www.ijramr.com

ISSN : 2350-0743

International Journal of Recent Advances in Multidisciplinary Research

Vol. 05, Issue 05, pp.3796-3801, May, 2018

RESEARCH ARTICLE

RELATIONSHIP BETWEEN SYMMETRICAL VERSUS ASYMMETRICAL BILATERAL KNEE OSTEOARTHRITIS AND LUMBAR CURVATURE

[1]Amir M. Saleh, [2]Yasser M. Aneis, [3]Ashraf N. Moharram, [4,*]Ahmed M. Kamal

[1]Professor of Physical Therapy ,Basic Sciences Department, Faculty of Physical Therapy, Cairo University and Dean of Faculty of Physical Therapy, South Valley University, Egypt
[2]Assistant Professor of Physical Therapy, Basic Sciences Department, Faculty of Physical Therapy, Cairo University, Egypt
[3]Professor of Orthopaedic Surgery, Orthopedic Surgery Department, Faculty of Medicine, Cairo University, Egypt
[3]Physical Therapist, El-Hay El-Sades Medical Centre, Nasr City, Cairo, Egypt

ARTICLE INFO

Article History:

Received 27th February, 2018
Received in revised form
20th March, 2018
Accepted 18th April, 2018
Published online 30th May, 2018

Keywords:

Symmetrical,
Asymmetrical,
Bilateral Knee Osteoarthritis,
Lumbar Curvature,
Formetric II System.

ABSTRACT

Background: Knee osteoarthritis (OA) is a major health problem worldwide that affects lumbar spine.Objective: This study was conducted to determine the relationship between symmetrical versus asymmetrical bilateral knee OA and lumbar curvature in patients with knee OA.

Subjects: Sixty male patients with knee OA were selected from outpatient clinic of the Faculty of Physical Therapy, Cairo University. Their ages ranged from 40 to 54 years old, with a mean value of 48 ± 3.59 years old.

Methods: Patients were divided into three groups according to severity and symmetry of knee OA as follow; group A: Twenty patients with symmetrical bilateral knee OA (both knees grade II), group B: Twenty patients with symmetrical bilateral knee OA (both knees grade IV), and group C: Twenty patients with asymmetrical bilateral knee OA (one knee grade II and the other knee grade IV). Grades were determined according to Kellgren and Lawrence radiological classification system of OA. A Formetric II system was used to assess the lumbar curvature (lumbar lordotic angle and lateral deviation in the three groups).

Results: Regarding lumbar lordotic angle and lateral deviation, there was a statistical significant difference between the three groups ($F = 39.588$; $P = 0.001$) and ($F = 18.068$; $P = 0.001$) respectively. Regression analysis revealed that there was a statistical significant positive correlation between disease severity of knee OA and both lordotic angle, where ($R2 = 0.559$; $P = 0.001$) and lateral deviation, where ($R2 = 0.377$; $P = 0.001$). Increasing disease severity of OA from the least grade to the next one led to an increase in lordotic angle degree by 4.30 (95% CI = 3.296-5.304) and an increase in lateral deviation by 2.625 mm (95% CI = 1.758-3.492).

Conclusion: Patients with symmetrical bilateral knee OA (grade IV) have more lumbar lordotic angle and lateral deviation than those with symmetrical bilateral knee OA (grade II), however regarding symmetry, patients with asymmetrical bilateral knee OA had lumbar lordotic angle and lateral deviation more than those with symmetrical bilateral knee OA.

