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Effect of adding global postural reeducation to kendall exercises for treating asymptomatic forward head posture: A single-blinded randomized controlled trial

Walaa Abu-Taleb [a,b,*], Abeer Abdelrahman Yamany [b], Yasser M. Aneis [b,d], Shimaa T. Abu El Kasem [b,c]

[a] Physiotherapy, School of Human Sciences, London Metropolitan University, London, UK
[b] Department of Basic Science, Faculty of Physical Therapy, Cairo University, Giza, Egypt
[c] Department of Basic Science, Faculty of Physical Therapy, Galala University, Suez, Egypt
[d] Department of Physical Therapy, Oman College of Health Sciences, Sultanate of Oman

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ABSTRACT

Introduction: Forward head posture (FHP) is a common postural malalignment in young population that is associated with limitation of mobility and functional disability. Kendall exercises are one of the commonly used postural correction techniques to treat FHP. Global postural reeducation (GPR) is a postural correction exercise commonly used for musculoskeletal disorders. The current study aimed to investigate the combined effect of GPR and Kendall Exercises in the treatment of FHP.
Methods: A single-blinded parallel-groups randomized controlled trial was conducted. Forty-three participants aged 18–30 years were recruited with FHP marked by a craniovertebral angle (CVA) less than 50°. Participants were randomly allocated into two groups: group A (GrA) received GPR plus Kendall Exercises, and group B (GrB) received Kendall Exercises only. Variables were measured before and immediately after 12 sessions of treatment including CVA, gaze angle (GA), shoulder angle (SA), cervical range of motion (CROM), neck disability index (NDI), chest expansion, and spinal mobility.
Results: Between groups analysis revealed no statistically significant difference between either treatment in CVA, CROM, and NDI. There was a statistically significant improvement of chest expansion and spinal mobility in favor to GrA. Within-group analysis revealed that both interventions were statistically significant in improving CVA, CROM, and NDI ($P < 0.05$). Both treatments showed no statistical difference in GA and SA.
Conclusions: The added effect GPR technique to Kendall exercises significantly improved craniovertebral angle, cervical mobility and functional disability, chest expansion, and spinal mobility in people with FHP.

1. Introduction

Forward head posture (FHP) is a common non-structural malalignment of the cervical spine characterized by hyperflexion of the lower cervical spine (C2–C7), and hyperextension of the upper cervical vertebrae which includes the occiput, atlas and axis (C0–C2) (Khayatzadeh et al., 2017). FHP is notably spread among young adults and university students with a prevalence of 63.3%–90% in the population (Karthik et al., 2022; Kose et al., 2022). Some of the underlying causes of FHP include faulty postural habits, sedentary lifestyle and prolonged use of smart devices (Fercho et al., 2023).

The anterior head translation in FHP causes compression of the cervical vertebrae (Bonney and Corlett, 2002), which triggers overactivity of the cervical and suboccipital muscles that is required to counterbalance the weight of the head (Alowa and Elsayed, 2021). The muscles overactivity limits the cervical mobility and further increases the load on the vertebrae and intervertebral discs which raises the risk of spinal injury (Alowa and Elsayed, 2021; Bonney and Corlett, 2002; Sarraf and Varmazyar, 2022). The disturbance of the normal cervical mechanics extends to the thorax, resulting in diaphragmatic and

* Corresponding author. School of Human Sciences London Metropolitan University London, UK.
E-mail addresses: w.abutaleb11@gmail.com (W. Abu-Taleb), abeer.yamany@pt.cu.edu.eg (A.A. Yamany), dryassercom@yahoo.com (Y.M. Aneis), shaimaataha@cu.edu.eg (S.T. Abu El Kasem).

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respiratory dysfunction (Koseki et al., 2019). FHP is commonly associated with restricted cervical and chest mobility (Kim et al., 2018), impaired cervical neuromotor control (Khan et al., 2020), and declined pulmonary function (Koseki et al., 2019).

Correcting FHP and related symptoms are attainable by various corrective exercises and manual therapy techniques (Fathollahnejad et al., 2019; Sheikhhoseini et al., 2018). Kendall Exercises (KE) were first described by Florance Kendall to correct the acquired postural fault of FHP, kyphosis, and rounded shoulders. This technique is comprised of four exercises including: stretching the tight neck extensors and pectoral muscles and strengthening the weak deep neck flexors and scapular retractors (Kendall et al., 2005). Kendall's technique is recommended to correct head and shoulders faulty postures and improve mobility and functional ability of the neck and shoulder complex (Harman et al., 2005; Kim et al., 2015; Kong et al., 2017; Rahul S et al., 2024).

Global postural reeducation (GPR) is another spinal postural correction technique that uses a series of active symmetrical lengthening positions maintained by antagonists muscles contraction with breathing training (Pillastrini et al., 2018; Souchard et al., 2011). The postures of GPR restore a balanced activation between antero-posterior postural muscles within myofascial chains while avoiding substitutions (Mendes-Fernandes et al., 2021; Souchard et al., 2011). Maintaining the stretching position for 15–20 min in GPR is necessary to engage the viscoelastic trait "creep" of the tissues, to stimulate a reflex relaxation of the agonists and to increase the stretch tolerance (Fukaya et al., 2022; Souchard et al., 2011). GPR has shown significant effectiveness in the treatment of postural impairments and musculoskeletal (MSK) conditions with reported value in decreasing pain, restoring mobility, and decreasing physical and pulmonary functional disabilities (Carrasco-Lopez and Medina-Porqueres, 2016; Dimitrova and Rohleva, 2014; Ferreira et al., 2016).

