; FT = Final Testing.*

Figure 9. Pelvis alignment in the sagittal plane – female group.



The mean of the degrees measured at the pelvis in the sagittal plane decreased by 8.25 cm (82.1%), from 10.05 at the initial assessment to 1.80 cm at the final assessment. According to the t-test for significance, this decrease is statistically significant, with $p < 0.001 < 0.05$, for $t = 11.93 > 2.09$ (critical t) and df = 19.

Pelvic alignment improved significantly, with a clear decrease in the mean value from TI to TF, suggesting normalization of sagittal pelvic posture. The change is statistically significant ($p < 0.001$) and associated with a very large effect size (Cohen's d = 2.67), indicating a strong intervention effect.

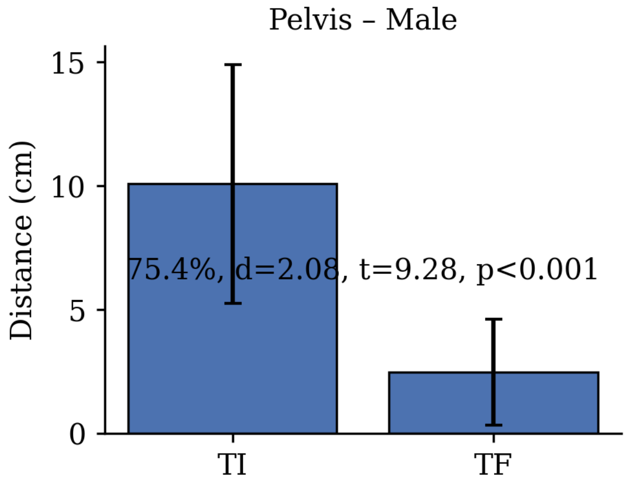
Tabel 8 Pelvis Male gourp

| Statistical indicators | IT | FT |
|---|---|---|
| Mean | 10.08 | 2.48 |
| Standard deviation | 4.82 | 2.14 |
| Minimum | 3.5 | 0.0 |
| Maximum | 17.0 | 8.0 |
| Range | 13.5 | 8.0 |
| Coef. of Variation | 47.9% | 86.3% |

| Statistical indicators | | |
|---|---|---|
| Diference in mean (FT - IT) | -7.60 | 75.4% |
| Paired-samples bilateral t-test | Critical t | df |
| | 2.09 | 19 |
| | t | p |
| | 9.28 | <0.001 |
| Effect size | | 2.08 |

*IT = Initial Testing; FT = Final Testing.*

Figure 10. Pelvis alignment in the sagittal plane – male group




In the sagittal plane, the mean value of the measurements performed at the pelvis in the male baseline group decreased by 7.60 cm (75.4%), from 10.08 at the initial assessment to 2.48 cm at the final assessment. According to the paired-samples t-test for significance, this decrease is statistically significant, with $p < 0.001 < 0.05$, for $t = 9.28 > 2.09$ (critical t) and df = 19.

In the male group, pelvic alignment also shows a significant improvement from TI to TF. The result is statistically significant ($p < 0.001$) and the effect size is large (Cohen's d = 2.08), supporting clinical relevance, albeit with a slightly smaller proportional improvement than in females.

Very large effect sizes were observed across all analyzed sagittal segments, ranging from 2.06 to 3.54 (Head Female = 2.69 [95% CI: 1.75–3.63]; Head Male = 3.54 [95% CI: 2.36–4.72]; Spine Female = 2.43 [95% CI: 1.57–3.29]; Spine Male = 2.49 [95% CI:

1.61–3.37]; Shoulders Female = 2.31 [95% CI: 1.47–3.15]; Shoulders Male = 2.06 [95% CI: 1.30–2.82]; Pelvis Female = 2.67 [95% CI: 1.73–3.61]; Pelvis Male = 2.08 [95% CI: 1.30–2.86]), indicating a consistently robust and clinically meaningful intervention effect in both sexes.

3.3. Experimental Conclusions

The Nicolescu Protocol, through its sequence, produced substantial structural and functional improvements in posture. These findings confirm that targeted correction of neuromuscular imbalances can significantly restore sagittal alignment and eliminate postural-related pain even in adult subjects.