INTRODUCTION

Osteoarthritis (OA) is a frequent reason for pain and physical weakness leading to significant considerable problems for the individual and for his society. As age increases, the risk of appearance of OA also increases (Felson, 2009). The knee is one of the joints that are commonly affected by OA. Knee joint is a weight-bearing joint which is important for function and is frequently connected with many complaints in OA (Attur *et al*., 2013). In OA, pain prevents ability of the patient take part in occupational and non-occupational activities of daily living and decreases the quality of life (Filardo *et al*., 2011). To walk, human should maintain a balanced and straight ergonomic upright standing posture by coordination between the spine, pelvis and lower extremity limb, especially in the sagittal view (Le Huec *et al*., 2011; Legaye *et al*., 1998). Defect in any part of the trunk or lower limb causes disturbances in the whole postural balance, leading to compensatory alternations in other parts of the body (Wang *et al*., 2016). Chronic low back pain (LBP) is very popular in patients with knee OA, and this is called 'knee–spine syndrome' (Murata *et al*., 2003; Tsuji *et al*., 2002). However, the cause of the related LBP is not investigated well .The cause of this LBP may be due to the malalignment at the spine and pelvis that occurs in LBP patients (Chaléat-Valayer *et al*., 2011; Roussouly and Pinheiro-Franco, 2011; Jackson and McManus, 1994). Tanaka *et al*. (2007) stated that increase of knee OA is linked with biomechanical factors. In cases of knee OA, there is a considerable lean movement at the trunk during the gait. Knee

***Corresponding author:* Ahmed M. Kamal**
Physical Therapist, El-Hay El-Sades Medical Centre, Nasr City, Cairo, Egypt.

OA may be progressed due to this lean movement of the trunk that increases the load on the knee joint. Yanagisawa *et al.* (2015) conducted a study to investigate the relation between the knee joint and spinal alignment. They measured thoracic kyphosis angle, lumbar lordosis angle, sacral inclination angle, and trunk angle of inclination. There was a correlation between the knee joint and the spine including range of motion (ROM) of the spine as they affect each other. Also, (Gaballah, 2012) conducted a study that discussed the relationship between bilateral knee OA and lumbar lordotic angle, both knees have same grade of OA (symmetrical). The study investigated lumbar lordotic angle changes associated with knee OA, and shown that there was an increase in the lumbar lordotic angle related to the knee OA progression. To date, there have been no reported studies that have compared between the impact of symmetrical versus asymmetrical bilateral knee OA on spinal curvatures in both sagittal and frontal views. Therefore, the aim of this study was to assess spinal curvatures; lumbar lordotic angle and lateral deviation of the spine in subjects with symmetrical versus asymmetrical bilateral knee OA.

Subjects: Sixty male patients were selected from the outpatient clinic of the Faculty of Physical Therapy, Cairo University, their ages ranged from 40 to 54 years old.Patients were divided into three groups according to severity and symmetry of knee OA as follow; group A: Twenty patients with symmetrical bilateral knee OA (both knees grade II), group B: Twenty patients with symmetrical bilateral knee OA (both knees grade IV), and group C: Twenty patients with asymmetrical bilateral knee OA (one knee grade II and the other knee grade IV). Grades were determined according to Kellgren and Lawrence radiological classification system of OA. In this system, grade II means definite osteophytes, without narrowing of joint space and grade IV means large osteophytes with marked narrowing of joint space and sclerosis (Kellgren and Lawrence, 1957). Patients were selected to be enrolled into this study after they had fulfilled the inclusion criteria of the study; male patients with chronic knee OA (pain duration $\geq$ 6 months), their Body mass index (BMI) was $\leq$ 29.9 kg/m^2, waist hip ratio (WHR) was $\leq$ 0.9 and had the ability to walk and to perform other daily living activities independently. Patients had provided informed consent for participation in the study and for publication of the results. This study was approved by the Ethics Committee for Scientific Research of the Faculty of Physical Therapy, Cairo University (No: P.T.REC/012/001213). Subjects were excluded if they had previous orthopedic disorders or neurological deficits of the musculoskeletal system that might affect the lumbar curvature (e.g., traumatic conditions, congenital or acquired orthopedic deformities, foot and/or ankle dysfunction and previous back surgery), or scars at the area of measurement because scars may interfere with measurement with the Formetric system.

Instrumentation

***Weight and height scale**:* ZT-120 (Wincom Company Ltd., Hunan, China) was used to measure the weight and height of each participant and then calculate the BMI (weight (kg)/height (m^2)).

