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Research article

Effectiveness of an 8-Week Trunk Core Stretching Program in Improving Trunk Mobility in Women

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Abstract: The aim of the study was to evaluate the impact of implementing a standardized 8-week trunk core stretching program (2 ses-sions/week, 30–45 minutes/session) on trunk mobility in all planes of movement and on functional capacity in women with obesity, comparing responses between two distinct age groups: adults and older adults. A total of 86 Class I Obesity women vol-untarily participated in the study and were assigned to two age groups: the adult group (FG<65), consisting of 46 women aged 55–64 years, and the older adult group (FG>65), consisting of 42 women aged ⩾65 years. The evaluated parameters included body mass index (BMI), trunk length (TL), chest circumference (CC), abdominal circumference (AC), waist circumference (WC), hip circumference (HC), thoracic anteroposterior diameter (TAPD, cm), thoracic transverse diameter (TTD), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR). Integrated trunk mobility was calculated using the Composite Mobility Score (CMS) as a weighted sum of standardized scores. The 8-week trunk core stretching program included stretching exercises performed in all planes of movement (flexion, extension, lateral flexion, and axial rotation) and functional capacity components (thoracic ex-pansion and functional tests). All pre – post changes following the implementation of the trunk core training program showed very strong statistical significance ($p < 0.001$). The Composite Mobility Score (CMS) demonstrated the strongest statistical indicators ($t \approx 85–88$, $p < 0.001$, $d \approx 0.76–0.80$), with a mean change of approximately $\Delta X \approx 8$ points and narrow confidence intervals (± 0.2 points), indicating substantial improvements and high measurement reliability. Positive effects were observed in both age groups, under and over 65 years old, confirming that musculoskeletal plasticity is preserved in old age, and the application of interventional physical exercise programs may constitute a positive factor. Improvements in thoracic, lumbar, and rotational mobility further confirm the validity and reproducibility of the implemented experimental trunk core stretching program.

Keywords: trunk core, stretching exercises, trunk mobility, functional capacity

1. Introduction

The demographic aging trend of the population is associated with an exponential increase in the prevalence of musculoskeletal disorders and functional limitations, particularly among women. In this population, postmenopausal hormonal changes, accelerated sarcopenia, and central adiposity significantly amplify the risk of hypomobility and functional dependence. Trunk mobility represents a fundamental component of functional movement, postural control, and activities of daily living [1-3]. Adequate mobility of the lumbar and thoracic spine enables efficient load transfer between the upper and lower extremities, contributes to balance maintenance, and reduces mechanical stress on adjacent joints [4-5]. Studies have shown that in adult and older populations, especially among women, reduced trunk mobility is associated with impaired functional performance, increased prevalence of low back pain, decreased gait efficiency, and a higher risk of falls [6,7].

Longitudinal studies indicate an average decline of 20–30% in lumbar flexibility per decade after the age of 50, with a pronounced acceleration in postmenopausal women due to estrogen deficiency, reduced tissue elastin, and increased collagen stiffness caused by advanced glycation processes [8-10]. From an integrated perspective, trunk mobility is influenced by complex interactions among morphological characteristics, body composition, and neuromuscular control. Obesity in older women dramatically exacerbates trunk hypomobility. Excess adipose tissue, particularly when centrally distributed, generates abnormal mechanical loads on the spine, alters muscle activation patterns, and contributes to chronic low-grade inflammation, thereby accelerating osteoarticular degeneration and reducing segmental mobility [11,12].

Core musculature, defined as a system comprising over 29 paired muscles responsible for trunk stabilization and mobilization, plays a critical role in maintaining functional capacity in older adults. This musculature includes deep local stabilizers (multifidus, transversus abdominis, diaphragm, pelvic floor), which ensure intersegmental control, and global stabilizers (rectus abdominis, external and internal obliques, erector spinae, quadratus lumborum), which generate force and facilitate load transfer between the extremities [13,14]. In older adults, age-related alterations in motor function are observed, including reduced muscle activation capacity and diminished intermuscular coordination. These deficits directly contribute to spinal instability, hypomobility, and an increased risk of injury [5,15].

General exercise programs often demonstrate low adherence and limited specificity for improving trunk mobility in obese adults (Class I Obesity) and older individuals. A significant therapeutic gap exists in the use of targeted trunk-core stretching programs for this vulnerable population. This gap is driven

by the erroneous perception that older women cannot achieve meaningful improvements, fear of injury (kinesiophobia at both medical and patient levels), and insufficient age- and obesity-specific scientific evidence supporting effectiveness [16,17].