The present study demonstrates that the experimental intervention produced statistically significant and clinically meaningful improvements in sagittal plane postural alignment at the level of the head, thoracic spine, shoulders, and pelvis in both female and male baseline groups.

Segment-specific analysis revealed consistent patterns of improvement across all evaluated anatomical regions. At the level of the head, both female and male participants exhibited reductions exceeding 80% in sagittal deviation, accompanied by very large effect sizes. Although males showed slightly higher absolute effect sizes, the magnitude of improvement was comparable between genders, indicating a similarly strong response to the intervention.

Thoracic spine alignment improved substantially in both groups, with reductions of approximately 78–79% from initial to final assessment. The differences between female and male groups were minimal, suggesting that the intervention was equally effective in correcting sagittal spinal deviations irrespective of sex.

Shoulder alignment showed the greatest proportional improvement among all segments analyzed. Female participants demonstrated a slightly higher percentage reduction compared to males; however, both groups achieved reductions exceeding 80%, with very large effect sizes. These findings indicate a high responsiveness of anterior shoulder deviation to the applied postural correction program, with no clinically relevant gender disparity.

Pelvic alignment also improved significantly following the intervention. While both groups showed large and statistically significant reductions in sagittal pelvic deviation, the proportional improvement was marginally greater in the female group. Nevertheless, effect sizes remained large in both genders, confirming the clinical importance of the observed changes and supporting the effectiveness of the intervention for pelvic posture correction.

Overall gender-based comparison indicates that, although minor differences in the magnitude of improvement were observed for certain segments, these variations did not reach a level of clinical relevance. Both female and male participants benefited substantially from the intervention, with consistent and robust improvements across all postural parameters.

In conclusion, the experimental program proved effective in correcting sagittal plane postural deviations at multiple anatomical levels, regardless of gender. The statistically significant outcomes, large effect sizes, and consistent segmental improvements support the integration of structured postural correction programs

**3. Discussion**

The present study demonstrated that a structured, sequence-based protocol targeting neuromuscular imbalances can effectively correct thoracic kyphotic posture in adults. The significant reductions across all sagittal plane parameters support the hypothesis that postural deviations can be improved even after the period of skeletal maturity, provided that interventions respect the principles of reciprocal innervation and functional muscle balance.

Previous research has shown that corrective exercise programs, when properly designed, can restore spinal curvature and postural stability [4-7]. Gonzalez-Galvez et al. [8] reported that strengthening rather than stretching plays a key role in reducing thoracic kyphosis, while Seidi et al. [9] and Kamali et al. [10] emphasized the efficacy of combined stretching and resistance exercises.

The clinical improvements—elimination of pain, enhanced joint mobility, and muscle tone normalization—suggest that postural deviations are largely functional in nature and reversible when neuromuscular coordination is restored. The absence of relapse during the six-month intervention indicates that the Nicolescu Protocol may induce long-term neuromuscular adaptations, possibly through enhanced proprioceptive control and central motor reprogramming.

From a biomechanical perspective, reducing forward head posture and thoracic hyperkyphosis decreases mechanical load on the cervical and lumbar regions, thereby preventing compensatory stress and secondary musculoskeletal disorders [11–13]. These findings are consistent with recent ergonomic and rehabilitation literature, which emphasizes dynamic posture and movement variability as key preventive factors [19,20].

Despite the promising outcomes, this study has limitations. Pain outcomes (VAS) were not analyzed quantitatively. The sample size was moderate, and long-term post-intervention follow-up was not performed. Moreover, electromyographic or imaging data could further validate the neuromuscular changes induced by the protocol. Future research should focus on expanding the sample, including older adults and individuals with structural kyphosis, and exploring the integration of this protocol within occupational health and sports rehabilitation programs.

In conclusion, the results highlight the clinical relevance of addressing postural deficits through neuromuscular sequence training. The Nicolescu Protocol offers an efficient, non-invasive method to correct adult thoracic kyphosis and improve postural health, representing a valuable addition to the field of functional rehabilitation and preventive kinesiology.

