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INFLUENCE OF BILATERAL HAMSTRINGS MUSCLES SHORTENING ON SOME RADIOLOGICAL PARAMETERS OF LUMBOSACRAL SPINE

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ABSTRACT

Background: *Bilateral Hamstrings muscles shortening is a common condition found in symptomatic and asymptomatic subjects. Tightness of this muscle can play a role in low back pain, postural deficits, lumbar spine disorders and sport related injuries.* ***Purpose of this study:*** *was to investigate the influence of bilateral hamstrings muscles shortening on certain radiological parameters of lumbosacral spine.* ***Materials and Methods:*** *Thirty normal subjects of both genders participated in this study. Subjects were classified into two equal groups; Group A: The Control group: was consisted of fifteen normal subjects without hamstring shortening with mean age, weight, height and BMI were 26.8 ± 4.34 years, 74.6 ± 17.45 kg, 174 ± 15.5 cm , and 24.28 ±2.67 kg/m^2 respectively. Group B: The Study group: was consisted of fifteen subject with bilateral shortening of the hamstrings with mean age, weight, height and BMI were 25.8 ±3.91 years, 66 ± 9.69 kg, 164.2 ±7.43 cm , and 24.38± 2.81 kg/m^2 respectively. The shortening of the hamstrings was assessed with Active Knee Extension (AKE) Test, and the radiological parameters of lumbosacral spine were assessed from X-Ray image using Paxera Viewer Software.* ***Results:*** *This study showed that there was a significant difference in certain radiological parameters of lumbosacral spine (Lumbar lordosis angle, Lumbosacral angle and Sacral inclination angle) in cases of bilateral hamstrings muscle shortening as p value was (<0.05) .* ***Conclusion:*** *Bilateral hamstrings muscle shortening has significant effect on lumbosacral spine angles.*

Keywords: *Hamstring flexibility, Lumbosacral spine, Sacral Inclination Angle, Lumbar Lordosis Angle, Lumbosacral Angle.*

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INTRODUCTION

Four muscle group are responsible for supporting the pelvis in its antero-posterior alignment: the erectorspinae, hamstrings, abdominals, and hip flexors. and suggest that when the muscle are in balance the pelvis is maintained in proper alignment. however, if muscle imbalance occurs, the pelvis is thought to tilt anteriorly or posteriorly **(1).**

Evaluation of the extensibility of the hamstring muscles is a standard assessment in osteopathic clinical examination **(2),** because of its perceived relationship to performance **(3),** injury prevention **(4),** postural alignment and lumbopelvic motion **(5),** low back pain **(6),** and hamstring muscle injury **(7).** Reduced hamstring extensibility has been proposed as a predisposing factor for non specific low back pain **(8).**

Clinically hamstring muscle length is commonly measured indirectly by angular measurements of unilateral active or passive knee extension with the hip flexed to 90 degrees (popliteal angle [PA]) **(9).**

Because the hamstring muscles originate at the ischial tuberosity of the pelvis, the tension in the hamstring muscles has an influence on pelvic posture **(10).** The position of the pelvis plays a vital role in how the spine above it and the femur (thigh bone) below it will function **(11).** For this reason, a change in hamstring extensibility should have some influence in pelvic and spinal postures when the hamstring muscles are subjected to moderate or high tension **(12).**

There is an increasing recognition of the clinical importance of the sagittal plane alignment of the spine. The description of the physiological spinal sagittal balance serve as a baseline in the evaluation of pathological conditions associated with abnormal angular parameter values **(13).**

Nowadays, measurements of lumbar spine curvature and motion has become common place in the clinical assessment of Low Back Pain. It helps in assessment of spinal function and is often used as an outcome measure for clinical intervention studies **(14).**

The Sacral inclination (SIA), Lumbar lordosis (LLA) and Lumbosacral (LSA) angle are useful parameters that are employed in the evaluation of spinal function or assessment of low back pain **(15).**

The purpose of this study was that most of rehabilitation programs of Low Back Pain cases didn't consider the mechanical changes that might occur in the lumbar spine due to bilateral shortening hamstrings, and, so this study would help to direct attention of physiotherapists to such changes which will facilitate early detection, prevention and rehabilitation of the lower back problems.

