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NR 3/2020 (20) KWARTALNIK ISSN 1642-0136

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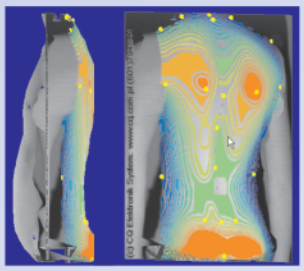

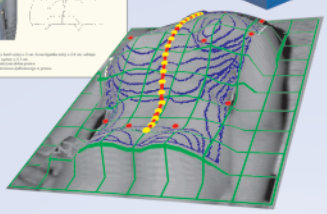

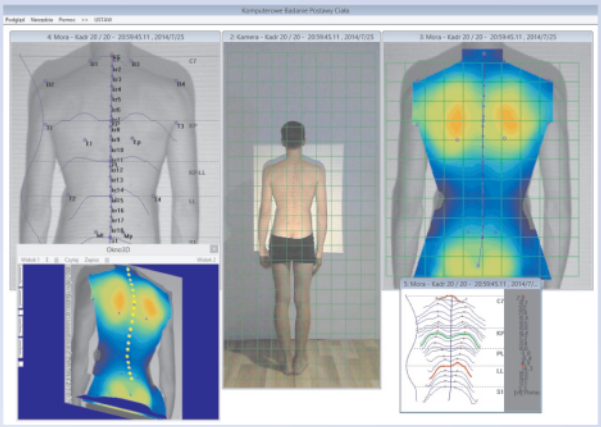

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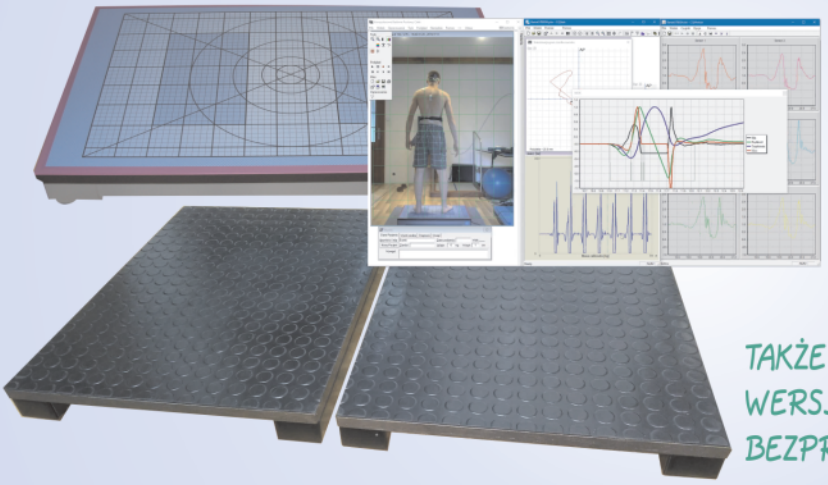

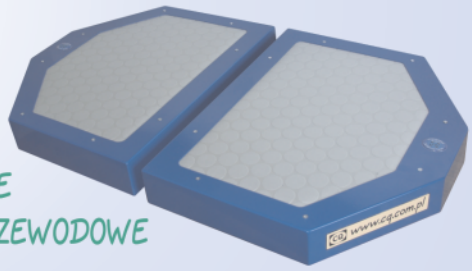

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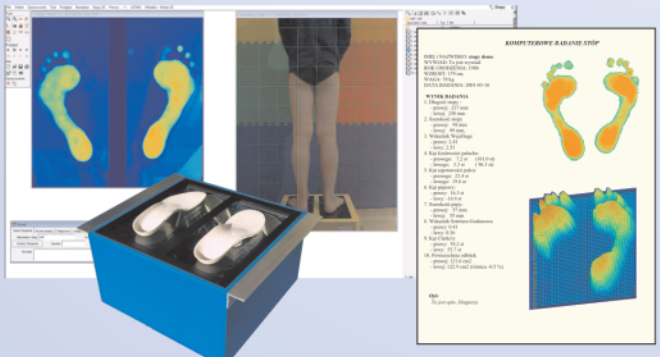

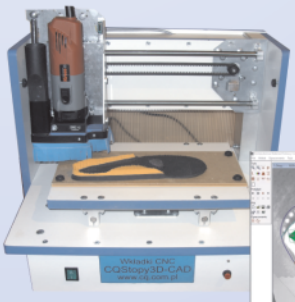

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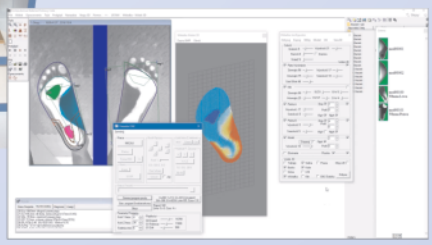

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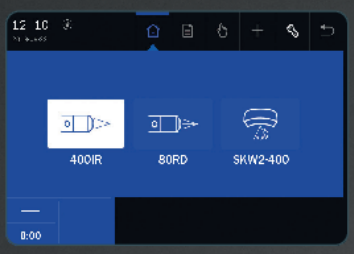

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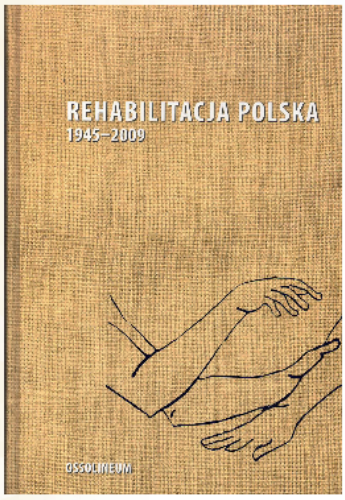