Three building principles support the GPR technique: Individuality (Individualité), where a personalized care is offered to patients, Causality (Causalité), where a MSK condition may be caused by a distant area, and Globality (Globalité), where the body is connected via myofascial chains and must be treated wholistically (Ferreira et al., 2016; Souchard et al., 2011). The globality principle in GPR may be supported by the contemporary research around fascia (Wilke et al., 2016; Wilke and Krause, 2019). The fascial system extends across the whole body to support and connect the different elements of the MSK system, creating an interconnected web of myofascial chains (Blottner et al., 2019; Bordoni and Myers, 2020). The facial continuum can retain and transmit up to 50% of the muscles' tension, which allows the fascia to coordinate the interplay of movements across the myofascial chains longitudinally and transversely in local and global areas via what is known as myofascial force transmission (Bordoni and Myers, 2020; Findley et al., 2015; Huijing, 2009; Stecco et al., 2023; Wilke et al., 2018).

Empirical research has investigated the applicability of myofascial force transmission. In the study by Wilke et al. (2017) stretching exercise applied proximally (cervical) or distally (calf) was equally effective in improving cervical mobility and supporting the value using myofascial force transmission in rehabilitation. Several studies further compared the superiority of global techniques (e.g. GPR) and local techniques in the rehabilitation of various MSK conditions (De Amorim et al., 2014; França et al., 2012; Matsutani et al., 2023; Mendes Fernandes et al., 2023; Rosário et al., 2012). However, the studies did not lead to a consensus on the comparability of these techniques or the value of combining both treatments in MSK conditions. The proven benefits of using Kendall Exercises added to the hypothesized efficacy of GPR may lead to better outcomes in patients with FHP. To the best of the authors' knowledge, no study considered adding GPR to local treatment as a treatment approach in the treatment of FHP. This study aimed at assessing the effect of GPR added to KE on postural angles (craniovertebral angle (CVA), gaze angle (GA), and shoulder angle (SA)), cervical range of motion (CROM), neck disability index (NDI), chest expansion (CE), and spinal mobility in people with FHP.

2. Materials and methods

2.1. Design

The current study was designed as a prospective single-blinded parallel-group RCT that was conducted between September 2020–October 2021. The study followed the recommendations of CONSORT for randomised clinical trials (Fig. 1). The study was approved and registered by the research ethical committee of the Faculty of Physical Therapy, Cairo University, Giza, Egypt (P.T.REC/012/002671) and registered in ClinicalTrials.gov (NCT04723511).

2.2. Subjects

Subjects were recruited via electronic and written adverts in the faculty of physiotherapy at Horus University in Egypt with the opportunity to be screened for FHP for a research project where those identified with FHP were invited to participate in this study. Participants were recruited from both sexes, age 18–30 years old, asymptomatic or neck pain <3 on the visual analogue scale (VAS) (the score below 4 is interpreted as no pain) (Jensen et al., 2003), CVA $<50^{\circ}$ (Moustafa et al., 2020), and body mass index (BMI) ranges from 18.5 to 28. Participants were excluded from the trial if they had a history of traumatic neck injury, scoliosis, severe temporomandibular or visual problem, spinal surgeries or fixations, sever respiratory condition, daily screen time for >4 h (Jung et al., 2016), a neurologic deficit (Cunha et al., 2008), or received any treatment for the neck in the last three months.

2.3. Sample size

Sample size calculation was performed using G*Power 3.0.20 software (Faul et al., 2007), using the results of the primary outcome CVA from a pilot study. The pilot study was conducted on 10 participants with FHP who received the same interventions and divided equally between the experimental and control groups. T-test was used within and between interaction, the effect size $= 0.8$, $\beta = 0.2$, and $\alpha = 0.05$, revealed that 38 (19 per group) participants were the appropriate sample size. Five participants were then added to compensate for any withdrawals. The appropriate sample was 43 participants divided into 2 groups.

2.4. Randomization

Seventy-eight participants were recruited and screened for FHP using measurement of CVA via photogrammetry and kinovea. The participants who did not fulfill the inclusion criteria ($n = 35$) were excluded; the details of this number can be followed up in Fig. 1. The randomization was carried out using a computer-generated numbers in opaque sealed envelopes. Participants were assigned to one of the two groups in a 1:1 ratio. Allocation was performed by one of the authors who was not involved in either data collection or treatment. To maintain allocation concealment, envelopes were opened only at the time of enrolment of each subject. The participants were blinded to their allocation to minimize bias until the study concluded (Page and Persch, 2013). The procedure was explained and informed consent forms were then signed by the participants.

2.5. Interventions

The intervention was provided for 12 treatment sessions over four weeks (Im et al., 2016), by a physiotherapist who has over 15 years of MSK clinical experience. As a general rule, participants were instructed to work ergonomically and practice treatment exercises at home, and to avoid poor posture and excessive smart devices exposure. An ergonomic online training was provided by the principal researcher and the exercises were printed for all the participants.