METHODS

This study was conducted in outpatient clinic of El-Hosary Hospital in 6 October City and radiological imaging in First Scan Radiology Center in 6 October City from January 2016 to June 2016.

The subjects:

Thirty subjects were selected for this study. The subjects were divided into two equal groups : **Group A**: **The Control group**: 15 subjects without hamstring shortening (popliteal angle is greater than 160 degrees). **Group B: The Study group** 15 subjects with bilateral shortening of the hamstrings (popliteal angle ranges from 130-160 degrees).

Inclusion Criteria: 30 normal subjects**,** Both genders (males and females)**,** Age ranged from 18-35 years **,** Body mass index not more than 29.9 kg/m² and All subjects were screened for bilateral hamstring muscles shortening with AKE test for both lower limbs (the positive sign of AKE test is the inability to achieve greater than 160 degrees of knee extension with hip joint at 90 degrees of flexion).

Exclusion Criteria*:* The subjects were excluded if they have: Any history of chronic or systemic disease or abnormality that may affect the spine, pelvis or even the lower limbs, low back problems, spinal injuries or surgeries, History of musculoskeletal deformity or disease that may affect the spine or/and hamstring muscle flexibility, hamstring muscle strain or surgery , or leg length discrepancy.

Instrumentation:

1- Weight and Height Scale: The standard medical weight and height scale was used to measure the weight and the height of the subjects to calculate BMI of each subject.

2- X-ray Machine: The X-ray instrument was used for all subjects to get the roentgenograms of the lumbosacral spine.

3- Universal Goniometer: The Universal goniometer was used to measure range of motion of knee extension (popliteal angle) during assessment of hamstring shortening by active knee extension test.

4-Paxera Viewer software: This software was used to measure angles of lumbosacral spine on radiographs.

Assessment Procedures:

1- Assessment of Hamstring Muscles Flexibility:

Hamstring muscles flexibility was assessed by Active Knee Extension Test (AKE Test). The Test-Retest reliability coefficient for AKE Test was reported to be 0.99 for both lower limbs, and this has been attributed to the strict body stabilization method, the well-defined end point of motion and accurate instrument placement of the test **(16).**

Procedures:

1) The subject was placed in supine lying position without pillow underneath the head, the left (untested) lower limb was extended (at hip and knee joints) ,with the pelvic strap was frapped over the anterior superior iliac spines to stabilize the pelvis and prevent any accessory movement .
2) The right (tested) lower limb was flexed 90 degrees of both the hip and knee joint, while the right ischial tuberosity placed against the supporting box to maintain proper position of the hip and the thigh.
3) By using a skin permanent marker, mark the landmarks used to measure popliteal angle of knee joint. These land marks are the greater trochanter of the femur, the lateral condyle of the distal end of the femur, and the lateral malleolus.
4) The fulcrum of the goniometer was centered over the lateral condyle of the femur with the stationary arm secured along the femur using the greater trochanter as a reference, the movable arm was aligned with the lower leg using lateral malleolus as a reference.
5) The subject was instructed to actively extend the knee till the end of mild discomfort feeling in the back of the thigh (this is the terminal position of knee extension which is the point of hamstring tightness).
6) At this point measure the angle of knee joint extension (popliteal angle) that can be achieved actively by the subject using the universal goniometer. Positive sign of AKE test was inability to achieve greater than 160 degrees of knee extension with hip joint at 90 degrees of flexion.
7) The test was repeated three repetitions and the mean measurement of the three times was the used as the final reading for knee extension ROM (hamstring tightness- popliteal angle [PA])
8) Repeat test procedure by the same steps for the left lower limb and measure the mean of knee extension ROM for left (untested) lower limb.

2- Assessment of Radiological Parameters of Lumbosacral Spine:

Standing left Lateral Lumbosacral roentgenogram was obtained for each subject in this study. Each subject in both groups was asked to assume natural comfortable standing position with feet apart with a distance in between equal to the width of the pelvis. The upper limbs were flexed 90 degrees in front of him/her .The hips and knees were in full extension. The side of the trunk was in optimal contact with the film cassette, and this position was sustained during exposure. For each subject, a standing left lateral radiograph including lumbosacral spine was obtained.