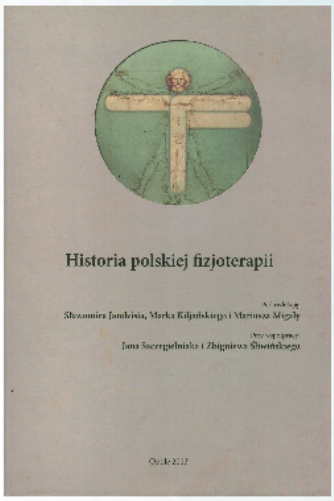

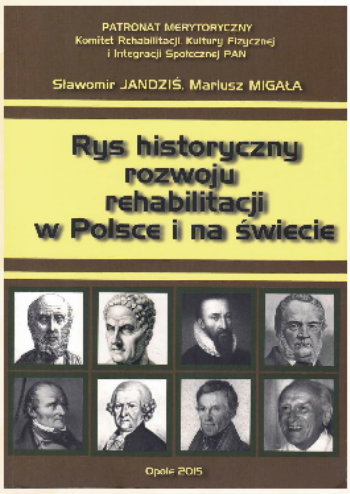

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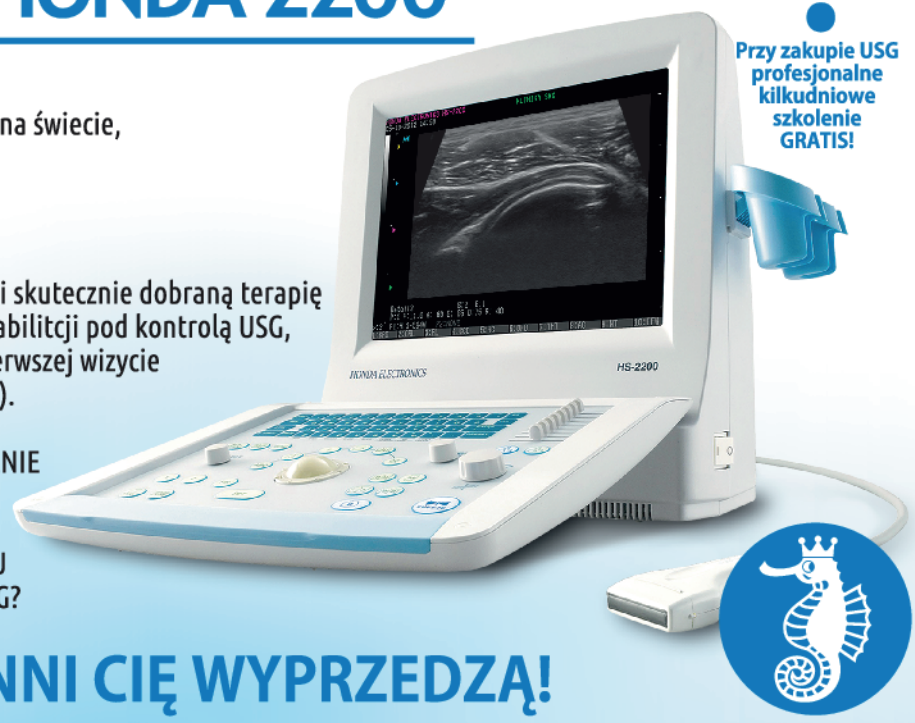

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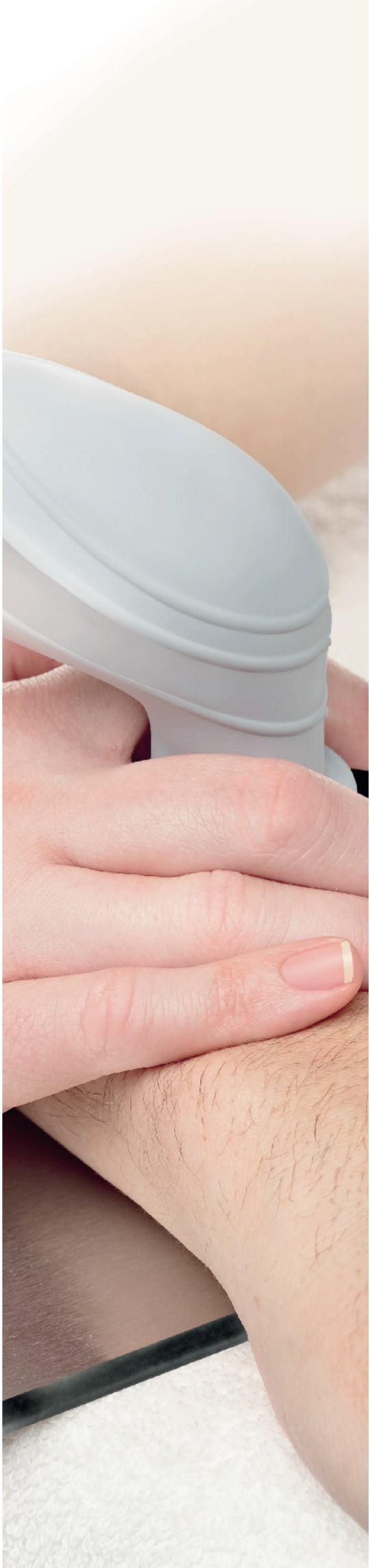

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Effect of Forward Head Posture Correction Added to Lumber Stabilization Exercises on Lumbopelvic Organization in Mechanical Low Back Pain Patients: A Randomized Clinical Trial

Wpływ korekcji postawy, gdzie głowa jest wysunięta do przodu dodanej do ćwiczeń na stabilizację kręgosłupa lędźwiowego na organizację odcinka lędźwiowo-miednicznego u pacjentów z mechanicznym bólem krzyża: Randomizowane badanie kliniczne