Recent studies focusing on core-centered training programs have demonstrated promising therapeutic potential through multiple complementary mechanisms. At the tissue level, stretching promotes collagen remodeling through fiber realignment along applied tensile forces, reduction of pathological cross-links, viscoelastic plasticity, and sarcomerogenesis, collectively contributing to increased optimal muscle length and reduced stiffness [18,19]. Recent evidence confirms that core-strengthening programs in individuals over 60 years of age increase lumbar range of motion, while Pilates-based programs with a core focus in postmenopausal women improve flexibility [4,5,20].

Nevertheless, the current literature presents notable limitations that justify the present study. Most research combines both sexes without gender-specific analysis, despite the distinct postmenopausal biological characteristics of women—such as estrogen deficiency, accelerated sarcopenia, osteopenia/osteoporosis prevalence after 55 years, and gynoid fat distribution—which influence responsiveness to interventions [2,21]. Furthermore, relatively few studies focus exclusively on trunk mobility, with most prioritizing core muscle strength, and evidence remains limited for Class I Obesity of older adults, who are frequently excluded from clinical trials due to safety concerns [22,23]. Another limitation is the scarcity of comparative studies between adult and older women using identical stretching protocols to test the hypothesis of preserved neuromuscular plasticity at advanced ages—an essential aspect for optimizing preventive and therapeutic strategies.

To address these gaps, the present study introduces a Composite Mobility Score (CMS) that integrates multiple objective and functional mobility measures into a single standardized index. This approach treats trunk mobility as a global functional outcome, enabling the application of advanced statistical models to identify independent predictors and age-related differences. The study aims to generate original scientific evidence to guide preventive and physiotherapeutic practice in managing trunk hypomobility in Class I Obesity adult and older women, to validate a standardized, replicable trunk core stretching program applicable across diverse rehabilitation contexts, and to contribute to active aging policies by demonstrating that age does not represent an absolute barrier to positive responses to structured therapeutic interventions.

The purpose of the study was to evaluate the impact of implementing a standardized 8-week trunk core stretching program (2 sessions/week, 30–45 minutes/session) on trunk mobility across all planes of movement (flexion, extension, lateral flexion, axial rotation) and on functional capacity (thoracic expansion and functional tests) in women with obesity, comparing responses between two distinct age groups: adults (55–64 years) and older adults (≥65 years).

1. Materials and Methods

2.1. Participants

A total of 86 overweight women volunteered for the study and were assigned to two age groups: the adult group (FG<65), comprising 46 women aged 55–64 years, and the older adult group (FG>65), comprising 42 women aged ≥65 years. Participants were recruited from community-based health promotion and physical activity programs and enrolled voluntarily. Inclusion criteria were female sex, age ≥55 years, body mass index (BMI) ≥30 kg/m^2 defines as Class I Obesity, medical clearance for moderate-intensity physical exercise, and the ability to independently perform trunk mobility assessments. Exclusion criteria included acute musculoskeletal injuries, neurological disorders, recent spinal surgery, uncontrolled cardiovascular diseases, or participation in other structured exercise programs within the previous six months.

2.2. Study Design

A quasi-experimental pre–post intervention design was employed. Initial testing (IT) and final testing (FT) were conducted before and after the intervention, respectively, with the experimental program implemented over 8 weeks. All assessments and the order of test administration were identical for both age groups. The 8-week trunk core stretching program was implemented under similar conditions for both groups.

All participants provided written informed consent prior to participation. The study protocol complied with the principles of the Declaration of Helsinki and was approved by the Ethics Committee of the Faculty of Physical Education and Mountain Sports, Transilvania University of Brașov (approval no. 309/19.12.2024).

2.3. Trunk Core Stretching Intervention Program

Participants in both groups completed an 8-week structured trunk-core stretching program (2 sessions per week, 30–45 minutes per session) to improve trunk mobility and promote muscular conditioning. The program included stretching exercises in all planes of movement (flexion, extension, lateral flexion, and axial rotation), as well as components targeting functional capacity (thoracic expansion and functional tests). Exercises were adapted to participants' age, sex, level of obesity, and prophylactic and therapeutic objectives [10,13,20,24]. The intervention protocol was identical for both the FG<65 and the FG>65 groups, differing only in individualized intensity adjustments based on participant tolerance and safety considerations.

Each training session was structured as follows:

— Warm-up (5 minutes), aimed at selective activation of the musculoskeletal system and preparation for exercise;
— Stretching phase (10–12 minutes), focused on improving flexibility and mobility of the spine and joints;
— Muscle toning phase (12–15 minutes), targeting the development of trunk musculature;
— Cool-down phase (3–5 minutes), aimed at restoring physiological parameters (respiratory rate and heart rate) and promoting relaxation.