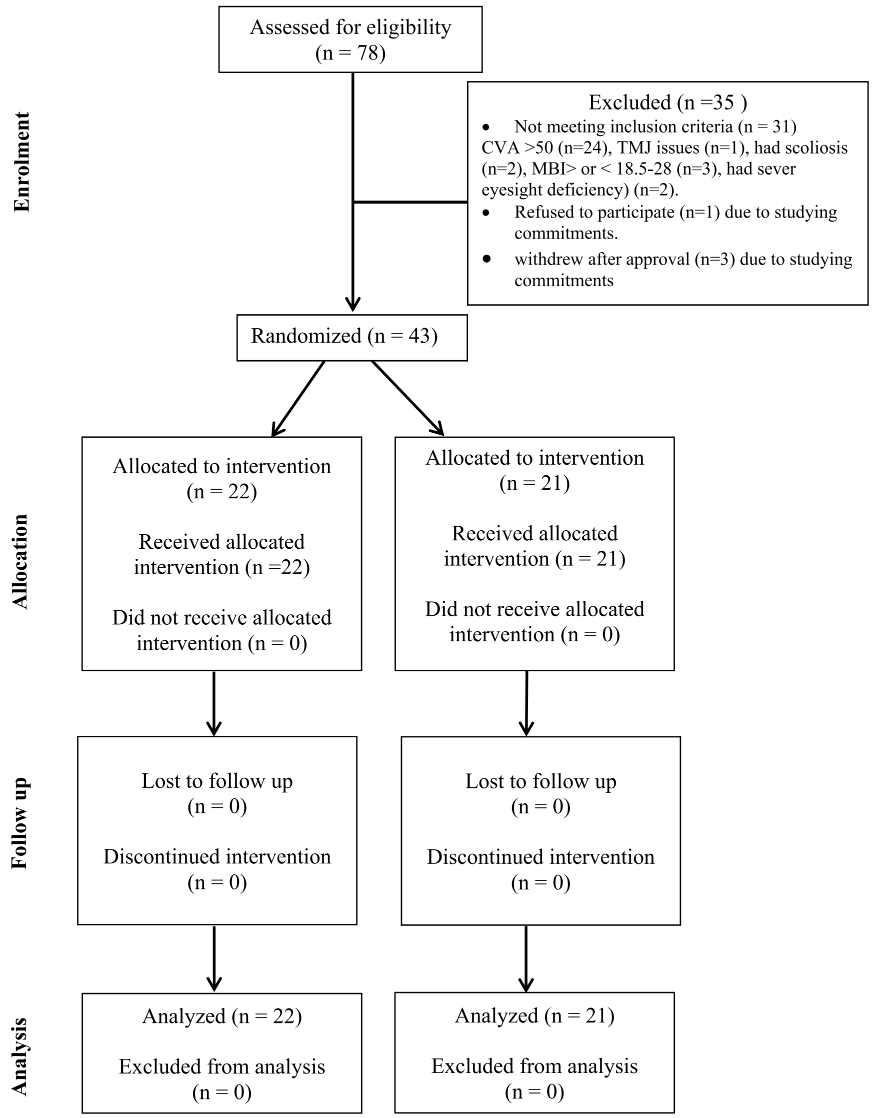


Fig. 1. Flow diagram (CONSORT) of the progress through the study.

Kendall Exercises were performed actively by all the participants (completed in 20–30 min) while the therapist observed the execution of the exercises, corrected faulty performance and timed the stretching exercises with a stopwatch. The difficulty of the exercises was gradually incremented if the subject can complete 10 correct exercise repetitions for three sets with ease (Harman et al., 2005; Kim et al., 2015), The description, dose, and progression of KE is available in Table 1 (Kendall et al., 2005; Kim et al., 2015).

GPR sessions started with 5 min of gentle diaphragmatic release and training of deep diaphragmatic breathing to stretch the diaphragmatic (respiratory) chain. Diaphragmatic release involved applying gentle pressure with the fingertips of the therapist starting from the xyphoid process moving towards the lateral lower ribs and was repeated three times (Moreno et al., 2007). Diaphragmatic breathing was performed actively in supine and the therapist applied cervical traction and corrected accessory muscles activation. It was performed five times at the start of the session then repeated three times every 5 min during the GPR positions.

The GPR postures selected in this trial aimed to stretch the anterior and posterior chains commonly affected in FHP (Fernández-De-Las-Peñas et al., 2005). Postures difficulty (lying to standing) and the amount of tension applied were incrementally increased as the treatment progressed to allow the subject to gain more strength and motor control and to build stretch tolerance (Mendes-Fernandes et al., 2021; Souchard et al., 2011). During the treatment, a cephalic traction of the head and caudal traction at sacral levels were passively applied by the therapist to flatten and elongate the spine, which was repeated during the session was deemed necessary (Silva et al., 2012). Treatment time of GPR ranged from 35 to 70 min according to the progression phase. Postures images are displayed in Fig. 2 while details of the GPR technique applied are in Table 2.

To enhance the therapist's ability to provide accurate, personalized, and symmetrical postural correction in GPR positions, a smartphone application with gridline view was used. ACPP Core2 (Jinnyu Technology CO, LTD), is free smartphone application that displays a calibrated gridline with squares of 0.25 cm^2 area and a plump line to allow for posture symmetry that was not detectable by the naked eye. The participants were instructed to assume the GPR postures as symmetrically as possible, and a photo was taken. The researcher then used the ACPP Core2 to correct the postures and take a photo of the corrected position. The photos were then shown to the participants to reinforce visual feedback of correct the posture (Xu et al., 2019). Body awareness training is an effective non-invasive treatment in postural deviations that could improve posture anomaly, postural control and vertical

Table 1
Kendall Exercises description, dose, and progression.

Exercise	Dose	Description and Progression
Strengthening of deep cervical flexors	5 sets of 10 repetitions, each set interrupted by 30 s break.	Chin tucks in supine lying with the head in contact with the floor. Progression from the third week by lifting the head off the floor in a tucked position and holding it for 2–8 s.
Stretching the cervical extensors	Five repetitions were held for 60 s each and followed by 60 s break.	A chin drop-in sitting progresses by chin drop with hand assistance by placing both hands on the occipital area.
Strengthening shoulder retraction	Five sets of 10 repetitions, each set interrupted by 30 s break.	Shoulder retraction from standing by holding a TheraBand moving scapular blades inwards. Progression to prone lying weight-free then using the weight of 1 kg.
Stretching the pectoralis muscle	Five repetitions were held for 60 s each and followed by 60 s break.	Unilateral Pectoral Stretch using the door frame or wall. Progresses to bilateral stretch and increases the force of stretch as tolerated.

perception (Yagci et al., 2018).

2.6. Outcome measures

Evaluations were performed before and after the completion of the 12 treatment sessions. The assessments were performed by one of the authors that was not involved in randomization or treatment process. The primary outcome measure for this study was craniovertebral angle (CVA) while the secondary outcome measures included gaze angle (GA) and shoulder angle (SA) measured by photogrammetry and analyzed by Kinovea software, cervical range of motion (CROM) measured by cervical range of motion instrument, neck function measured by neck disability index (NDI), and a tape measure was used to measure both the circumference of the chest expansion (CE) and the spinal mobility via fingers to floor test (FTF).