Radiographic parameters:

The *Paxera viewer* software was used to measure the three angles (radiological parameters) of lumbosacral spine

a) Lumbar lordosis angle (LLA): From lateral view, The Lumbar Lordosis Angle was obtained as the angle between line drawn parallel to superior surface of L1 vertebra and line parallel to superior sacral plateau.

Fig (1): Lumbar Lordosis Angle (LLA)

b) Lumbosacral angle (LSA): From lateral view, The Lumbosacral Angle was obtained as the angle between line drawn parallel to inferior surface of L5 vertebra and line parallel to superior sacral plateau.

Fig (2): LumboSacral Angle (LSA)

c) Sacral inclination angle (SIA): From lateral view, The Sacral Inclination Angle was obtained as the angle between line drawn parallel to the ground and line drawn parallel to the superior sacral plateau.

Fig (3): Sacral Inclination Angle (SIA)

Fig (4): Lateral X-Ray Image for a subject without bilateral shortening of the hamstrings

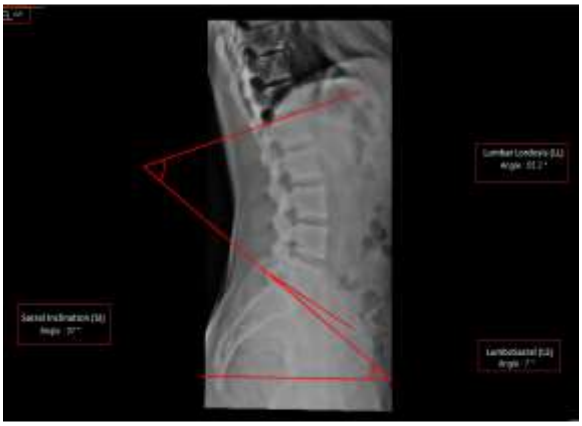

Fig (5): Lateral X-Ray Image For a Subject with Bilateral Shortening of The hamstrings

<u>Statistical Analysis:</u>

Statistical analysis was conducted using SPSS for windows, version 18 (SPSS, Inc., Chicago, IL). The current test involved one **independent variable**, it was the (groups); between subject factor which had two levels **(group A represent control group and group B represent bilateral shortening of hamstring muscles).** In addition, this test involved three tested **dependent variables (lumbar lordosis angle, lumbosacral angle, and sacral inclination angle).**

The collected results are analyzed statistically through using:

1. **Descriptive statistics**: including mean and standard deviation for all variables.

2. **Interferential statistics:** in the form of one way MANOVA to identify the differences between the study group and the control group.

All statistically significant differences are determined at p value <0.05.

The mean physical characteristics of the subjects in both groups (A&B) are as presented in table 1.

1. General Characteristics:

As indicated by the independent t-test, there were no significant differences (p>0.05) in the mean values of age, weight, height and BMI between both tested groups (Table 1). Also, Chi square revealed there was no significant differences between both groups in sex distribution (p>0.05) (Table 2).

Table (1): Physical characteristics of the subjects in both groups (A&B).

Items	Group A	Group B	Comparison		S
	Mean ± SD	Mean ± SD	t-value	P-value	
Age (yrs)	26.8 ± 4.34	25.8 ±3.91	0.662	0.513	**NS**
Weight (Kg)	74.6 ± 17.45	66 ± 9.69	1.668	0.106	**NS**
Height (cm)	174 ± 15.5	164.2 ±7.43	2.208	0.05	**NS**
BMI (Kg/m^2)	24.28 ±2.67	24.38± 2.81	-0.105	0.23	**NS**

***SD: standard deviation, P: probability, S: significance, NS: non-significant.**

Table (2): Distribution of sex in both groups

	Group A		Group B		Chi -Square	
	Females	**Males**	**Females**	**Males**	**X^2**	**P -value**
No.	5(33.3%)	10 (66.7%)	9(60%)	6(40%)	2.143	0.143
Total	15 (100%)		15 (100%)			

2. One Way MANOVA:

The one-way MANOVA revealed a significant difference for the tested variables of interest between the two tested groups (F = 6.644, p = 0.002*).