The detailed structure of the trunk core stretching program is presented in Table 1.

Table 1. Structure of the 8-week trunk core stretching exercise program implemented in the study groups

Week	Objective	Exercise intensity	Warm-up (5 min)	Stretching (10–12 min)	Trunk strengthening (12–15 min)	Cool-down (3–5 min)
1–2	Adaptation and mobility, body awareness	Very low	Neck, shoulder, elbow, and wrist joint mobility. Light marching in place. Deep breathing.	Neck and shoulder joints. Lateral trunk muscles. Trunk rotator muscles.	Diaphragm muscles. Abdominal muscles. Shoulder muscles. General low-intensity cardio.	Slow diaphragmatic breathing. Relaxation of neck and shoulder muscles. Light trunk stretching.
3–4	Increase in muscular endurance	Low–moderate	Neck, shoulder, trunk, and hip joint mobility. Marching with trunk and arm mobility exercises. Arm rotations.	Exercises from weeks 1–2. Lower back (lumbar) muscles. Abdominal oblique muscles.	Rectus abdominis. Hip flexors (iliopsoas). Shoulder muscles + triceps. Abdominal oblique muscles.	Deep breathing. Abdominal and back stretching. Muscle relaxation.
5–6	Strengthening of postural muscles and balance	Moderate	Full joint mobilization. Active marching in place and with displacement. Trunk rotations. Core activation.	Exercises from weeks 1–4. Pectoral muscles. Hip flexor muscles.	Complete core musculature (stabilizers). Spinal erectors + deep abdominal muscles. Rectus abdominis. Gluteal muscles + spinal erectors.	Controlled breathing. Complete trunk stretching. Relaxation of gluteal and back muscles. Postural correction.
7–8	Stretching and functional exercises	Moderate	Dynamic joint mobilization. Walking with mobility exercises.	Full circuit from previous weeks. Paraspinal muscles along the entire spine.	Combined hip flexors + obliques. Core stabilizing muscles. Circuit: lower limbs (quadriceps, gluteals) + shoulders (deltoids) + trunk.	Recovery breathing. Full-body stretching. Progressive muscle relaxation.

2.4. Assessment Instruments

The study included two categories of assessment instruments: anthropometric and body composition evaluation, and assessment of trunk mobility parameters.

— Anthropometric and body composition assessment included the following parameters: body mass index (BMI), trunk length (TL, cm), chest circumference (CC, cm), abdominal circumference (AC, cm), waist circumference (WC, cm), hip circumference (HC, cm), thoracic anteroposterior diameter (TAPD, cm), thoracic transverse diameter (TTD, cm), waist-to-hip ratio (WHR), and waist-to-height ratio (WHtR).
— Integrated assessment of trunk mobility was calculated using the Composite Mobility Score (CMS), based on six functional components:
  - Lumbar flexion (LF) – The Modified Schober Test combined with digital inclinometry was used. With the participant standing, feet shoulder-width apart, the lumbosacral junction (L5–S1) and a point 10 cm superior were marked. Participants performed maximal forward flexion without knee flexion, while lumbar flexion angle was measured using dual digital inclinometers placed at T12 and S1.
  - Lumbar extension (LE) – Using dual digital inclinometers positioned at T12 and S1, participants performed maximal backward extension from a standing position with hands placed on the hips. The difference between the inclinometer readings provided the lumbar extension range of motion.
  - Left and right lateral flexion (LLF / RLF) – With a digital inclinometer positioned at T12–L1, participants performed maximal lateral flexion to the left and right sides from a standing position, arms at the sides, sliding the hand down the lateral thigh. The degrees of lateral inclination were recorded.
  - Axial rotation left and right (ARL / ARR) – Participants were seated on a backless stool with the pelvis stabilized using a belt and feet flat on the floor. A rod was placed across the shoulders to define the plane of rotation. Using a digital goniometer aligned with the rod, maximal rotation to the left and right was measured.
  - Thoracic expansion (TE) – Thoracic circumference was measured at the xiphoid process level using a flexible steel tape during maximal expiration, at rest, and during maximal inspiration. Thoracic expansion was calculated as the difference between inspiration and expiration.
  - Functional trunk tests (FMS) – A trunk rotation stability test was performed and scored from 0 to 3 according to standardized criteria. Additionally, a seated trunk rotation test was conducted with and without assistance to differentiate between active and passive mobility limitations.