Aliaa M Elabd[1(A,B)], Ahmed I Elerian[2(B)], Salah-Eldin B Ahmed[2(B,E,F)], Haytham M Elhafez[2,3(C,D)], Ahmed F Geneidy[4(A)], Ahmed Atteya Ashour[5(C,D)], Omar M Elabd[6(C)]

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Abstract

Background. Although current Lumbar Stabilization Exercises (LSEs) is beneficial for chronic mechanical low back pain (CMLBP), further research is recommended focusing on normalizing sagittal lumbopelvic alignment. Subjects with forward head posture (FHP) possibly have a problem with the regulation of static upright posture.
Purpose. This study was conducted to determine the effects of adding FHP correction to LSEs on pain, functions and lumbopelvic sagittal alignment in CMLBP patients.
Materials and Methods. Forty adult patients with CMLBP and FHP were assigned into one of two groups. Group A received FHP correction exercises in addition to LSEs for 12 weeks, while group B received only lumber stabilization for 12 weeks. The primary outcome was lumber lordosis (LL). Secondary outcomes included pain intensity, back specific physical functioning, cranio-vertebral angle (CVA), pelvic tilt (PT), pelvic incidence (PI), and sacral slope (SS). Patients were assessed pre and post treatment by an assessor blinded to the patients' allocation. Reported data was analyzed by Mixed-model-MANOVA.
Results. MANOVA indicated a significant group-by-time interaction (P= 0.00, Partial η2= 0.65). LL, Pain, and SS were reduced in group A more than B. Physical function, CVA, and PT were increased in A when compared to B. There was no significant group-by-time interaction for PI. Within-group comparisons revealed significant differences for all measured variables in both groups except for CVA and PI in the control one.
Conclusion. The addition of FHP correction to LSEs for management of CMLBP seemed to positively affect pain, functioning, and lumbopelvic organization.

Key words:
Exercises, Low Back Pain, Posture, Stabilization

Streszczenie

Informacje wprowadzające. Chociaż ćwiczenia na stabilizację kręgosłupa lędźwiowego (LSE) są korzystne w przypadku przewlekłego mechanicznego bólu krzyża (CMLBP), zaleca się dalsze badania koncentrujące się na normalizacji strzałkowego ustawienia lędźwiowo-miednicznego. Osoby z głową wysuniętą do przodu (FHP) mogą mieć problem z regulacją statycznej pozycji wyprostowanej.
Cel. Niniejsze badanie zostało przeprowadzone w celu określenia wpływu wprowadzenia korekcji postawy, gdzie głowa jest wysunięta do przodu do programu ćwiczeń na stabilizację kręgosłupa lędźwiowego na ból, funkcje i ustawienie strzałkowe lędźwiowo-miedniczne u pacjentów z CMLBP. Materiały i metody. Czterdziestu dorosłych pacjentów z CMLBP i FHP przydzielono do jednej z dwóch grup. Grupa A wykonywała ćwiczenia korekcyjne FHP oraz program LSE przez 12 tygodni, podczas gdy grupa B była poddawana jedynie stabilizacji kręgosłupa lędźwiowego przez 12 tygodni. Głównym rezultatem była lordoza lędźwiowa (LL). Drugorzędne rezultaty obejmowały intensywność bólu, specyficzne funkcjonowanie fizyczne pleców, kąt czaszkowo-kręgowy (CVA), pochylenie miednicy (PT), zapadalność miednicza (PI) i nachylenie kości krzyżowej (SS). Pacjenci byli oceniani przed i po leczeniu przez osobę nieświadomą podziału pacjentów na grupy. Zgłoszone dane analizowano za pomocą Mixed-model-MANOVA.
Wyniki. Narzędzie MANOVA wskazało na istotną interakcję pomiędzy przynależnością do grupy a czasem (P = 0,00, Częściowe η2 = 0,65). Zaobserwowano obniżenie LL, bólu i SS w grupie A bardziej niż w grupie B. Czynność fizyczna, CVA i PT zwiększyły się w grupie A w porównaniu z grupą B. Nie zaobserwowano istotnej interakcji pomiędzy przynależnością do grupy a czasem dla PI. Porównania wewnątrzgrupowe ujawniły istotne różnice dla wszystkich mierzonych zmiennych w obu grupach z wyjątkiem CVA i PI w grupie kontrolnej.
Wnioski. Wprowadzenie korekcji FHP do programu LSE w ramach leczenia CMLBP wydawało się pozytywnie wpływać na ból, funkcjonowanie i organizację lędźwiowo-miedniczą.

Słowa kluczowe:
Ćwiczenia, bóle krzyża, postawa, stabilizacja

Introduction

Low back pain (LBP) is an extremely enormous and challenging condition that is experienced by many persons at some time in their life. It represents a leading cause of disability worldwide and the second cause for a medical consultation with estimation that, 1% of the world population involved [1, 2].

The economic impact of LBP is huge and still growing all over the world [3]. Mechanical low back pain (MLBP) arises from the spine, surrounding soft tissues, or intervertebral disks [4]. It has been estimated that 5-10% of cases will develop chronic LBP, leading to patients' suffering and increased costs for treatment [1].

A large number of nonoperative interventions are available to manage Chronic MLBP (CMLBP), including education, manual therapy, medications, exercises, and modalities (hot packs, electrical stimulation, ultrasound, etc). However, the most effective management approach remains unclear [5-7]. Anti-inflammatory medications have small effects in improving patient outcomes [8]. Opioids appear to have low evidence [9].

The evidence which supports complementary and alternative medicine (such as acupuncture, massage, electrotherapy and spinal manipulative therapy) to manage CMLBP is limited [10, 11]. Recently, there has been a focus on lumbar stabilization exercises (LSEs) that is proved to be effective and may be superior to general exercises for CMLBP treatment with different evidence degrees [12, 13]. However, further researches are recommended focusing on the development of new predictions for novel stabilization exercise programs and/or combination of interventions [14].