2.7. Postural angles and photogrammetry

Photogrammetry is a valid and reliable method to measure postural angles (Singla et al., 2017). Three angles were assessed in this study including CVA for forward head posture, GA for upper cervical posture, and SA for rounded shoulders (See Fig. 3) (Singla et al., 2017). The assessed postural angles were considered normal when CVA $>50^\circ$, GA $< 15^\circ$ and SA $> 52^\circ$ (Moustafa et al., 2020; Ruivo et al., 2017; Van Det et al., 2008).The photographs were taken with a smartphone's Camera (12-megapixel) mounted on the tripod 1.5 m away from the subjects and the height was adjusted to each participants's neck (Puig-Diví et al., 2019). Self-adhesive markers were placed on C7 and the acromion processes bilaterally to improve the visualization of bony landmarks in the captured photos. Six photos from the sagittal planes were taken for each subject in standing position. Analysis of photogrammetry was performed via open-access Kinovea Software (Version 0.9.5) under the GPL v2 license (Charmant and Contributer, 2021). Kinovea is valid, precise, and reliable for angles and distances (Lee et al., 2017; Puig-Diví et al., 2019). The measurement technique used followed the guidance of Mun Cheung Lau et al. (2010)

2.8. Cervical mobility

Cervical range of motion instrument has good validity and reliability in the assessment of neck mobility 95% confidence interval (CI), ICC = 0.89–0.98 (Audette et al., 2010; Tousignant et al., 2006). Active CROM was measured in flexion, extension, bilateral side bending, and bilateral rotation. Following familiarization with the procedures and warming up, CROM was assessed according to the procedures explained by Wang et al. (2002). The measurements were repeated 3 times, and the average was calculated. Any contaminated trial by trunk or shoulder substitution was discarded and replaced with another (Wang et al., 2002).

2.9. Neck function

Macdelilld et al. (2009) reported that NDI is a valid and reliable scale that can be used for acute and chronic MSK dysfunctional conditions. NDI for mechanical neck pain without upper extremity symptoms exhibited excellent reliability 95% CI, ICC = 0.88 (Pt et al., 2018). NDI is a self-administered test for the neck functional assessment in 10 activities of daily living (Ackelman and Lindgren, 2002). Each of the activities is scored by progressive statements from no disability to maximum disability. Each statement is then scored from zero to 5, where the zero equates not having any disability and 5 stands for maximum disability (Vernon and Mior, 1991). Participants in this trial were instructed to select the statement that represents them best.

2.10. Chest expansion

Chest Expansion/mobility (CE) via tape measure has shown to be valid and highly reliable for the upper and lower chest expansion indicating chest mobility and indirectly lung function (Najwatul et al., 2016). Tape measure has a very good interrater and interrater reliability measuring upper and lower chest expansion with 95% CI, ICC = 0.78–0.84, and 0.85–0.93 respectively (Reddy et al., 2019). Assessment of the chest expansion was done at two levels: upper thoracic or axial at the level of the armpit, and lower thoracic/xyphoid at the level of the xiphoid process (Bennett et al., 2021; Mohan et al., 2012; Reddy et al., 2019). The measurement procedures were done following the approach of Reddy et al. (2019) and the average of three trials were calculated.

2.11. Spinal mobility

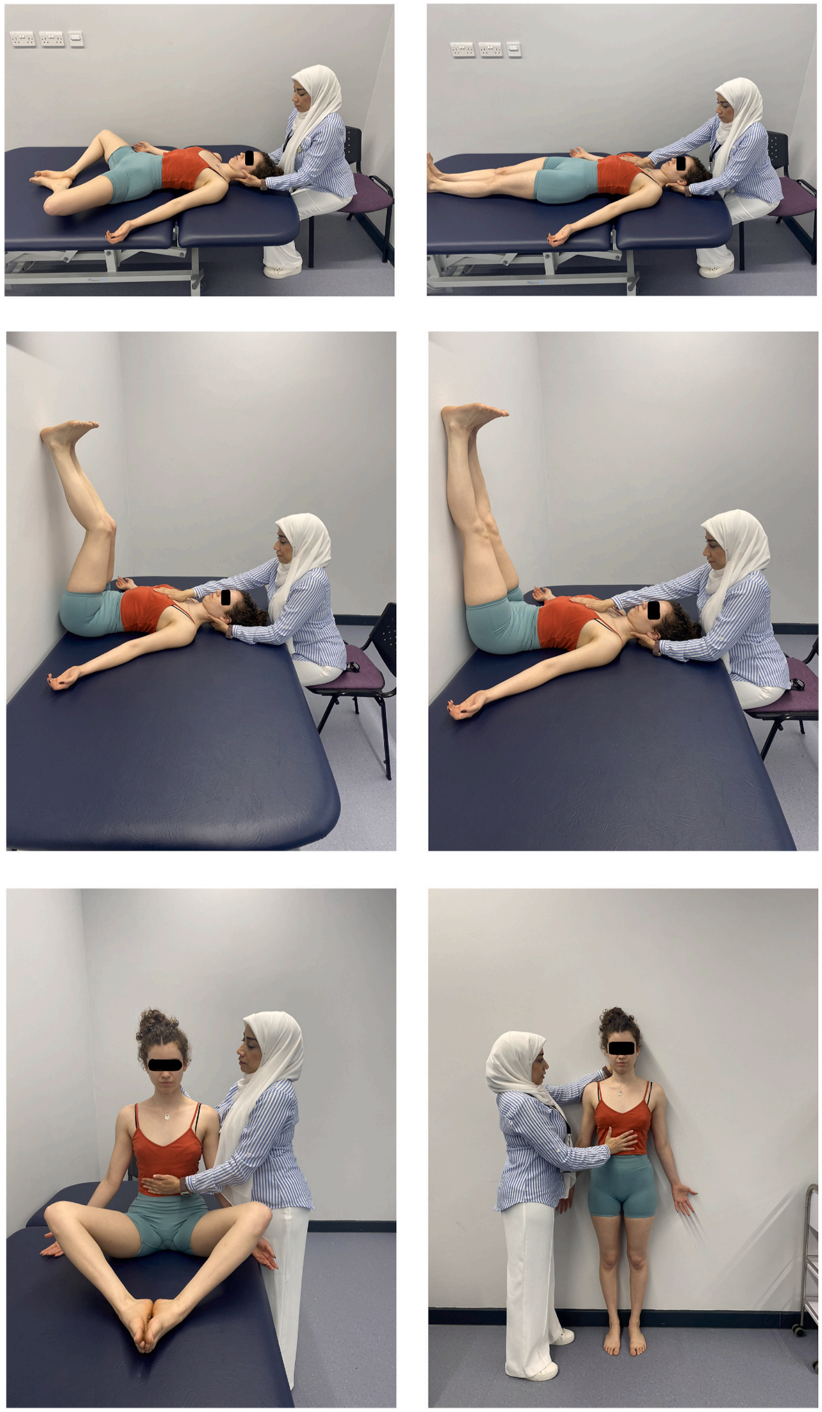
Fingertips to floor test (FTF) was used to assess the spinal mobility. FTF test is a valid and reliable test with a 95% CI, ICC = 0.96 (Hecimovich and Hebert, 2016; Perret et al., 2001), and has a strong correlation to spinal mobility (Guo et al., 2023). The test involves measuring the distance between the middle finger to the floor without knee flexion via tape measure (Perret et al., 2001).