— The raw composite score was calculated as a weighted sum of standardized scores, according to the formula:

$$CMSraw = 0.20\cdot zLF + 0.20\cdot zLE + 0.20\cdot zLatFlex + 0.25\cdot zAxRot + 0.10\cdot zTE + 0.05\cdot zFMS.$$

To facilitate clinical interpretation and statistical comparability, the raw score was transformed to a standardized 0–100 scale, with higher values indicating greater trunk mobility, using the following formula:

$$CMS = [(CMSraw - CMSmin) / (CMSmax - CMSmin)] \times 100$$

The CMS represents a complex mobility assessment parameter that has been used and validated in previous studies [25-27].

During both initial and final assessments, the same evaluation devices and equipment were used for both groups under identical testing conditions.

2.5. Statistical Analysis

Collected data were processed and analyzed using SPSS software version 12.0 (Statistical Package for the Social Sciences, Chicago, IL, USA). Data normality was assessed using the Shapiro–Wilk test. Variables were expressed as mean ± standard deviation (SD). Intra-group differences between pre-test and post-test measurements were analyzed using paired samples *t*-tests, while inter-group comparisons were conducted using independent samples *t*-tests. Reported statistical parameters included mean difference (ΔX), standard deviation (SD), Student's *t* value, probability level (p), 95% confidence interval of the difference (95% CI), Cohen's effect size (d), and the intraclass correlation coefficient (ICC). The threshold for statistical significance was set at $p < 0.05$. Cohen's d effect size was interpreted according to standard criteria: $d = 0.2$ (small effect), $d = 0.5$ (medium effect), and $d = 0.8$ (large effect). The ICC was used to assess measurement reliability and interpreted as follows: ICC < 0.50 (poor reliability), ICC 0.50–0.75 (moderate), ICC 0.75–0.90 (good), and ICC > 0.90 (excellent). Result interpretation considered both statistical significance (p) and practical significance (Cohen's d and 95% CI).

2. Results

Statistical analysis demonstrated that all studied parameters were normally distributed, as assessed by the Shapiro–Wilk test ($p > 0.05$). The anthropometric and body composition characteristics of the two groups are presented in Table 2. Descriptive statistics obtained following the implementation of the 8-week trunk core stretching training program are detailed in Table 3. Intra-group comparative analysis of trunk mobility parameters, performed using paired samples t-tests, is presented in Table 4, while inter-group comparisons of the same parameters, conducted using independent samples Student's t-tests, are illustrated in Table 5.

Table 2. Anthropometric and body composition characteristics of the study groups

Parameters	Group	Mean	SD	Min.	Max	Dif. means
BMI	FG<65	30.98	2.57	27.13	34.98	-0.17
	FG>65	31.15	2.24	27.19	34.91	
Trunk length (TL)	FG<65	50.36	3.10	45.07	54.84	0.89
	FG>65	49.47	2.64	45.15	54.76	
Chest circumference (CC)	FG<65	101.69	5.83	90.21	109.85	1.53
	FG>65	100.16	6.08	90.29	109.90	
Abdominal circumference (AC)	FG<65	103.76	7.46	91.19	115.12	-2.72
	FG>65	106.48	7.01	95.08	119.25	
Waist circumference (WC)	FG<65	100.01	7.14	87.11	110.37	-2.08
	FG>65	102.09	7.34	90.10	114.96	
Hip circumference (HC)	FG<65	112.51	8.30	100.11	124.73	-1.26
	FG>65	113.77	6.95	100.87	124.68	
Thoracic anteroposterior diameter (TAPD)	FG<65	22.84	1.79	20.02	25.96	-0.34
	FG>65	23.18	1.80	20.19	25.93	
Thoracic transverse diameter (TTD)	FG<65	28.99	1.70	26.02	31.98	-0.20
	FG>65	29.19	1.59	25.91	32.17	
Waist-hip ratio (WHR)	FG<65	0.91	0.17	0.84	1.00	-0.02
	FG>65	0.93	0.04	0.88	1.12	
Waist-to-height ratio (WHtR)	FG<65	0.54	0.07	0.39	1.10	-0.18
	FG>65	0.62	0.04	0.55	0.70	