Tape measure: To measure waist and hip circumferences to measure the WHR and to measure the leg length from the anterior superior iliac spine to the medial malleolus of both lower limbs of each subject to exclude subjects with leg length discrepancy.

Formetric instrument system (Diers International GmbH, Schlangenbad, Germany): A valid and reliable method for three-dimensional analysis of spinal deformities without exposure to ionizing radiation.The device analyze the back configuration based on the dimensional scan (Drerup and Hierholzer, 1994).

Procedures

Determination of grade of knee OA: First of all the grade and symmetry of knee OA were determined by Kellgren and Lawrence radiological classification system of OA through X-ray (by the radiologist).

Preparation of the patient: Firstly, data on the subjects' demographic and clinical characteristics was collected in the first session. Weight (kg) was measured to the closest 0.1 kg using a standard weight scale. Height was measured to the closest 0.1 cm with the subject standing in an erect position against a vertical scale of a portable stadiometer. BMI (kg/m2) was estimated as weight in kilograms divided by squared height in meters to exclude BMI more than 30.

Assessment of lumbar lordotic angle and lateral deviation: Each patient stood with bared feet in a neutral, upright posture at a distance of 2 meter in front of the 3D scanning system (photo camera) with his trunk bared skin, the column height was adjusted according to the subject height to move the relevant parts of the patient's back into the center of the control monitor. To insure the best position of the patient a permanent mark was made on the floor in the form of foot print using marker.

- The patient's back surface (including buttocks) was lied completely bare in order to avoid disturbing image structures.
- For any patient a free standing posture was preferable. A rigidly erect standing posture was avoided.
- When the patient and the system were correctly positioned, the system would be ready for image recording. The projector lamp was automatically switched on under program control when the exposure control is started.
- The best moment for releasing image capture was the (slightly) breathed out state. Each patient was first asked for normal breathing. The moment of breathing out was observed on the control monitor. The patient was then asked to stop breathing for some seconds while image capture is released.
- The scanning time was very short (40 ms), in order to eliminate movement artifact. The Formetric II system analyzes the back surface form in a sophisticated, anatomic way with no need for manual fixation of markers on the vertebrae. Anatomical landmarks, vertebral position and rotation were anatomically detected, using the reconstructed high resolution surface, anatomical, and pathological model. The resulting model showed the complete form and the measured data of the examined spine and pelvis. If any of the following landmarks vertebral prominence (VP), sacrum point (SP), left dimple (DL), and right dimple (DR) were not showed clearly, the analysis would not be accounted.

Analysis of the image: The 3D analysis of the spine was conducted and the data were taken from the frontal and sagittal views. This data were then printed (Figure 1 and 2). On each of the collected images, the software automatically indicated the location of the left (DL) and right (DR) sacral dimples associated with the posterior superior iliac spine (Drerup and Hierholzer, 1987) and the location of the vertebral prominence (VP), which is typically located at C7(18).

RESULTS

Demographic and clinical characteristics of subjects in all groups

Demographic and clinical characteristics of subjects in all groups regarding age, weight, height, BMI, WHR in the three studied groups are shown in Table (1).