2.12. Statistical analysis

An unpaired *t*-test was conducted for the comparison of participants' demographic characteristics between groups and Chi-squared test was used for comparison of sex distribution. Shapiro-Wilk test was used to test normality of the data while the homogeneity of variances between groups was confirmed by Levene's test. Mixed MANOVA was performed to compare within and between groups effects of the treatment interventions on CVA, GA, SA, CROM, CE (axillary and xyphoid) and spinal mobility (FTF test). Bonferroni corrections were carried out for subsequent multiple comparisons. Mann–Whitney test was used for comparison of NDI between groups and Wilcoxon signed ranks test was used for comparison between pre- and post-treatment in each group. The statistical analysis was completed using the statistical package for social studies (SPSS) version 25 for Windows (IBM SPSS, Chicago, IL, USA). The level of significance for all statistical tests was set at $p < 0.05$.

3. Results

Forty-three participants completed the study without drop-out, hazards or adverse effects reported from the participants during treatment. Table (3) shows demographic characteristics of both GrA and GrB.



A

B

C

Fig. 2. GPR postures used in this study. A: Progression of frog on the ground posture with upper limbs in adduction and open hip angle. B: Progression of frog in the air posture with upper limbs in adduction and closed hip angle. C: Sitting with upper limbs in adduction and closed hip angle. D: Standing against the wall with upper limbs in adduction and open hip angle.

There was a match at the baseline between groups in age, sex and BMI $p > 0.05$. Mixed MANOVA revealed that there was a significant interaction between treatment*time ($F = 13.38$, $p = 0.001$). There was also a significant main effect of time ($F = 23.45$, $p = 0.001$), but there was no significant main effect of treatment ($F = 0.99$, $p = 0.47$).

Between group analysis revealed that there was no significant difference between groups pretreatment ($p > 0.05$). There was no statistically significant difference in CVA, GA, SA, CROM and NDI between groups post-treatment ($p > 0.05$). There was a significant increase in axillary and sternal circumferences, and a significant decrease in FTF of GrA compared with GrB ($p < 0.01$) (Tables 4 and 5).

Within group analysis revealed that there was a post-treatment significant statistical improvement in both groups in CVA, CROM ($p < 0.01$), and NDI ($p < 0.05$) compared with pretreatment. There was a significant increase in axillary and sternal CE and a significant decrease in FTF in GrA ($p < 0.001$), while there was no significant change in GrB ($p > 0.05$). There was no significant difference in post treatment measurements of GA and SA in both groups ($p > 0.05$). Table 5 shows the significant decrease in NDI of groups A and B post-treatment compared with pretreatment.

Table 2
GPR postures, sequence, and description as used in the current study.

Shoulder and Hip Angles	Postures	Engaged Chains	Application time and duration	Description
Open coxofemoral (hip joint) and shoulders adducted	Frog on the ground	Anterior chain, respiratory chain, anterior arm, upper scapular chains, and anteromedial and lateral hip chains.	Week 1 and 2 applied for 15 min.	Supine position, neck, and shoulders retracted, arms adducted from 45° to 0° throughout the sessions, elbow extended, abdomen retracted, pelvis posteriorly tilted, hips abducted, and externally rotated, knees flexed, and feet faced.
	Standing against the wall	Anterior chain, respiratory chain, anterior arm, upper scapular chains, and anteromedial and lateral hip chains. This also improves balance and proprioception.	Week 3 and 4 applied for 15 min.	Standing against the wall, focus on the alignment of the spine, chin retracted, shoulders retracted, arms adducted from 45° to 0° over the course of the sessions, elbow extended, abdomen retracted, pelvis posteriorly tilted, hips extended, and knees bent to extension as tolerated.
Closed coxofemoral (hip joint) and shoulders adducted	Frog in the air	Posterior chain, respiratory chain; anterointernal of the shoulder, anterior arm, and side chain of the hip.	Week 1 and 2 applied for 15 min.	Supine, chin retracted, shoulders posteriorly tilted, elbows extended, abdomen retracted, pelvis posteriorly tilted, hips flexed, knees flexed and the ankles resting on the wall with the arms started at 45°–0°.
	Sitting	Posterior chain, respiratory chain; anterointernal of the shoulder; scapular chain, anterior arm, and side chain of the hip.	Week 4 applied for 15 min.	Sitting, focus on the alignment of the spine, chin in, shoulders retracted as tolerated, abdomen retracted, knees bent, arms adducted 45°–0°.