Analysis of anthropometric characteristics revealed a high degree of homogeneity between the FG<65 and FG>65 groups, with negligible mean differences for most parameters (Table 2). Both groups presented class I obesity (BMI ≈ 31), with a minimal between-group difference (−0.17). Comparative analysis indicated that the primary difference between groups was related to fat distribution. The FG>65 group exhibited greater trunk adiposity, with higher abdominal circumference (AC) by 2.72 cm (106.48 vs. 103.76 cm), waist circumference (WC) by 2.08 cm (102.09 vs. 100.01 cm), and waist-to-height ratio (WHtR) by 0.08 units (0.62 vs. 0.54). The WHtR value of 0.62 in the FG>65 group exceeds the cardiometabolic risk threshold (>0.5), indicating an android-type fat distribution pattern and increased cardiovascular risk. Both groups demonstrated WHR values >0.90, suggesting metabolic risk across both age categories. The FG<65 group showed minor structural advantages in fat distribution, including a greater trunk length by 0.89 cm and a larger chest circumference by 1.53 cm, possibly reflecting age-related postural changes and early sarcopenia in older participants. Thoracic diameters (TAPD and TTD) showed non-significant differences (<0.4 cm) between groups (Table 2). Overall, both groups exhibited elevated cardiometabolic risk based on anthropometric criteria (AC >102/88 cm, WHR >0.90), with a more pronounced risk in the FG>65 group due to the predominance of visceral adiposity. The recorded data support the implementation of a trunk flexibility enhancement program incorporating adapted stretching and trunk muscle toning exercises.

Table 3. Descriptive statistics of outcome measures following the 8-week trunk core stretching program

Parameters	Group	Mean	SD	Mean	SD
Lumbar flexion (LF)	FG<65	52,049	6,628	57,188	6,710
	FG>65	53,121	6,328	58,088	6,496
Lumbar extension (LE)	FG<65	25,230	5,929	29,253	5,917
	FG>65	24,554	5,958	28,482	5,940
Left Lateral flexion (LLF)	FG<65	24,092	3,499	27,128	3,595
	FG>65	24,782	3,712	27,739	3,689
Right Lateral flexion (RLF)	FG<65	24,706	3,694	27,634	3,731
	FG>65	23,596	3,480	26,561	3,673
Axial rotation left (ARL)	FG<65	38,951	5,661	42,915	5,581
	FG>65	39,688	5,751	43,741	5,827
Axial rotation right (ARR)	FG<65	40,855	5,526	44,860	5,469
	FG>65	40,353	6,461	44,315	6,340
Thoracic expansion (TE)	FG<65	4,655	,748	5,658	,861
	FG>65	4,596	,688	5,463	,918
Functional trunk tests (FMS)	FG<65	1,807	,412	2,221	,765
	FG>65	1,770	,446	2,222	,648
Composite Mobility Score (CMS)	FG<65	57,734	10,426	65,711	10,513
	FG>65	58,479	9,995	66,447	9,939

Table 3 presents the means and standard deviations for trunk mobility measures across the two study groups. Both groups demonstrated improvements, with no substantial differences in the magnitude of response. Thoracic expansion (TE) showed the greatest improvements, increasing by 1.003 cm in the FG<65 group (d = 1.25, large effect) and by 0.867 cm in the FG>65 group (d = 1.08, large effect), corresponding to relative increases of 21.5% and 18.9%, respectively. Left lateral flexion (LLF) also exhibited notable gains, with improvements of 3.036 cm (d = 0.85) in the FG<65 group and 2.957 cm (d = 0.80) in the FG>65 group. Functional scores further confirmed enhancements in overall functional capacity: the functional trunk test (FMS) increased by 0.41–0.45 points, while the Composite Mobility Score (CMS) improved by approximately 8 points in both groups, representing relative gains of 13.6–13.8%. The similar responses observed between groups suggest that trunk core stretching programs can be implemented with effectiveness in older adults, challenging assumptions regarding age-related limitations in the trainability of core musculature.

Table 4. Paired Sample test analysis of trunk mobility parameters according to grupus of study.

Parameters	Group	ΔX (TF-TI)	SD	95% CI LL	95% CI UL	t	p	d	ICC
Lumbar flexion (LF)	FG<65	5,138	,549	5,301	4,975	63,482	<0.001	0,768	,997
	FG>65	4,966	,573	5,145	4,787	56,095	<0.001	0,769	,996
Lumbar extension (LE)	FG<65	4,023	,577	4,195	3,851	47,234	<0.001	0,679	,995
	FG>65	3,928	,590	4,112	3,744	43,115	<0.001	0,661	,995
Left Lateral flexion (LLF)	FG<65	3,036	,489	3,181	2,890	42,081	<0.001	0,851	,990
	FG>65	2,957	,537	3,124	2,789	5,658	<0.001	0,800	,989
Right Lateral flexion (RLF)	FG<65	2,927	,577	3,098	2,756	34,409	<0.001	0,787	,998
	FG>65	2,964	,570	3,142	2,786	33,675	<0.001	0,813	,987
Axial rotation left (ARL)	FG<65	3,964	,536	4,123	3,805	50,162	<0.001	0,704	,995
	FG>65	4,052	,574	4,231	3,873	45,714	<0.001	0,700	,995
Axial rotation right (ARR)	FG<65	4,005	,605	4,185	3,825	44,879	<0.001	0,728	,994
	FG>65	3,961	,545	4,131	3,791	47,090	<0.001	0,618	,996
Thoracic expansion (TE)	FG<65	1,002	,567	1,171	,834	11,987	<0.001	1,247	,753
	FG>65	,867	,625	1,061	-,672	8,990	<0.001	1,078	,703
Functional trunk tests (FMS)	FG<65	,413	,616	,596	,230	4,548	<0.001	0,685	,497
	FG>65	,451	,570	,629	,274	5,137	<0.001	0,824	,475
Composite Mobility Score (CMS)	FG<65	7,976	,616	8,159	7,793	87,810	<0.001	0,760	,998
	FG>65	7,967	,610	8,157	7,777	84,621	<0.00 1	0,798	,998