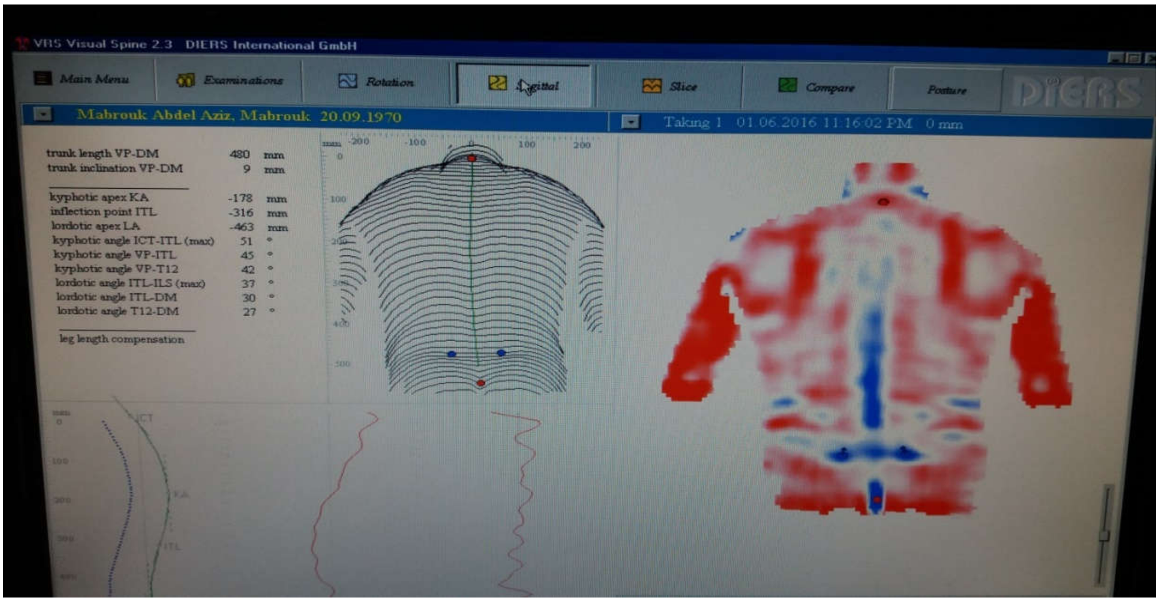

Fig. 1. The printed report of Formetric II showing maximum lordotic angle (Sagittal view)

Fig. 2. The printed report of Formetric II showing maximum lateral deviation (Frontal view)

The middle point between the dimples (DM) was determined from the location of DL and DR. The maximum lordotic angle is the angle between the thoraco-lumbar inflection point (ITL) and the Lumbar-sacral inflection point (ILS) near DM (Drerup and 1994). The maximum lateral deviation of the spinal midline from the line VP-DM. A positive or negative value indicates a deviation to the right or left respectively (Fann, 2002).

Outcome measures

The following parameter were calculated and recorded: lumbar lordotic angle (Max) for lordosis from the sagittal view and lateral deviation (Max) for scoliosis from the frontal view.

Results revealed that there were non-significant differences between the three groups with regard to demographic characteristics and clinical parameters where (P>0.05).

Lordotic angle among the three studied groups: The mean value of lordotic angle in groups A, B and C were (34.85 ± 2.13, 40.65 ± 3.07 and 43.45 ± 3.90), respectively. Analysis of variance (ANOVA) revealed that there was a statistical significant difference between the three groups (F = 39.588; P = 0.001). Multiple pairwise comparison tests (Post-hoc tests) revealed that the mean value of lordotic angle in group C was significantly higher than its corresponding level in both groups A and B (P = 0.001). Also, its level was significantly higher in group B than in group A (P = 0.001) (Table 2).

Table 1. Demographic and clinical characteristics of subjects in all groups

	Group A (n= 20)	Group B (n= 20)	Group C (n= 20)	F value	P value
Age (yrs.)	47.40 ± 3.47	48.65 ± 3.50	47.95 ± 3.87	0.600	0.552 (NS)
Weight (kg.)	78.00 ± 8.10	78.30 ± 4.16	80.85 ± 7.51	1.056	0.354 (NS)
Height (cm)	170.30 ± 5.69	169.55 ± 3.20	170.00 ± 4.90	0.128	0.880 (NS)
BMI (kg/m^2)	26.87 ± 2.15	27.20 ± 1.72	27.94 ± 1.56	1.777	0.178 (NS)
WHR	0.87 ± 0.02	0.87 ± 0.02	0.88 ± 0.01	0.444	0.643 (NS)

Data are expressed as mean ± SD. NS= p> 0.05= not significant.

Table 2. Comparison between mean values of lordotic angle (degree) in the three studied groups

	Group A (n= 20)	Group B (n= 20)	Group C (n= 20)	F value	P value
Mean ± SD	34.85 ± 2.13	40.65 ± 3.07	43.45 ± 3.90	39.588	0.001 (S)
p vs group A	----	0.001 (S)	0.001 (S)		
p vs group B	----	----	0.001		

S= p< 0.05= significant.