Focusing on pathoanatomy as an etiological factor of CMLBP ignoring the significant role of dysfunction may be one of the most common challenges the clinicians face in the management of LBP because, functional activity involves interactions between neural, biomechanical, and environmental dynamics that give rise to meaningful motor behaviors [15].

Differences in sagittal spinal alignment between normal subjects and those with LBP have been reported [16]. The morphology of the spine may affect the load and stress acting on the structures of the spine [17]. Thus, sagittal lumbopelvic parameters, and especially the lumber lordosis, are useful parameters and are employed in the assessment of spinal function and LBP [18].

Many postural reflexes are located or occur in the head and neck region, so subjects with forward head posture (FHP) possibly have a problem with the repositioning sense and neurologic regulation of static upright human posture [19], and abnormal afferent information [20], in addition to the several mechanical factors explaining the link between FHP and LBP [21].

Given the high incidence of FHP, correction of this faulty posture may be a direct consequence for restoring the normal afferentation process in self-orientation of the spine occurs in accordance with the normalized reference point [19-22]. In this regard, correction of FHP was effective in the management of scoliosis [23], and lumbosacral radiculopathy [24]. Thus, this study was conducted to examine the effect of adding FHP correction exercises to LSEs on lumbopelvic organization, pain intensity, and back specific physical functioning in CMLBP patients.

Materials and methods

This study was conducted according to the 1964 Helsinki declaration and its later amendments, approved by the research ethics committee of Faculty of Physical Therapy, Cairo University (P.T.REC/012/003152). It was prospectively registered (PACTR201710002660565). Participation was voluntary and a written informed consent was obtained from each patient before participation in the study.

Study design

Randomized blinded clinical trial.

Participants

Forty patients from both sexes (23 males and 17 females) participated in this study, their age ranged from 18 to 35 years. They were referred by orthopedist with a diagnosis of CMLBP to physical therapy at the outpatient clinic of Faculty of Physical Therapy, Cairo University. They all were either students or office workers. They subjected to a standardized physical examination and were screened for eligibility criteria by an assessor blinded to patients' allocation [25].

Inclusion criteria were CMLBP with symptoms lasting longer than 3 months, mild to moderate disability according to the Oswestry Disability Index (up to 40%), and cranio-vertebral angle (CVA) less than 50° because increased FHP was found to be associated with a decreased CVA [26]. Exclusion criteria were surgery or contracture affecting the lumbar spine, current physical therapy or medical treatment for LBP, pathologies such as skin diseases, inflammatory diseases, neurological diseases, congenital diseases, fractures, dislocations, neoplasms, infection, degenerative changes, and visual or auditory impairment.

Randomization

A computer generated randomized table of numbers was used for concealed allocation. Sequentially numbered index cards with the randomly assigned intervention group were folded and placed in sealed, opaque envelopes. A second therapist blinded to the examination findings opened the envelope and proceed with the treatment according to the group assignment.

Interventions

All patients received the intervention on the initial examination day by an an experienced therapist (10- years practice) according to their group; Group A: 20 Patients received FHP correction exercises added to LSEs, Group B: 20 Patients received LSEs only (control group). Patients in both groups received the prescribed program 3 sessions per week for 12 weeks.

Lumbar Stabilization Exercises (LSEs) program applied for the two groups

Lumbopelvic stabilization program involved a problem-solving approach by performing a comprehensive muscular system evaluation through assessing the muscles for any evidence of weakness, over activity or tightness, as well as for motion quality [27]. Phasic muscles have a tendency towards weakness, whereas postural muscles have a tendency towards tightness [28]. Crossed-pelvic syndrome is associated with weak deep muscles of the abdomen, gluteus maximus and gluteus medius, in addition to tight thoracolumbar extensors, iliopsoas and rectus femoris muscles. Such imbalance results in joint dysfunction [29].

Treatments were divided into progressive stages (Figure 1), one stage of assessment and treatment was ideally completed prior to proceeding to the next stage. Phase 1 aimed to obtain segmental control over the primary stabilizers re-establishing directly the simultaneous contraction of the deep muscle synergy independently of the secondary stabilizers and mobilizers by using the postural cue to "draw in the abdominal wall" to restore kinesthetic awareness and lumbopelvic position sense, usually found to be impaired in the patient with LBP.

The hollowing-in maneuver was used for a suitable contraction of transversus abdominis (TrA), participants were instructed to "take a relaxed breath in and out, hold the breath out and then draw in your lower abdomen without moving your spine". To get a suitable activation of the lumber multifidus (LM), a submaximal contraction was elicited with the contralateral arm lift maneuver, while holding a small hand weight [30].