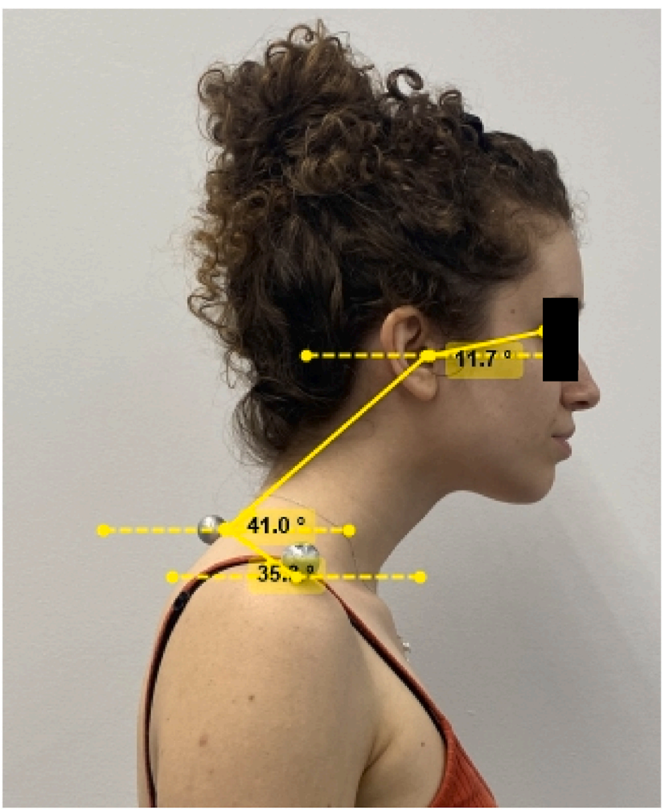


Fig. 3. The measured angles from top to bottom: (1) Gaze angle (Sagittal head tilt angle): the angle between a line connecting the tragus and the Canthus of the eye with the horizontal line, (2) Craniovertebral angle: the angle between a line extending from C7 to the tragus of the ipsilateral ear and the horizontal line., and (3) Shoulder angle (sagittal shoulder-C7 angle): the angle between a extending from C7 to the Midpoint of acromion and the horizontal line (Singla et al., 2017). Interrupted lines represent the horizontal line.

Table 3
Comparison of subject characteristics between groups A and B.

	Group A	Group B	MD	t- value	p-value
Age (years)	21.09 ± 3.10	22.71 ± 3.72	−1.62	−1.55	0.13
Weight (kg)	77.91 ± 14.72	75.88 ± 10.47	2.03	0.52	0.61
Height (cm)	167.41 ± 8.32	170.09 ± 11.17	−2.68	−0.89	0.37
BMI (kg/m^2)	27.88 ± 5.09	26.41 ± 4.26	1.47	1.03	0.31
Sex, n (%)					
Female	12 (54.5%)	11 (52%)		(χ^2 = 0.02)	0.88
Male	10 (45.5%)	10 (48%)			

SD, Standard deviation; t, unpaired t value; χ^2, Chi-squared value; p-value, Level of significance.

4. Discussion

The current study aimed to identify the effect of adding GPR to KE on postural angles (CVA, GA and SA), cervical mobility (CROM) and functional disability (NDI), chest expansion (CE), and spinal mobility (FTF) in patients with FHP. The results showed a statistically significant difference in favor to the experimental group (GrA) only in CE and FTF. Within groups analysis showed significant statistical improvement in both groups in CVA, CROM, and NDI while there was not any significant difference in GA and SA.

The measures of CE were improved by 5.69 cm and 7.04 cm in axial and xyphoid diameters respectively. The improvement exceeded the minimum clinically important difference (MCID) of 3.60 cm for the axial CE and 4.40 cm for the xyphoid CE (Reddy et al., 2019). This improvement may be facilitated by the adoption of GPR positions and repeated breathing workout which corrects the mechanical fault of the neck and thorax and restores the normal function of respiratory muscles and diaphragm (Koseki et al., 2019; Rocha et al., 2018). The breathing workout in GPR is postulated to increase the recruitment of respiratory muscle fibers while simultaneously stretching the diaphragmatic chain and augmenting the extensibility of the diaphragm (Rocha et al., 2018). In agreement with the current study, GPR was reported as beneficial in augmenting the respiratory muscle strength, chest mobility, maximal respiratory pressure and reducing pain among other benefits in the rehabilitation of MSK dysfunction (Moreno et al., 2007).

FTF test is typically utilized in clinical setting and in research as a screening tool for spinal mobility in low back pain and ankylosing spondylitis patients (Bonetti et al., 2010; Silva et al., 2012). However, it was used in the current study, similar to that by Cavalcanti et al. (2020) as an indicator of the globalized effect of GPR stretching exercises on posterior myofascial chain that extends from upper trapezius to the foot intrinsic muscles (Bonetti et al., 2010). Our results showed a significant improvement of FTF scores from baseline by 7.68 cm which exceeded the minimal detectable change of 4.5 cm (Guo et al., 2023). The improvement of FTF following GPR could be a result of stretching the posterior myofascial chain for a prolonged time using GPR positions

Table 4
Mean CVA, GA, and SA, CROM, Chest expansion (axillary and xyphoid), and fingers-to-floor test pre and post-treatment of groups A and B.