ΔX—difference of means, SD—standard deviation, t—Student's t-test value, *p*—probability level, 95% CI—95% confidence interval of the difference, d- Cohen's effect size, ICC – interclass correlation.

Paired-sample *t*-test analysis revealed statistically significant improvements ($p < 0.001$) across all trunk mobility parameters in both study groups (Table 4**).** All pre–post changes following the implementation of the trunk core training program demonstrated very strong statistical significance ($p < 0.001$), with t values ranging from 4.548 to 87.810, substantially exceeding critical thresholds. The 95% confidence intervals were narrow and did not include zero, confirming true and reproducible differences. Thoracic expansion (TE) exhibited the largest effect sizes: $d = 1.247$ in the FG<65 group (ΔX = 1.002 cm, 95% CI: 0.834–1.171, $t = 11.987$) and $d = 1.078$ in the FG>65 group (ΔX = 0.867 cm, 95% CI: 0.672–1.061, $t = 8.990$), both classified as large effects according to Cohen's criteria ($d > 0.8$). Lumbar mobility showed significant improvements with medium-to-large effect sizes. Lumbar flexion (LF) demonstrated d values of 0.768–0.769 (ΔX ≈ 5 cm, $t > 56$, ICC > 0.996), while lumbar extension (LE) exhibited d values of 0.661–0.679 (ΔX ≈ 4 cm, $t > 43$, ICC = 0.995). Lateral flexion parameters showed effect sizes ranging from $d = 0.787$ to 0.851 (ΔX ≈ 3 cm, $t > 33$–42, ICC > 0.987). Left lateral flexion (LLF) presented the largest effect size for lumbar mobility in the FG<65 group ($d = 0.851$), with marked test differences ($t = 42.081$, $p < 0.001$). Axial trunk rotations (ARL and ARR) demonstrated consistent improvements, with effect sizes ranging from $d = 0.618$ to 0.728 (ΔX ≈ 4 cm, $t > 44$, ICC > 0.994), classified as medium-to-large effects. Functional testing (FMS) showed more modest yet statistically significant improvements (d = 0.685–0.824, ΔX ≈ 0.41–0.45, t ≈ 4.5–5.1, p < 0.001), accompanied by lower ICC values (0.475–0.497), suggesting greater variability in functional performance outcomes. Functional scores confirmed improvements in overall trunk mobility capacity. The Composite Mobility Score (CMS) demonstrated the strongest statistical indicators (t ≈ 85–88, p < 0.001, d ≈ 0.76–0.80, ICC = 0.998), with a mean increase of approximately ΔX ≈ 8 points and very narrow confidence intervals (±0.2 points), indicating substantial gains and extremely high measurement reliability. Segmental mobility parameters exhibited excellent reliability (ICC > 0.95), including LF, LE, ARL, ARR, RLF, LLF, and CMS (ICC range: 0.987–0.998), reflecting high test–retest consistency and minimal measurement error. Thoracic expansion showed moderate reliability (ICC: 0.703–0.753), which is acceptable for dynamic respiratory measurements.

The FMS demonstrated the lowest reliability (ICC: 0.475–0.497), reflecting the complex and multidimensional nature of functional testing and its inherent variability. The ICC values obtained (0.475–0.497) fall below the commonly accepted threshold of 0.75 for adequate reliability, suggesting that FMS scores should be interpreted with caution when used as outcome measures in longitudinal monitoring or as primary endpoints in intervention studies. The trunk-specific functional tasks included in this assessment demand a high degree of dynamic stability and inter-segmental coordination, both of which are influenced by proprioceptive feedback loops and cortical motor control systems that are inherently more variable than the passive mechanical properties measured.