A. Lumbar lordosis angle

As presented in table (3) and figure (6), between group's comparison the mean ± SD values of lumbar lordosis angle in the group A and group B were 61.65 ±7.19 and 54.31±7.44 respectively. The univariate tests revealed that there was significant differences in the mean values of the "lumbar lordosis angle" between both groups with (F=7.542, P=0.01). So, Multiple pairwise comparison tests (Post hoc tests) revealed that there was significant reduction in the lumbar lordosis angle with (P=0.01) in favor to group B

Table (3):*Descriptive statistics and one way MANOVA for lumbar lordosis angle between both groups.*

	Group A	Group B	*Mean difference*	
lumbar lordosis angle	61.65 ±7.19	54.31±7.44	7.34	
The univariate tests for the mean of lumbar lordosis angle between different groups				
	F-value		**P-value**	
lumbar lordosis angle	7.542		0.01*	
Multiple pairwise comparison tests (Post hoc tests) for the lumbar lordosis angle between both groups				
lumbar lordosis angle	**Group A**	**vs.**	**Group B**	**p = 0.01***

***Significant at alpha level <0.05**

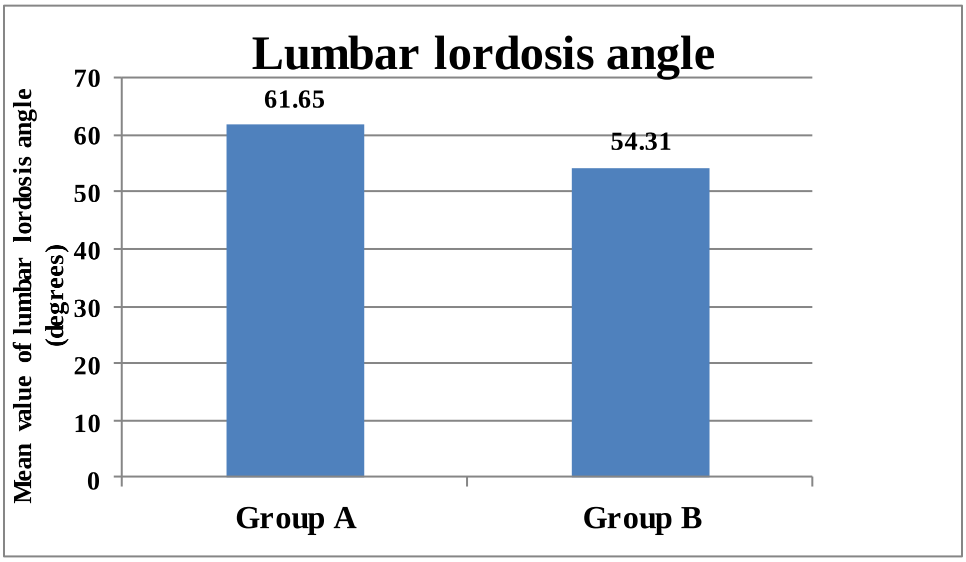

Fig (6): Mean values of lumbar lordosis angle between both groups.

B. Lumbosacral angle

As presented in table (4) and figure (7), between group's comparison the mean ± SD values of lumbosacral angle in the group A and group B were 11.76±2.24 and 9.17±1.77 respectively. The univariate tests revealed that there was significant differences in the mean values of the "lumbosacral angle" between both groups with (F=12.309, P=0.002). So, Multiple pairwise comparison tests (Post hoc tests) revealed that there was significant reduction in the lumbosacral angle with (P=0.002) in favor to group B

Table (4):*Descriptive statistics and one way MANOVA for lumbosacral angle between both groups.*

	Group A	Group B	*Mean difference*	
lumbosacral angle	11.76±2.24	9.17±1.77	2.593	
The univariate tests for the mean of lumbosacral angle between different groups				
	F-value		P-value	
lumbosacral angle	12.309		0.002*	
Multiple pairwise comparison tests (Post hoc tests) for the lumbosacral angle between both groups				
lumbosacral angle	Group A	vs.	Group B	p = 0.002*