## 5. Conclusions

The present study confirms that structured, sequence-based interventions addressing neuromuscular imbalances can substantially improve thoracic kyphotic posture in adults. The Nicolescu Protocol produced statistically and clinically significant improvements in all sagittal alignment parameters, independent of gender.

Beyond structural correction, the intervention resulted in substantial pain relief, enhanced mobility, and improved muscle tone, indicating the restoration of functional balance within the neuromuscular system. These findings highlight the importance of addressing postural dysfunctions not merely as static deviations but as dynamic expressions of muscle imbalance and central motor control.

As clinical and functional outcomes, beyond the quantitative measures, participants reported significant reduction of neck and back pain, improved joint mobility and muscle flexibility within 30 days and no regression across the six-month period. Additionally, participants demonstrated weight reduction and increased muscular tone with normalization of all clinical postural tests at the end of the program.

The results obtained and the interpretation of sagittal plane measurements, in both the female and male groups, indicate that even in adulthood, deviations from correct posture (postural dysfunctions) can be improved, and that the therapeutic approach proposed in this study is effective and appropriate.

Data collected from the structured anamnesis indicated that deficient posture (kyphotic attitude) is associated with a common pattern of clinical manifestations. These included anteriorly displaced shoulders; shoulder asymmetry, characterized by one shoulder positioned higher than the other and potentially related to cervical spine pain, this asymmetry being interpreted as a compensatory response to postural imbalance; lateral head inclination, also considered a compensatory strategy and headaches associated with excessive anterior head translation, with pain intensity increasing proportionally to the distance between the plumb line and the tragus. Additionally, headaches or migraine-type symptoms were observed in individuals presenting increased cervical lordosis, likely related to compression of vascular structures by the suboccipital, scalene, and associated musculature.

Subjects with positive internal or external rotation tests at the glenohumeral joint experienced various upper limb paresthesias, with symptom distribution depending on test positivity. Pain or functional blockages at the scapulohumeral joint were observed both as a consequence and as a potential cause of kyphotic posture. Reduced endurance of the supraspinatus, infraspinatus, subscapularis, and teres minor muscles explains the frequent shoulder and neck pain reported by kyphotic individuals.

Reduced thoracic spine mobility was a common finding, despite the physiological requirement for mobility in this region, with stability normally ensured by the cervical and lumbar spine. In kyphotic posture, thoracic rigidity leads to excessive mechanical loading of the cervical and lumbar regions. Additionally, shortened pelvic flexors and hip adductors resulted in decreased hip mobility and compensatory lumbar hyperlordosis. More than 80% of the subjects showed positive results on pelvic mobility testing using the Thomas and FABER tests.

Pain was predominantly reported in the cervical and lumbar regions, with only one case of thoracic pain. Prolonged sitting at the workplace was a common factor among most subjects. Of the total sample of 80 participants, 17 required corrective lenses; failure to use visual correction during prolonged computer work contributed to ocular fatigue and anterior head posture.

Gender-based analysis did not reveal meaningful differences between female and male participants, as outcomes were comparable across all evaluated parameters, as confirmed by statistical analysis.

Based on the conducted research, the following conclusions were drawn:

1. Subjects included in the experimental study achieved correction of kyphotic posture through the identification and treatment of neuromuscular imbalances.
2. Although the intervention primarily targeted kyphotic posture, improvements were also observed in frontal plane postural deviations, such as head tilt, shoulder elevation, or pelvic asymmetry.
3. No significant differences were identified between female and male subjects in initial versus final assessment outcomes.
4. Following implementation of the therapeutic protocol, pain symptoms were reduced or absent in many participants, based on self-report.
5. Periodic assessments, particularly after the first 30 days, showed improved muscular mobility and joint range of motion in all participants, assessed using the Kinetisense system.
6. No cases of regression were recorded during the six-month intervention period; subjects will continue to be monitored after program completion.
7. All participants demonstrated weight reduction, increased muscle strength, and improved muscle tone.
8. At final evaluation, all subjects presented negative results on the clinical tests included in the assessment protocol.

Given its non-invasive and reproducible nature, the Nicolescu Protocol represents a valuable tool for both clinical rehabilitation and preventive kinesiology. Future studies should expand its application across diverse age groups and include long-term follow-up to determine the persistence of neuromuscular adaptations over time.

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