Overall, the 8-week trunk core training program induced statistically significant and clinically meaningful improvements in lumbar, thoracic, and functional trunk mobility, with effects in Class I Obesity women aged over 55 years across both age categories (<65 and ≥65 years), demonstrating therapeutic, preventive, and motor effectiveness.

Table 5. The Independent Student t-test analysis between groups for the trunk mobility parameters of the study

Parameters	Initial Test			Final Test		
	ΔX(Ft-It)	SDE	p	ΔX(Ft-It)	SDE	p
Lumbar flexion (LF)	-1,072	1,384	,441	-,899	1,410	,525
Lumbar extension (LE)	,675	1,268	,596	,770	1,265	,544
Left Lateral flexion (LLF)	-,689	,768	,372	-,610	,777	,434
Right Lateral flexion (RLF)	1,109	,767	,152	1,072	,790	,178
Axial rotation left (ARL)	-,737	1,217	,546	-,825	1,216	,499
Axial rotation right (ARR)	,501	1,278	,696	,545	1,259	,666
Thoracic expansion (TE)	,058	,153	,704	,194	,189	,309
Functional trunk tests (FMS)	,037	,091	,686	-,001	,151	,994
Composite Mobility Score (CMS)	-,744	2,181	,734	-,736	2,186	,737

It—initial test; Ft—final test, ΔX-difference of means, p—statistical significance.

Independent-samples Student's t-test analysis revealed no statistically significant differences between the FG<65 and FG>65 groups at either baseline or post-intervention assessments (p > 0.05 for all parameters) **(**Table 5**).** The standard errors of the differences (SDE: 0.091–2.181) were proportional to the variability of the assessed parameters, reflecting normal distributions and homogeneous variances between groups. Also, p-values well above the significance threshold (p = 0.05), with most exceeding 0.30, do not merely indicate a lack of evidence for differences but rather suggest active evidence of equivalence between groups. Moderate standard errors (SDE < 2.2 for all parameters) and a symmetrical distribution of differences (with negative and positive values approximately balanced) support adequate statistical power to detect clinically relevant differences (>2–3 cm for mobility measures and >1 point for composite scores), had such differences existed. The absence of significant baseline differences validates group comparability and allows causal attribution of the observed improvements to the experimental intervention (8 weeks of trunk core training). The persistence of non-significant differences at post-intervention further excludes age-by-intervention interactions, demonstrating that program effects ($d = 0.62$–1.25, $p < 0.001$) were consistent across age categories. Overall, independent t-test analysis confirms that the 8-week trunk core program is equally effective in both age groups of Class I Obesity women (<65 years and ≥65 years). These findings validate the generalizability of the intervention and support the prophylactic and therapeutic implementation of adapted stretching and trunk-muscle toning programs tailored to sex, anthropometric characteristics, and age.

3. Discussion

The present study demonstrates that implementing a structured 8-week trunk core stretching program produces statistically significant and clinically meaningful improvements in trunk mobility in both adult and older women. The findings confirm the effectiveness of targeted stretching interventions in enhancing segmental and functional trunk mobility, with consistent effects observed across both age groups.

The substantial improvements in thoracic expansion observed in this study align with previous findings and the existing literature, which emphasize the importance of thoracic mobility for respiratory and postural function in adult and older women [28,29]. Several studies have shown that exercise programs targeting the thoracic musculature significantly improve thoracic mobility in older women with hyperkyphosis, leading to reductions in kyphotic curvature over longer intervention periods [30,31]. Reduced thoracic mobility has been linked to respiratory dysfunction, postural alterations, and compensatory mechanisms in adjacent spinal segments [32-34]. Research involving older women has further shown that thoracic mobility restrictions induce significant compensation in the cervical and lumbar regions, potentially impairing overall spinal function [35,36]. Similarly, the significant improvements in lumbar flexion, extension, and lateral flexion observed in the present study are supported by strong evidence regarding the effectiveness of stretching and exercise programs targeting the lumbar region [37,38]. Previous studies have concluded that stretching and strengthening exercise programs significantly enhance lumbar mobility and reduce pain in individuals with chronic low back pain, while motor control and lumbar stabilization exercises lead to meaningful improvements in lumbar mobility and functional performance [39-41]. Enhanced lateral flexion improves lateral muscle balance and reduces injury risk associated with asymmetric movements [42,43].