***Significant at alpha level <0.05**

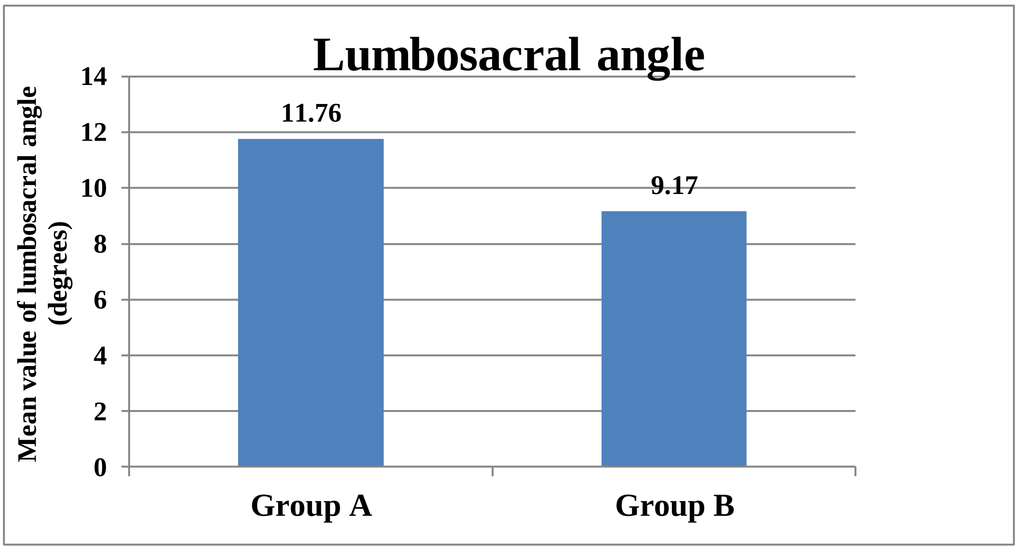

Fig (7): Mean values of lumbosacral angle between both groups.

C. Sacral inclination angle

As presented in table (5) and illustrated in figure (8), between group's comparison the mean ± SD values of sacral inclination angle in the group A and group B were 42.49 ±6.71 and 35.55±3.86 respectively. The univariate tests revealed that there was significant differences in the mean values of the " sacral inclination angle" between both groups with (F=12.029, P=0.002). So, Multiple pairwise comparison tests (Post hoc tests) revealed that there was significant reduction in the sacral inclination angle with (P=0.002) in favor to group B.

Table (5): ***Descriptive statistics and one way MANOVA for sacral inclination angle between both groups.***

	Group A		**Group B**	***Mean difference***
Sacral inclination angle	42.49 ±6.71		35.55±3.86	6.94
The univariate tests for the mean of sacral inclination angle between different groups				
	F-value		**P-value**	
Sacral inclination angle	12.029		0.002*	
Multiple pairwise comparison tests (Post hoc tests) for the sacral inclination angle between both groups				
Sacral inclination angle	**Group A**	**vs.**	**Group B**	**p = 0.002***

***Significant at alpha level <0.05**

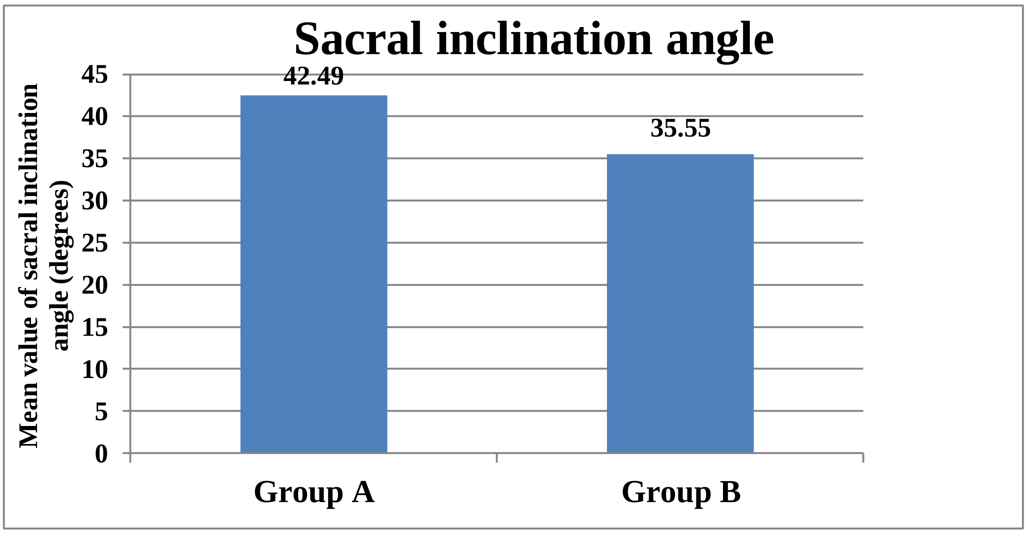

Fig (8): Mean values of sacral inclination angle between both groups.