Table 3. Comparison between mean values of lateral deviation (mm) in the three studied groups

	Group A (n= 20)	Group B (n= 20)	Group C (n= 20)	F test	P value
Mean ± SD	6.95 ± 2.37	9.45 ± 2.87	12.20 ± 3.00	18.068	0.001 (S)
p vs group A	----	0.006 (S)	0.001 (S)		
p vs group B	----	----	0.003 (S)		

S= p< 0.05= significant.

Table 4. Effect of degree of knee OA (disease severity) on lumber curvature using regression analysis in the three studied groups

	Adjusted R Square	Beta coefficient	P value	95% Confidence Interval for beta coefficient	
				Lower Bound	Upper Bound
Lordotic angle	0.559	4.30	0.001	3.296	5.304
Lateral deviation	0.377	2.625	0.001	1.758	3.492

S= p< 0.05= significant.

Lateral deviation among the three studied groups: The mean value of lateral deviation in groups A, B and C were (6.95 ± 2.37, 9.45 ± 2.87 and 12.20 ± 3.00 mm), respectively. ANOVA revealed that there was a statistical significant difference between the three groups (F = 18.068; P = 0.001). Multiple pairwise comparison tests (Post-hoc tests) revealed that the mean value of lateral deviation in group C was significantly higher than its corresponding level in both groups A and B (P = 0.001; P = 0.003, respectively). Also, its level was significantly higher in group B than in group A (p= 0.006) (Table 3).

Correlation between disease severity of knee OA and lumbar curvature among the three studied groups

Regression analysis test, revealed that there was a statistical significant positive correlation between disease severity of knee OA and both lordotic angle degree (R^2 = 0.559; P = 0.001) and lateral deviation (R^2 = 0.377; P = 0.001) (Table 4). So, disease severity of knee OA was found to be a predictor for increased lumber curvature (lordotic angle degree and lateral deviation) as noted by increasing disease severity of OA from the least grade to the next one led to an increase in lordotic angle degree by 4.30 (95% CI = 3.296-5.304) and an increase in lateral deviation by 2.625 mm (95% CI = 1.758-3.492) (Table 4).

DISCUSSION

Knowing that the human body is a multi-segmental series where all the segments act together in closed kinematic chain, activities and any change in the alignment of one segment is associated with compensatory changes in the alignment of nearby segments and joints.

The present study was conducted to assess spinal curvatures; lumbar lordotic angle and lateral deviation of the spine in subjects with symmetrical versus asymmetrical bilateral knee OA. The results of present study showed that patients with symmetrical bilateral knee OA (both knees grade IV) have more lumbar lordotic angle and lateral deviation than those with symmetrical bilateral knee OA (both knees grade II). However, regarding the symmetry, patients with asymmetrical bilateral knee OA had lumbar lordotic angle and lateral deviation more than those with symmetrical bilateral knee OA. The increase of lumbar lordotic angle was explained by Bennell *et al*. (1998) who stated that patients with knee OA have a greater ROM at the knee joint during walking and stair descent when compared with normal. This increase in knee ROM is a mechanism aiming to decrease pain at the knee joint, leading to shifting the line of gravity of the body posterior to the knee joint leading to increase in the anterior pelvic tilting and thus increasing the lumbar lordotic angle. Mundermann *et al*. (2005) and (Buckland-Wright, 2004) reported that patients with knee OA change the pattern of their gait to decrease the load at the knee joint by changing the moment and increasing load in other lower limb joints and the pelvis.