Outcome Measures		Group A	Group B			
		Mean ± SD	Mean ± SD	MD (95% CI)	p-value	Effect size
CVA (degrees)	Pretreatment	44.94 ± 2.13	44.87 ± 2.59	0.07 (−1.39: 1.52)	*0.92*	
	Post-treatment	51.83 ± 3.32	51.13 ± 4.61	0.7 (−1.76: 3.17)	*0.56*	0.17
	MD (95% CI)	−6.89 (−8.60: 5.18)	−6.26 (−8: 4.5)			
	% of change	15.33	13.95			
		p = 0.001*	***p = 0.001****			
GA (degrees)	Pretreatment	17.35 ± 6.97	±3.51 17.99	0.64 (−4.06–2.79)	*0.711*	0.006
	Post-treatment	17.79 ± 5.45	18.59 ± 5.04	0.8 (−3.93–2.33)	*0.609*	
	MD (95% CI)	0.62 (−2.18–1.31)	0.6 (−2.39–1.19)			
	% of change	3.57	3.34			
		P = 0.617	*P = 0.500*			
SA (degrees)	Pretreatment	49.57 ± 13.11	54.33 ± 15.48	−4.76 (−13.58: 4.06)	*0.28*	
	Post-treatment	53.25 ± 11.34	50.49 ± 13.93	2.76 (−5.04: 10.57)	*0.48*	0.22
	MD (95% CI)	−3.68 (−9.55: 2.19)	3.84 (−2.16: 9.85)			
	% of change	7.42	7.07			
		p = 0.21	*p = 0.20*			
Flexion (degrees)	Pretreatment	51.39 ± 10.56	52.22 ± 11.82	−0.83 (−7.73: 6.07)	*0.81*	
	Post-treatment	57.80 ± 10.09	58.22 ± 7.42	−0.42 (−5.90: 5.06)	*0.87*	0.05
	MD (95% CI)	−6.41 (−10.60: 2.2)	−6 (−10.29: 1.71)			
	% of change	12.47	11.49			
		p = 0.004*	***p = 0.007****			
Extension (degrees)	Pretreatment	52.32 ± 7.79	55.79 ± 9.41	−3.47 (−8.78: 1.83)	0.19	
	Post-treatment	60.30 ± 11.37	62.11 ± 10.46	−1.81 (−8.55: 4.93)	0.59	0.16
	MD (95% CI)	−7.98 (−12.77: 3.20)	−6.32 (−11.22: 1.42)			
	% of change	15.25	11.33			
		p = 0.002*	***p = 0.01****			
Right side bending (degrees)	Pretreatment	40.50 ± 6.37	39.92 ± 6.96	0.58 (−3.53: 4.69)	0.77	
	Post-treatment	46.06 ± 8.55	45.87 ± 6.15	0.19 (−4.42: 4.80)	0.93	0.03
	MD (95% CI)	−5.56 (−8.86: 2.26)	−5.95 (−9.33: 2.57)			
	% of change	13.73	14.90			
		p = 0.002*	***p = 0.001****			
Left side bending (degrees)	Pretreatment	38.69 ± 6.99	40.67 ± 8.59	−1.98 (−6.78: 2.84)	0.41	
	Post-treatment	44.09 ± 8.32	46 ± 8.93	−1.91 (−7.22: 3.41)	0.47	0.22
	MD (95% CI)	−5.4 (−8.55: 2.24)	−5.33 (−8.56: 2.11)			
	% of change	13.96	13.11			
		p = 0.001*	***p = 0.002****			
Right rotation (degrees)	Pretreatment	58.45 ± 12.35	58.63 ± 10.43	−0.18 (−7.24: 6.88)	*0.96*	
	Post-treatment	67.12 ± 6.59	65.35 ± 8.84	1.77 (−3.01: 5.56)	*0.46*	0.23
	MD (95% CI)	−8.67 (−13.37: 3.96)	−6.72 (−11.53: 1.90)			
	% of change	14.83	11.46			
		p = 0.001*	***p = 0.007****			
Left rotation (degrees)	Pretreatment	59.45 ± 8.11	57.08 ± 11.53	2.37 (−3.74: 8.49)	0.43	
	Post-treatment	67.80 ± 9.33	65.83 ± 7.88	1.97 (−3.36: 7.31)	*0.45*	0.23
	MD (95% CI)	−8.35 (−12.74: 3.96)	−8.75 (−13.24: 4.25)			
	% of change	14.05	15.33			
		p = 0.001*	***p = 0.001****			
Axillary circumference (centimeter)	Pretreatment	99.36 ± 8.54	98.76 ± 7.89	0.6 (−4.47: 5.67)	*0.81*	
	Post-treatment	105.05 ± 8.34	98.62 ± 8.56	6.43 (1.22: 11.63)	***0.01****	**0.76**
	MD (95% CI)	−5.69 (−6.96: 4.41)	0.14 (−1.16: 1.44)			
	% of change	−5.73	0.14			
		p = 0.001*	*p = 0.83*			
Sternal circumference (centimeter)	Pretreatment	90.05 ± 8.78	91.47 ± 7.17	−1.42 (−6.38: 3.52)	*0.56*	
	Post-treatment	97.09 ± 8.87	90.38 ± 7.77	6.71 (1.56: 11.86)	***0.01****	**0.80**
	MD (95% CI)	−7.04 (−8.46: 5.63)	1.09 (−0.35: 2.54)			
	% of change	7.82	1.19			
		p = 0.001*	*p = 0.13*			
Finger to floor test (centimeter)	Pretreatment	9.97 ± 9.58	9.88 ± 9.99	0.09 (−5.93: 6.13)	*0.97*	
	Post-treatment	2.29 ± 8.49	9.14 ± 9.61	−6.85 (−12.43: 1.27)	***0.01****	0.75
	MD (95% CI)	7.68 (6.24: 9.12)	0.74 (−0.73: 2.21)			
	% of change	77.03	7.49			
		p = 0.001*	*p = 0.32*			

SD, Standard deviation; MD, Mean difference; CI, Confidence interval; p-value, Probability value.* indicate significance.

(Bonetti et al., 2010). This is in agreement with the previous results of Cavalcanti et al. (2020) who found similar decline of FTF scores following 10 sessions of GPR in their pilot study of 18 subjects with spinal pain despite not showing any change in posture.

Further, GPR uses isometric contraction of the antagonistic muscles which may cause a reflex inhibition of agonists and facilitate increased the length of muscles (Silva et al., 2012). This phenomenon is known as reciprocal inhibition which is commonly used to explain the value of proprioceptive neuromuscular facilitation stretching technique (Hindle et al., 2012). Furthermore, Oliveri et al. (2012) investigated the effect of GPR standing position and reported an inhibition of the motor cortical area controlling the agonists muscles and an activation of cortical regions controlling the antagonists which further supports the proposed effect of GPR.