DISCUSSION

Hamstring muscles have an effect on positioning the pelvis in neutral position in order to restore proper mechanics around the pelvic girdle. the position of the pelvis plays a vital role in how the spine above it and the femur (thigh bone) below it will function. it would be fair to say that an abnormal position of a structure will result in an abnormal movements of that respected structure **(11).**

In the current study, there was a significant correlation between popliteal angle (which is the main indicator of bilateral hamstring muscle shoterning) and Lumbar Lordosis Angle, LumboSacral Angle and Sacral Inclination Angle.

The explanation of these Findings may be due to that Hip muscles, such as the iliopsoas and hamstring, influence the degree of lordosis in static upright posture. These muscles are able to move the pelvis in the sagittal plane - anterior and posterior pelvic tilt. Posterior pelvic tilt can result from contraction or tightness of the hamstring muscles, leading to a more horizontal sacral endplate and hypolordosis (the smaller lordosis would be necesary to keep the line of gravity close to the acetabulum) **(17).**

The findings of this study are in agreement with a study done by Mohamed, **(18)** who demonstrated that there is a relation between degree of hamstring muscle tightness and pelvic tilt and sacral slope. When hamstring tightness increase, the pelvic tilt increase and sacral slope decrease, which leads to flattening of lumbar spine and low back pain.

The findings of this study are in agreement with the results of study done by Roussouly and Nnadi,**(19)** which reported that there is a close correlation exists between the lordosis angle (the common measure of lumbar lordosis) and other postural variables. Many researchers have found a high correlation between the lumbar lordosis angle and pelvic and thoracic orientation in space. Greater lordosis angles correlate with a more horizontally inclined sacrum (increased sacral slope, more vertical sacral endplate), increased pelvic incidence, and increased pelvic tilt. Small lordosis angles usually correlater with a more vertical sacrum, small pelvic tilt, pelvic incidence.

The findings of this study are in agreement with Jonathan et al., **(20)** who demonstrated that forward tilt of the pelvis is related to lumbar hyperlordosis and backward tilt is associated with lumbar flattening. Lower extremity muscle tightness is common with LBP, two patterns are common, First, tight hip flexor muscles (iliopsoas and rectus femoris) result in excessive anterior pelvic tilt and increased lumbar lordosis. The second pattern involves tight hamstring muscles that cause excessive posterior pelvic tilt and decrease lumbar lordosis.

The findings of this study are in agreement with Mccarthy and Betz**, (21)** who demonstrated that there is a correlation between tight hamstrings, as measured by the popliteal angle, and decreasing lumbar lordosis, especially when sitting. They found a significant correlation between the sitting lumbar curve and popliteal angle (Pearson correlation value -0.77, P < 0.01). As the popliteal angle increased, the amount of lumbar lordosis decreased. This correlation was less significant when the patient was standing (Pearson correlation value -0.59).

The findings of this study are contradicted with the results concluded by **Beninato et al.,(22)** who underwent a study on the correlations among lumbar lordosis, pelvic tilt , and the lengths of the hamstring, iliopsoas and rectus femoris muscles. On 30 volunteer physical therapy students (aged 20-30 years), by using a caliper with an attached inclinometer and a flexible ruler, Lumbar Lordosis and Pelvic Tilt were measured in a relaxed standing position. The goniometer was used to measure hamstring length by the degree of straight leg, and Rectus femoris and iliopsoas length by Thomas Test and Modified Thomas Test. The results indicated that there were no correlation of low back or pelvic posture with hamstring muscle length or hip flexor muscle length and also, no correlation found between pelvic tilt and lumbar lordosis.

Conclusion:

Within the limitation of this study, the following conclusion is warranted:

Bilateral hamstrings muscles shortening has a significant effect on the lumbosacral spine and its angles (lumbar lordosis angle, lumbosacral angle and sacral inclination angle). The relation between bilateral hamstrings muscle shortening and radiological parameters of lumbosacral spine could help in setting a rehabilitation program for postural deficits, low back pain and gait abnormalities.

Declaration of interest: The authors report no conflict of interest.

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