The consistent improvements in axial trunk rotation observed in this study are consistent with research highlighting the importance of rotational mobility for functional movement capacity [44,45]. Reduced rotational mobility is common in sedentary and older populations and contributes to muscular imbalances, stiffness, and an increased risk of falls [44,46]. The present findings suggest that the trunk core stretching program effectively addressed this deficit, with potential positive effects on functional autonomy and quality of life, as supported by studies documenting strong associations between trunk mobility and functional independence in older adults [47-

49]. Although improvements in functional performance were more modest than those in segmental mobility parameters, these findings confirm the transfer of mobility gains to global functional capacity. Such transfer is essential for independence in activities of daily living and has been demonstrated in studies examining physical performance and disability in older adults [48,50].

The use of a composite mobility score that integrates multiple parameters provides a holistic perspective on overall trunk function and represents a valid indicator of the effectiveness of therapeutic interventions. Comprehensive functional assessment increasingly requires composite indicators rather than isolated parameters to reflect global functional capacity [51,52]. Composite scores offer greater reliability than individual measurements by mitigating random measurement error through the aggregation of multiple components [52,53].

Evidence from studies on musculoskeletal aging indicates that senescence induces changes in tissue properties and neuromuscular plasticity; however, appropriately designed interventions can elicit significant adaptations [54,55]. Stretching programs have been shown to improve joint mobility across all age groups over 60 years, with no substantial differences between decades [56,57]. These findings are consistent with the present study, which demonstrated comparable effectiveness among participants aged 65 and older and those aged 65 and younger.

Previous research has shown that core training programs improve the activation and coordination of trunk-stabilizing muscles, facilitating movement execution through greater ranges of motion [58,59]. Physical exercise programs also reduce stretch reflex excitability, promoting muscle relaxation and facilitating access to increased trunk and segmental movement amplitudes [60-62]. The analysis of exercise-induced improvements in motor and functional capacity among adult and older populations—particularly those with obesity necessitates interdisciplinary and integrative approaches [63-66]. The examination of flexibility-targeted training protocols and their effects on physical fitness outcomes, particularly those with sedentary lifestyles, warrants systematic and evidence-based interdisciplinary approaches [37,58,61].

4.1. Study Limitations

This study presents several methodological limitations. The absence of a control group limits the ability to attribute observed changes exclusively to the intervention. The lack of long-term follow-up represents a significant limitation, as the maintenance of benefits at 6–12 months post-intervention and the identification of optimal strategies for sustaining effects could not be evaluated. The greater variability observed in functional testing suggests the need for more rigorous, standardized protocols to assess global functional performance. Additionally, the generalizability of the findings is limited to adult and older women, restricting extrapolation to men or populations with substantially different demographic or clinical characteristics.

4.2. Clinical and Practical Implications

The results support the implementation of trunk core stretching programs across various contexts to improve trunk mobility in women aged 55 years and older. From a therapeutic perspective, the program can be effectively integrated into rehabilitation strategies targeting mobility impairments in adult and older women, providing a structured intervention with demonstrated efficacy. The demonstrated cross-age applicability allows the use of standardized protocols without extensive age-specific customization, thereby simplifying implementation in physiotherapy and preventive practice. The 8-week duration represents a reasonable and sustainable time frame for participants, balancing intervention effectiveness with practical feasibility. From a preventive standpoint, improvements in trunk mobility contribute to the prevention of chronic low back pain, reduction of fall risk, and maintenance of functional autonomy—key determinants of quality of life in older age. Such programs can be implemented in diverse settings, including rehabilitation centers, outpatient physiotherapy services, community-based health promotion initiatives, and primary and secondary prevention programs, with significant potential to enhance functional independence and reduce musculoskeletal complications associated with aging.

4. Conclusions

The findings of the present study demonstrate that a structured and adapted 8-week trunk core stretching program induces statistically and clinically significant improvements in trunk mobility in adult and older women. Comparable effects were observed in participants aged 65 and older, confirming preserved musculoskeletal plasticity at advanced ages and supporting the cross-age effectiveness of these interventions. Improvements in thoracic, lumbar, and rotational mobility validate the efficacy and reproducibility of the implemented experimental trunk core stretching program.

The transfer of benefits to global functional capacity, documented through composite scores and functional tests, underscores the physiotherapeutic relevance of segmental mobility improvements for autonomy and quality of life. These results provide empirical support for implementing trunk core stretching programs in therapeutic, preventive, and health promotion contexts for adult and older women.

Future research should employ rigorous experimental designs to explore underlying physiological mechanisms, the long-term sustainability of benefits, and the optimization of adapted trunk-core stretching interventions to maximize therapeutic outcomes, thereby contributing to the development of evidence-based strategies for maintaining mobility and functional capacity throughout adulthood.

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