These compensatory mechanisms might affect pelvic motion and lumbar spine mobility. This work is supported by a study conducted by (Gaballah, 2012) to assess lumbar lordotic angle in patients with symmetrical bilateral knee OA (Grade II and Grade III) from the sagittal plane. Results revealed a significant change in the lumbar lordosis in subjects with grade (III) than subjects with grade (II) knee OA. Shifting of trunk in cases of knee OA might be due to hip muscles weakness as stated by Hinman *et al*. (2010) and Deasy *et al*. (2016) who conducted a study to compare the strength of the hip musculature in people with symptomatic medial knee OA with asymptomatic controls. They stated that patients with knee OA have greater hip muscle weakness than normal subjects. This work is also supported bySimic *et al*. (2012) and Van der Esch *et al*. (2011) who stated that patients with medial compartment knee OA demonstrate a lateral lean of the trunk towards the affected knee at the stance phase. This motion changes the position of the centre of gravity of the body, thus decreasing load at the affected knee joint so decreasing pain. They also stated that the trunk lean is towards the more affected knee. Patients with asymmetrical bilateral knee OA demonstrated the greatest impact on their lordotic angle and their spinal lateral deviation. This might be due to the high association between lateral deviation and lumbar lordotic angle as evidenced by Jae-Young *et al*. (2017) who stated that scoliosis leads to increase in the lumbar lordotic angle and changes in frontal view causes changes at sagittal view of the spine.

Conclusion

Regarding the severity, patients with symmetrical bilateral knee OA (grade IV) have more lumbar lordotic angle and lateral deviation than those with symmetrical bilateral knee OA (grade II), however regarding symmetry, patients with asymmetrical bilateral knee OA had lumbar lordotic angle and lateral deviation more than those with symmetrical bilateral knee OA. So, back assessment needs immense attention and represents an essential part of the evaluation process in patients with knee OA.

REFERENCES

Attur, M., Krasnokutsky-Samuels, S., Samuels, J. and Abramson, SB. 2013. Prognostic biomarkers in osteoarthritis. *Curr Opin Rheumatol.,* 25:136–144.

Bennell, K., Wajswelner, H., Lew, P., Schall-Riaucour, A., Leslie, S., Plant, D. and Cirone, J. 1998. Isokinetic strength testing does not predict hamstring injury in Australian rules footballers. *Br J Sports Med*., 1998; 32: 309-314.

Buckland-Wright, C. 2004. Subchondral bone changes in hand and knee osteoarthritis detected by radiography. *Osteoarthritis Cartilage*, 12Suppl A:S10-9.

Chaléat-Valayer, E., Mac-Thiong, JM., Paquet, J., Berthonnaud, E., Siani, F. and Roussouly, P. 2011. Sagittal spino-pelvic alignment in chronic low back pain. *Eur Spine J.,* 20:634-640.

Deasy, M., Leahy, E. and Semciw, AI . 2016. Hip strength deficits in people with symptomatic knee osteoarthritis: A Systematic Review with Meta-analysis. *J Orthop Sports Phys Ther*., 46:629-639.

Drerup, B. and Hierholzer, E. 1985. Objective determination of anatomical landmarks on the body surface: measurement of the vertebra prominens from surface curvature. *J Biomech.,* 18:467–474.

Drerup, B. and Hierholzer, E. 1987. Automatic localization of anatomical landmarks on the back surface and construction of a body-fixed coordinate system. *JBiomech.,* 20:961–970.

Drerup, B. and Hierholzer, E. 1994. Back shape measurement using videoeastereography and three-dimensional reconstruction of the spinal shape. *Cli nBiomech.,* (Bristol, Avon). 9 :28-36.

Fann, V. 2002. The prevalence of postural asymmetry in people with and without low back pain. *Arch Phys Med Rehabil*., 83:1736-1738.

Felson, DT. 2009. Developments in the clinical understanding of osteoarthritis. *Arthritis Res Ther*., 11:203.

Filardo, G., Kon, E., Buda, R., Timoncini, A., Di, Martino. A,, Cenacchi, A. and Fornasari, PM. 2011. MarcacciM.Platelet-rich plasma intra-articular knee injections for the treatment of degenerative cartilage lesions and osteoarthritis. Knee Surg Sports *TraumatolArthrosc.,* 19:528–535.

Gaballah, HA. 2012. Relationship between bilateral knee osteoarthritis and lumbar curvature.UnpublishedMaster Thesis, Cairo University, Egypt. 48-73.