Our results showed no improvement of GA and SA as a result of GPR and KE treatments despite improving CVA which indicates the correction of FHP. This contrasts the findings of previous studies that utilized KE to correct FHP (Heydari et al., 2022; Kim et al., 2015). This study

Table 5
Median NDI pre- and post-treatment of groups A and B.

Outcome Measures		Group A	Group B		
		Median (IQR)	Median (IQR)	U-value	p-value
NDI (%)	**Pretreatment**	4 (4–2)	4 (4–4)	201	0.40
	Post-treatment	2 (4–2)	2 (4–2)	215.5	0.66
	Z-value	2.31 *p = 0.02**	2.48 *p = 0.01**		

IQR, Interquartile range; Z-value, Wilcoxon signed ranks test value; U- value, Mann-Whitney test value; p-value, Probability value. * indicate significance.

assumes that as the inclusion criteria of the participants were only marked by CVA angle not GA or SA, the awareness of the participants' body behavior, and postural habits which in turn affects self-education and correction may have not extended to the upper cervical or shoulder (Schwertner et al., 2018; Siemonsma et al., 2013). Another possible explanation of the lack of improvement in GA might be provided in the findings of Lin et al. (2022) who studied cadavers with mild FHP and found that rectus capitis (occipital DNF) was in a shortened position while longus capitis (cervical DNF) was in a lengthened position. This may suggest that applying exercises to activate both of these muscles equally might not evidently be the best option to improve cervical and head position (CVA and GA) simultaneously (Lin et al., 2022).

The results of this study showed significant improvement of CVA, CROM and NDI in both groups. The post-treatment CVA scores exceeded the cutoff value of 50° that identifies participants with FHP in both groups by (≥6°, $p = 0.001$), and surpassed the MCID in photogrammetry at 1.40° (Heydari et al., 2022; Lee et al., 2016). Further, CROM also improved in both groups by (5.33°–8.75°, $p = 0.001$) which lies within the reported MCID 3°-10 (Jørgensen et al., 2017; Williams et al., 2010). A significant improvement of NDI after treatment is evident in both groups ($p = 0.001$).

The improvements of CVA, CROM, and NDI in the current study may be attributed to the effect of normalizing the cervical curve. Two FHP correction techniques were used in this study to re-establish the normal antero-posterior muscle balance: Kendall technique work by strengthening the weak deep neck flexors (DNF) and scapular retractors and stretching the tight neck extensors and shoulder protractors. While GPR technique applies active spinal lengthening technique with breathing control that is further accentuated by a passive manual cervical/sacral traction by the therapist. Both techniques encompass DNF activation, that is renowned for normalizing the cervical curve in FHP (Alowa and Elsayed, 2021; Chang et al., 2023).

Activating DNF, particularly longus capitis and longus colli, was found in functional MRI to cause flexion of the carnio-cervical junction and flattening of cervical lordosis (Cagnie et al., 2008). Further, strong DNF allows relaxation of the overly active accessory muscle that contribute to the maintenance of FHP and fosters restoration of cervical mobility and functionality (Alowa and Elsayed, 2021; Kong et al., 2017). The normalization of the curve would then correct the biomechanical faults of the cervical spine and leads to improvement of limited ROM and cervical dysfunction.

Previous studies found that smaller CVA is associated to with higher NDI score and lower CROM (De-La-Llave-Rincón et al., 2009; Kinjal Bagthariya and Kakkad, 2024; Yip et al., 2008). Similarly, Chang et al. (2023) reported in their systematic review that correcting the postural deviation of FHP and rounded shoulders is reflected in restoring cervical mobility and improving both pain and functional disability. However, it is important to remember that these interpretations are correlational not causational.

As evident in our findings are comparable to previous studies that reported and improvement of CVA, cervical mobility, and functional disability as a result of utilizing the Kendall technique (Kim et al., 2015; Kong et al., 2017). On the other hand, no previous studies were found assessing the use of GPR for FHP but it was repeatedly used for cervical pain other spinal conditions. GPR is found to be fruitful in improving VAS, NDI, CROM and neck muscle electrical activity (Cunha et al., 2008; De Amorim et al., 2014; Mendes Fernandes et al., 2023; Pillastrini et al., 2018).

This randomized controlled study addressed an important issue related to the effectiveness of combined global and local treatment for asymptomatic FHP. The strengths of this study lies in its design, diverse sample, limitation of confounding factors, randomization, and the use of valid and reliable measurement tools all increase the robustness of our results and decreases bias in our findings.

Future research needs to address the limitations in this study that may limit the generalizability of the findings. The short-term (<four weeks) or the long-term effects (>four weeks) of the combined treatment techniques on cervical spine were not studied. Also, the effect of treatment on the thoracic or lumbar spines was not investigated. Furthermore, we did not investigate patient satisfaction and the cost and time effectiveness of both techniques in relation to achieved results.

5. Conclusion

The combined effect of global postural reeducation technique and Kendall exercises for 12 sessions has showed a significant improvement of FHP angle, cervical mobility, neck functionality, axial and xyphoid chest expansion, and spinal mobility in patients with FHP. The suggested added value of the combined treatments is emphasized in the improvement of chest expansion and spinal mobility.

Clinical relevance

- Both global postural reeducation added to Kendall exercises or Kendall exercises alone could be clinically used to improve FHP with consideration of the available treatment time.
- The combined effect of global postural reeducation with Kendall exercises do not have superior effect to Kendall exercise alone except for improving chest mobility, and spinal mobility in patients with FHP.
- Kendall exercises is proven to be a successful treatment for FHP.

CRediT authorship contribution statement

Walaa Abu-Taleb: Writing – review & editing, Writing – original draft, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Abeer Abdelrahman Yamany:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Yasser M. Aneis:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Conceptualization. **Shimaa T. Abu El Kasem:** Writing – review & editing, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

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