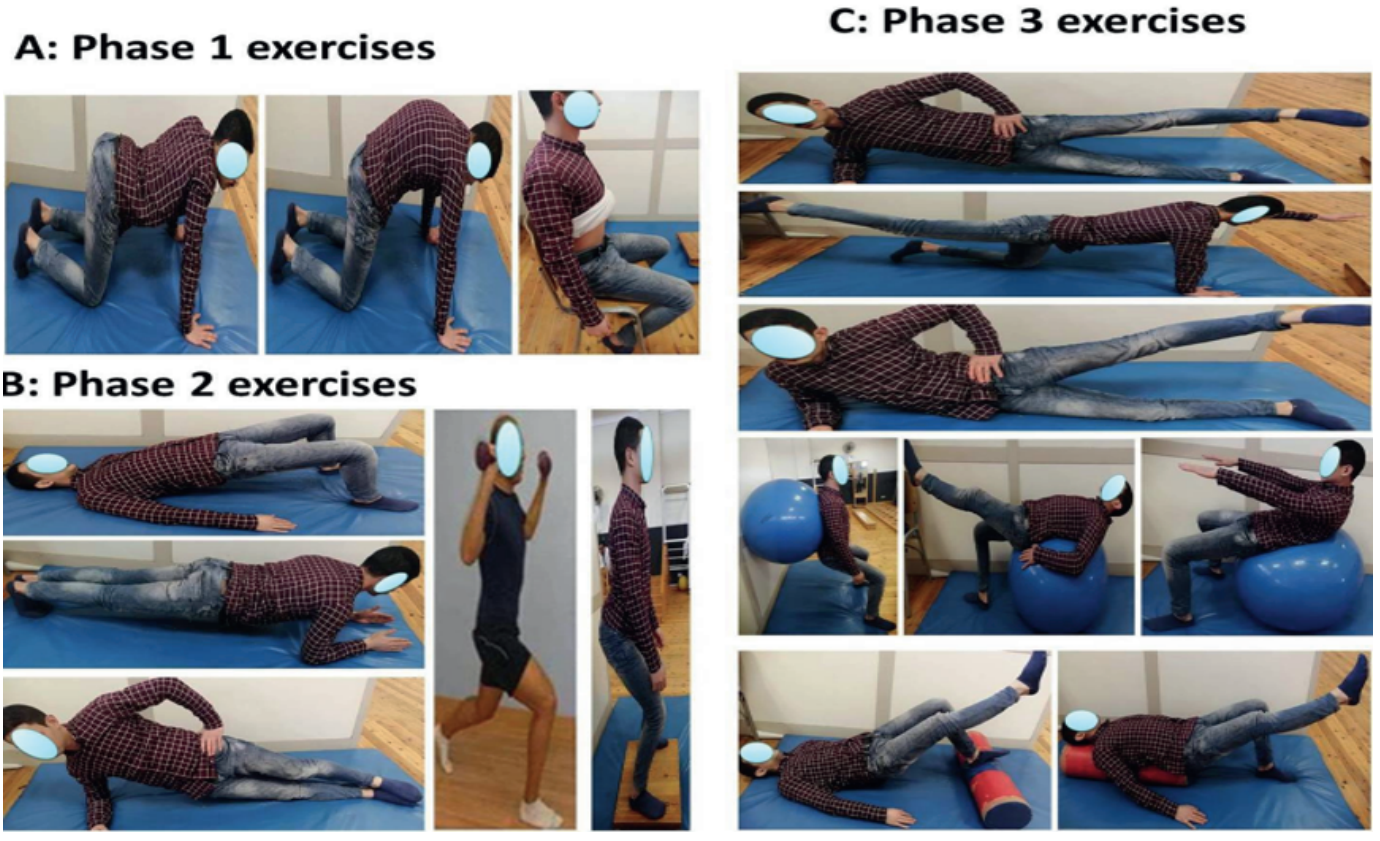

Figure 1. Lumber stabilization exercises; A: Phase 1, B: Phase 2, and C: Phase 3

The purpose of phase 2 was to maintain local muscle synergy contraction, while gradually progress load through the body using weight bearing closed chain exercises. Weight bearing load was added very slowly, ensuring activation of any weight bearing muscle at any kinetic chain segment to give effective antigravity support and to transfer load safely and efficiently via the body segments.

In addition, lifestyle factors of many patients, which might have led to a dysfunction in these muscles, were addressed to avoid the risk of sustaining further low back injury. Exercises performed in this phase were: Stand-up position on unstable surface, Closed chain lunge exercises, with the addition of hand weights, Bridge in prone position, Bridge in supine position, Lateral Bridge.

The aim of phase 3 was to continue to maintain local segmental control while load is added through open kinetic chain movement of adjacent segments to direct progression to allow all integration of all muscles into functional movement tasks in a formal way. This allowed any loss of segmental control during high loaded tasks to be detected, ensuring that there was no compensation by the more active muscles. Also, asymmetry of joints adjacent to the lumbopelvic region was addressed.

Performed exercises were: Lower limb abduction, open chain exercises of lower limb after co-contraction of TrA and LM. Stability ball exercises were performed with caution such as lying on gym ball with hip flexion, lying trunk curl strengthen abdominals, and squatting against ball. We started with 8 to 10 repetitions, and then increase to 12 to 15.

In addition, some exercises were performed on an unstable base of support. Each exercise was performed for 10 repetitions or 5 repetitions to each side if using single-side movements. Exercises were: supine-lying leg lift to develop back stability in an unstable lying position, bridge with heel raise on roller to develop spinal extensor and gluteal muscle endurance, prone tuck on roller to develop whole trunk strength and motion. This prescribed program comes in agreement with most accepted evidence [12, 14, 27, 31].

Forward head posture correction exercises performed for group B

The FHP corrective program began concurrently with the start of phase 1 LSES. The corrective exercises included two strengthening (deep flexor muscles of the cervical region and shoulder retractors) and two stretching (extensor muscles of the cervical region and pectoral muscles) exercises (Figure 2). This program has been proved to be effective in previous studies [23, 24].

Strengthening of deep cervical flexors was performed by asking the patient while sitting up straight on a comfortable chair to pull the head and neck into a position in which the head had more direct alignment over the thorax (chin in) while the eyes looking forward for 10 seconds. The patient was asked to move further with each repetition for 5 repetitions. To strengthen scapular retractors, each patient was asked to take deep inspiration and expand the chest then to move his or her shoulders backward bringing the scapulae together for 10 seconds.