Hinman, RS., Hunt, MA., Creaby, MW., Wrigley, TV., McManus, FJ. and Bennell, KL. 2010. Hip muscle weakness in individuals with medial knee osteoarthritis. *Arthritis Care Res.,* (Hoboken). 62:1190-1193.

Jackson, RP. and McManus, AC. 1994. Radiographic analysis of sagittal plane alignment and balance in standing volunteers and patients with low back pain matched for age, sex, and size. A prospective controlled clinical study. Spine (Phila Pa 1976) 19:1611-1618.

Jae-Young, H., Keon-Woo, K., Seung-Woo, S., Si-Young, P. and Jae-Hyuk, Y. 2017. Effect of coronal scolioticcurvature on sagittal spinal shape: Analysis of Parameters in Mature Adolescent Scoliosis Patients. *Clini Spine Surg.,* 30:418–422.

Kellgren, JH. and Lawrence, JS. 1957. Radiological assessment of osteo-arthrosis. *Ann Rheum Dis.,* 116:494–502.

Le Huec, JC., Saddiki, R., Franke, J., Rigal, J. and Aunoble S. 2011. Equilibrium of the human body and the gravity line: the basics. *Eur Spine J.,* 20:558-563.

Legaye, J., Duval-Beaupère, G., Hecquet, J. and Marty C. 1998. Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. *Eur Spine J.,* 7:99-103.

Mundermann, A. and Dyrby, CO. 2005. Andriacchi TP. Secondary gait changes in patients with medial compartment knee osteoarthritis : increased load at the ankle, knee, and hip during walking. *Arthritis Rheum.,* 52:2835-2844.

Murata, Y., Takahashi, K., Yamagata, M., Hanaoka, E. and Moriya, H. 2003. The knee-spine syndrome.Association between lumbar lordosis and extension of the knee. *J Bone Joint Surg Br.,* 85:95-99.

Roussouly, P. and Pinheiro-Franco, JL. 2011. Biomechanical analysis of the spino-pelvic organization and adaptation in pathology. *Eur Spine J.,* 20:609-618.

Simic, M., Hunt, MA, Bennell, KL., Hinman, RS. and Wrigley, TV. 2012. Trunk Lean Gait Modification and Knee Joint Load in People With Medial Knee osteoarthritis: The Effect of Varying Trunk Lean Angles. *Arthritis Care Res.,* (Hoboken). 64: 1545–1553.

Tanaka, K., Miyashita, K., Urabe, Y., Koshida, S., Takemoto,Y. and Ijiri, T. 2007. Relationship between pelvic rotation and trunk lean motion during walking in patients with symptomatic knee osteoarthritis. *J Biomech,* 40:508.

Tsuji, T., Matsuyama, Y., Goto, M., Yimin, Y., Sato, K. and Hasegawa, Y. 2002. Ishiguro N. Knee-spine syndrome: correlation between sacral inclination and patellofemoral joint pain. *J Orthop Sci.,* 7:519-523.

Van der Esch, M., Steultjens, MP., Harlaar, J., Noort, JC., Knol, DL. and Dekker, J. 2011. Lateral Trunk Motion and Knee Pain in Osteoarthritis of the Knee: a cross-sectional study. *BMC Musculoskelet Disord*., 12: 141.

Wang, WJ., Liu, F., Zhu, YW., Sun, MH., Qiu, Y. and Weng, WJ. 2016. Sagittal alignment of the spine-pelvis-lower extremity axis in patients with severe knee osteoarthritis: A radiographic study. *Bone Joint Res.,* 5: 198–205.

Yanagisawa, S., Sato, N ., Shimizu, M., Saito, K ., Yamamoto, A. and Takagishi, K. 2015. Relation among the knee, sagittal spinal alignment, and the spinal range of motion: Investigation in local medical check-ups using the SpinalMouse. *Asia-Pacific Journal of Sports Medicine, Arthroscopy, Rehabilitation and Technology,* 2: 68-71.

****