Figure 2. Cervical posture correction exercises; A: Chin-in, B: Scapular retraction, C: Pectoralis muscle stretching, D: Upper trapezius muscle stretching, E: scalene muscle stretching, and F: Sub-occipital muscles stretching

For bilateral pectoralis stretching, the patient's elbow was moved up and out to the end of the available range while the patient seated comfortably with his hands behind his head or it was performed by self-stretching while standing against the wall corner with horizontally abducted shoulder as U shape to stretch the sternal head or V shape to stretch the clavicular head, the patient lean his body toward the wall and hold for 20 seconds for 5 times.
To stretch the cervical extensors: the patient seated comfortably and the therapist moved the head for side bending to the opposite side to stretch upper fibers of trapezius, or toward semiflexion and rotation toward the same side to stretch scalene. For suboccipital muscles, the therapist fixates on C2 while nodding the neck. All stretch maneuvers were held for 20 seconds and repeated for 5 times.
In addition, patients were asked to continue the previous exercises as a home routine and they received precise instructions to maintain a good posture during various daily living activities (proper sitting, proper lying, for reading, proper lifting, using computer and telephone).

Outcome measures
Outcome measures were measured pre and post treatment by an assessor with 10 year experience. Lumber Lordosis (LL) was the primary outcome measure for this study, whereas the secondary outcomes were sacral slope (SS), pelvic incidence (PI), pelvic tilt (PT), back specific physical functioning, pain intensity, and CVA.
Toshiba Rotande unite model DRX3724HD/2009 was used for obtaining standardized lateral views radiographs in a standard neutral standing position for the whole spine with keeping a constant distance between the radiographic source and each participant. Views were analyzed using autocad software (version 2017) as follow:
Lumbar lordotic angle (LLA) was measured from the upper endplate of L1 to the inferior endplate of L5. This angle was chosen because it has excellent interrater and intrarater reliability (ICC = 0.98 and 0.97). The minimum detectable change was determined to be 3.9 degrees [32, 33].
Other parameters of lumbopelvic organization were measured as follow: SS: between the sacral plate and the horizontal line, PT: between the line connecting the center of the sacral plate to the axis of the femoral heads, and the gravity line, PI: between the perpendicular to the sacral plate at its midpoint and the line connecting the point to the middle axis of the femoral heads. [34] These measurements have excellent inter-rater reliability (ICC = 0.84, 0.92, and 0.78 respectively) and intra-rater reliability (ICC = 0.93, 0.86, and 0.89 respectively) [35]. The CVA was measured as the angle between a horizontal line through the seventh cervical vertebra and the line from the center of the ear tragus to the seventh cervical vertebra. Measurement of CVA in radiographs proved reliable and has been considered as an accurate indicator of FHP (ICC = 0.99 for both intrarater and interrater reliability) [36].
The back pain intensity was evaluated via the Numerical Pain Rating Scale (NPRS), with 0 representing absence of pain and 10 representing maximal pain. It is a valid and reliable tool (ICC= 0.95) for assessment of pain. It has 1.3 minimal detectable changes [37]. The physical functioning was assessed through a low back-specific version of the SF-36 physical functioning scale (SF-36 PF18), which represented a reliable method (ICC = 0.91). It comprises the 10-item SF-36 physical functioning scale and four items each from the Oswestry and Quebec back pain questionnaires. The overall score ranges from 0 to 100, with a higher score indicating superior function [38].

Statistical analysis
Reported data was analyzed using Statistical Package for Social Sciences (SPSS) computer program (version 23 windows) (Charles R Flint, New York, USA) using an intention-to-treat analysis. When post intervention data for five patients were missing, the last follow up scores were used. Testing for the homogeneity of covariance revealed that there was no significant difference with p values > 0.05. Normality test of data using Shapiro-Wilk test was used, that reflect the data was normally distributed. So, parametric analysis was performed.

Potential differences in baseline demographic between groups were examined using independent sample t-tests. 2×2 mixed design MANOVA was used to examine the effect of treatment on the measured dependent variables (LL, SS, PT, PI, pain intensity, back function, CVA) with group as the between-subject variable (experimental received FHP correction and LSEs and control received LSEs only), and time as the within-subject variable (pre and post treatment). The variable of interest was the group-by- time interaction at an a priori alpha level of 0.05 and 95% confidence interval.

Results
Fifty-six consecutive patients were screened for eligibility criteria. Forty patients (mean ± SD age, 27.4 ± 5.28 years; BMI, 26.66 ± 2.24; 23 males and 17 females) satisfied the eligibility criteria, agreed to participate, and were randomized to group A: LSEs and FHP correction exercises (n = 20) and group B (n = 20): LSEs only. The reasons for ineligibility are found in a flow diagram of the patients' recruitment and retention (Figure 3).
There was no significant difference between groups for both demographic (age, weight, height, BMI) and measured variables at baseline (Table 1).

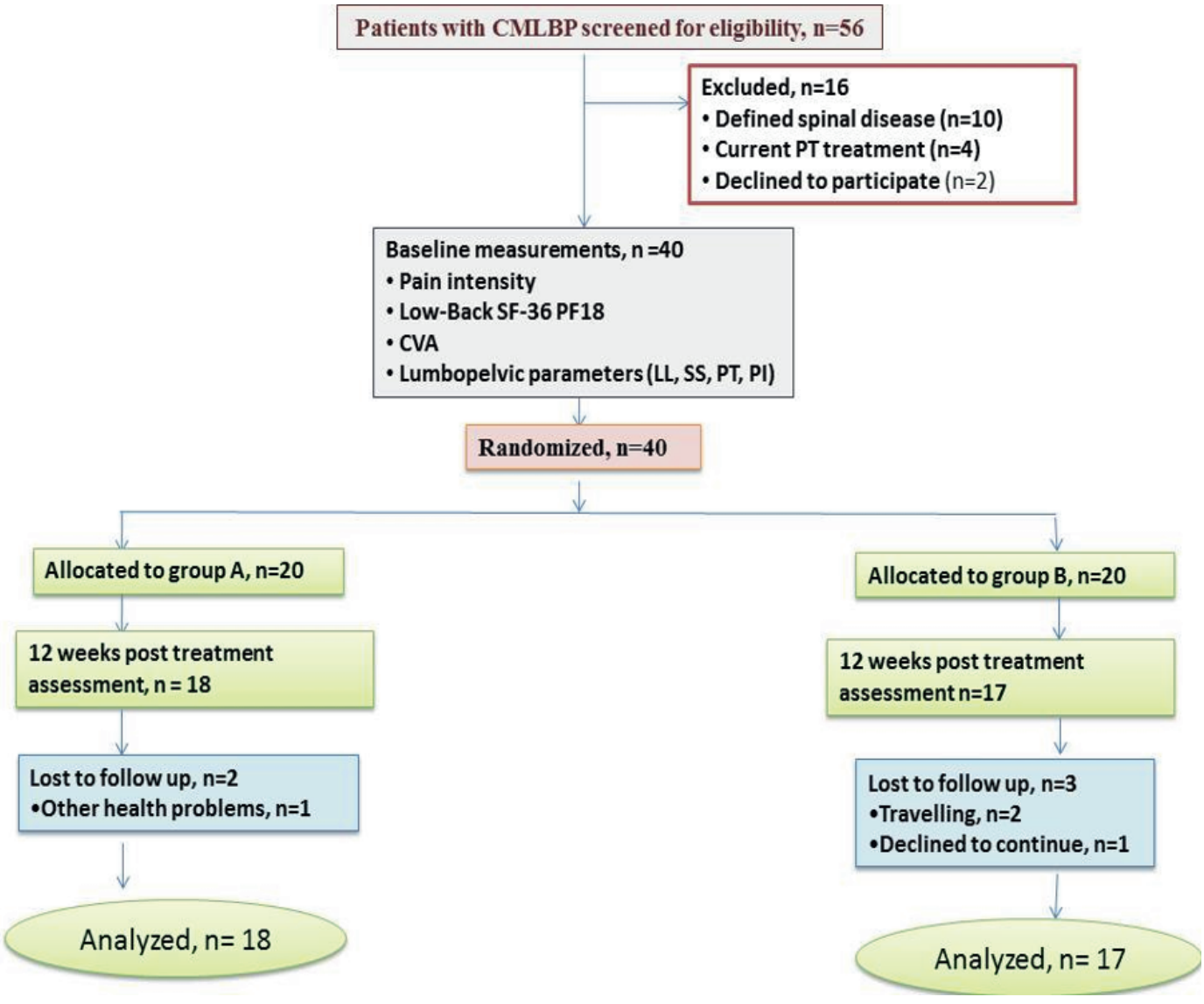

Figure 3. A flow diagram of patients' recruitment and retention

Table 1. Baseline measurements for the studied groups

	Group A (n = 20) Mean ± SD	Group B (n = 20) Mean ± SD	p-value
Age [years]	27.1 ± 5.82	27. 7 ± 4.81	0.724
Weight [kg]	78.9 ± 11.07	79.75 ± 11.24	0.811
Height [m]	1.7 ± 0.08	1.72 ± 0.07	0.598
BMI [kg/m^2]	26.34 ± 2.29	26.97 ± 2.2	0.387

NS= Not significant (p> 0.05).

Multivariate tests for outcome measures indicate a statistically significant effects for group (F = 20.57, p = 0.001, Partial η^2 = 0.67), time (F = 212.83, p = 0.001, Partial η^2 = 0.96), and group-by-time interaction (F = 24.5, p = 0.001, Partial η^2 = 0.65). Within group analysis revealed a statistical significant difference for all measured variables in the two studied groups (p < 0.01) except for PI in the experimental and control groups (p = 0.913 and 0.827 respectively) and CVA in the control one (p = 0.624). Between groups analysis revealed that, LL, Pain, and SS were reduced in group A more than B. CVA, physical function, and PT were increased in A when compared to B. There was no significant group-by-time interaction for PI. (Table 2).

Table 2. Baseline, post-intervention, within-group, and between-group differences and their associated 95% confidence intervals for outcome measures

Group	Pre-treatment*	Post- treatment*	Within group change (df = 19)		Between groups difference (df =	
			Scores#	p	Scores#	p
		Pain			-1.1 (-1.75 : -0.45)	0.001
Group A	7.6 ± 1	3.5 ± 1.1	-4.1 (-4.75 : -3.45)	0.001		
Group B	7.7 ± 0.98	2.4 ± 1.0	-5.25 (-5.9 : -4.6)	0.001		
		LB SF-36 PF18			5.6 (4.28: 6.9)	0.001
Group A	38 ± 2.65	52.25 ± 2.05	14.25 (12.93: -15.57)	0.001		
Group B	37.95 ± 1.99	46.65 ± 1.56	8.7 (7.38 : 10.02)	0.001		
		CVA			10.6 (8.98 : 12.22)	0.001
Group A	41.85 ± 2.68	53.15 ± 2.25	11.3 (9.68 : 12.92)	0.001		
Group B	42.15 ± 2.54	42.55 ± 2.78	0.4 (-1.22 : 2.02)	0.62		
		LL			-4.2 (-6.54 : -1.86)	0.001
Group A	61.1 ± 3.65	47.6 ± 3.02	-13.5 (-15.84 : -11.16)	0.001		
Group B	60.8 ± 3.56	51.8 ± 4.5	-9 (-11.34 : -6.66)	0.001		
		PT			1.45 (0.36: 2.54)	0.01
Group A	11.7 ± 1.75	17.75 ± 1.59	6.05 (4.96 : 7.14)	0.001		
Group B	11.9 ± 1.68	16.3 ± 1.87	4.4 (3.31: 5.49)	0.001		
		PI			0.4 (-1.42 : 2.22)	0.66
Group A	48.65 ± 2.92	48.55 ± 2.65	-0.1 (-1.92 : 1.72)	0.91		
Group B	48.35 ± 2.96	48.15 ± 2.99	-0.2 (-2.02 : 1.62)	0.83		
		SS			-2.15 (-3.94 : -0.36)	0.02
Group A	37.1 ± 3.02	30.05 ± 2.87	-7.05 (-8.84 : -5.26)	0.001		
Group B	36.45 ± 2.95	32.2 ± 2.48	-4.25 (-6.04 : -2.46)	0.001		

*A: Experimental group, B: Control group, * Values are mean ± SD, #Values are mean (95% confidence interval),*

Discussion

In spite of growing knowledge and medical development pertaining to spinal disorders, MLBP remains one of the most prevalent and costly health problems worldwide. The treatment of CMLBP has proven very challenging due to its negative impact on the socioeconomic status. There is no certainty about the most proper approach for a specific patient [1, 3, 4].

The purpose of this study was to examine the effect of correcting FHP with LSEs compared to performing LSEs only on lumbopelvic organization, pain intensity, and back specific physical functioning. According to our results, although patients in the two groups displayed significant changes of the outcomes, patients received combined interventions displayed greater reduction of their back pain, improvement of physical functioning and better restoration of normal sagittal alignment when compared to those performed LSEs only.

Previous studies have encouraged stabilization exercises as part of physical therapy for MLBP. However, the results were not sufficient [12, 13]. Ignoring the significant role of global spinal sagittal alignment may be considered as a challenge that clinician face [15, 17]. To the best of our knowledge, it is the first study that examine the effects of integrating FHP correction with the program of lumber stabilization exercises for MLBP management. Our results offer objective evidence about the negative influence of biomechanical defect (in terms of abnormal head posture) in addition to pathoanatomy of the lumbosacral area on CMLBP outcomes.

Normal posture restoration may be a direct consequence for restoring the normal afferentation process. The cervical spine plays a significant role in global posture of the spine [20, 21]. Forward displacement of the head increases strain on the head, cervical and shoulder muscles, leading to joint dysfunctions and subsequent dysafferentation (abnormal afferent information). Postural control is mainly involuntary and reflexive. Several postural reflexes (e.g. vestibulocollic reflex, cervicocollic reflex, pelvo-ocular reflex, vestibuloocular reflex, cervico-ocular reflex, and cervical somatosensory input) have been proven by previous studies to be located or happen in head and neck areas [19, 39].

Because this involuntary control depends upon cervical mechanoreceptors and afferent input from musculotendinous and ligament sources, correcting the postural abnormalities responsible for the dysafferentation process may be beneficial in normalizing global spinal alignment and subsequently treating CMLBP. [20] Our results agree with the results of the previous studies that suggested the beneficial effects of adding FHP correction exercises to the management of both idiopathic scoliosis [23] and lumbosacral radiculopathy [24].

Another explanation for FHP as a direct cause for dysafferentation may be that the resultant lack of blood flow due to increased strain placed upon various spinal muscles, forcing them to rely on an anaerobic metabolism. Building up of metabolites (e.g. histamine, bradykinin, and substance P) occurs, resulting in excitation of chemosensitive nociceptive receptors, pain afferent input and consequent dysafferentation [39].

Alterations in the spinal sagittal profile may be related to the strong relationship between FHP and pelvo-ocular reflex, which causes translation of the pelvis anteriorly to balance the centre of gravity of the head. Spinal curvature modifications in the sagittal plane have been associated with pelvic orientation changes [40, 41]. In the same way, these results are consistent with the theory of Levangie and Norkin [42] who reported that relocation of a body segment produces centre of mass shifting, and thus the line of gravity shifts in relation to the base of support.

In the same regard, our results agree with Protopsaltis et al [43] who found a correlation between changes in cervical lordosis and health related quality of life improvements in thoracolumbar deformity patients. This concept makes sense and agrees with Naserkhaki et al [17] who stated that consideration of the subject-specific sagittal curvature organization should be essential for lumbar spine mechanical analysis since the curvature of the spine can affect the location and magnitude of load on the spinal structures and cause kinematics and load-sharing alterations.

In contrast to our findings, Christensen et al [44] reported that postural abnormalities were of minor importance. Moreover, Nakipoğlu et al [18] were unable to find differences between the radiological values for spinal sagittal alignment in LBP patients. Any contradictory results in the previous studies might be due to a lack of uniform classification and measurement and poor experimental design because the previous conflicting results were obtained from correlational studies that were deficient in a cause and effect relationship.

The valuable impact of stabilization exercises could be related to improved lumbar segmental motor control, enhanced local muscular function, and co-activation of TrA and LM muscles [13, 14, 45].

Limitations of the study

The primary limitation was that, no follow up was conducted to know the long lasting effect and recurrence of symptoms. Additionally, electromyography was not used to assess lumber multifidus and transversus abdominis muscles particularly targeted to maintain spinal stability. We preferred to avoid the risks related to electromyography recorded by fine wire electrodes which is required for such deep muscles taking in to account that, the effects of stabilization exercises on paraspinal muscle electromyography have been proved in previous studies [46, 47].

Conclusion

Correction of FHP added to lumber stabilization exercises program may be an alternative treatment option for CMLBP. This combination may result in greater reduction in LBP intensity, and better physical functioning in addition to better restoration of balanced lumbo-pelvic sagittal alignment than application of stabilization exercises program alone.

Funding support and conflict of interest
This research received no specific grant from any funding agency in the public, commercial, or medical for-profit sectors. The Authors declare that there is no conflict of interest.

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