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RESEARCH ARTICLE – MEDICINE (MISCELLANEOUS)

The Impact of Twisting on The Extent of Lower Lumbar Spine Lateral Flexion Among Healthy Subjects

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Abstract

Background: It is acknowledged that 84% of cases of pain are related to the spine. In one instance, low back pain is reduced by the spinal adjustment technique, which is predicated on exerting external stresses on the shoulder and pelvis to twist the human spine. A deeper comprehension of the biomechanical behaviour of the typical lumbar spine in each lower trunk rotational position will yield important information that can be translated into improved physical treatment line.

Objective of study: The objective of this study was to utilize MRI to find how different lower trunk twisting positions influenced the extent of lower lumbar spine lateral flexion.

Materials and Methods: Sagittal T2 weighted Magnetic resonance images of fifteen males with healthy spine structures were collected in order to evaluate the consequences of right and left lumbar spine rotations on the extent of lateral flexion of their lower backs. The extent of the lateral flexion at each contiguous lower lumbar vertebrae was measured manually by using image J software.

Results: In proportion to the lower lumbar twisting positions, the extent of lateral flexion at the last three lumbar levels increased. At all twisting positions, the lateral flexion degree was greatest at fourth- fifth lumbar level. The mean differences of lateral flexion angle were significant only in the left twisting position at the fourth and fifth lumbar levels.

Conclusion: The extent of lateral flexion at all lower lumbar segments grew in synchrony with the lower lumbar twisting positions. fourth–fifth lumbar level had the largest lateral flexion angle. But only in the left rotational position did the effect become noticeable. Consequently, this level may be the primary target of manipulative therapy during treatment.

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Keywords: MRI; Low Back Pain; Lateral Flexion; Lumbar Spine.

1. Introduction

The spinal unit consists of vertebrae that connect through levers, pivots, ligaments, and muscles. Vertebral regions of the human spine have been shown to work together to maintain the body balanced. Vertebral motion involves turning around an axis and moving along one of the cardinal planes. Spinal rotation occurs when opposing forces act on different bones, generating a force combination. In turn, torque which is defined as the overall force that causes rotation can be combined with side bending (coupled motion), except in the atlanto-axial joint. Therefore, side bending is always a part of rotation process. Accordingly, each vertebra has six degrees of freedom due to their capacity to rotate and translate along an axis. So, spinal disorders are often linked to impaired vertebral mobility [1-5].

It is acknowledged that 84% of cases of pain correspond to the spine. Patients with back pain will therefore seek medical assistance. In the UK, the total projected direct healthcare expenses associated with back pain in 2008 were 2.1 billion pounds. Furthermore, it has been stated that 50 million underwent manipulation therapy each year by patients with back discomfort. In fact, the principle of spinal manipulation is accomplished by using twisting forces to reduce lumbago by minimizing disc bulging and releasing adhesions surrounding the prolapsed disc or facet joint [6-11].

Therefore, a deeper comprehension of the impact of lumbar twisting will offer insightful knowledge that will help shape future developments in physiotherapy. Moreover, the mechanical consequences of spine rotation will cause varying degrees of lateral bending at different intervertebral levels [12-16].

As a result, numerous techniques were employed to assess the extent of lateral bending. Nevertheless, some of these studies employed measurement techniques that exposed the participants to a risk of radiation exposure, while others employed techniques that were inaccurate. The extent of lateral flexion at each contiguous lower lumbar spinal level was assessed in this study using a riskless and highly reliable method based on a certain saturated pixel percentage with a predetermined magnification factor [17-23].

2. Materials and Methods

Sagittal T2 weighted Magnetic resonance images of fifteen males with healthy spine structures were collected in order to evaluate the consequences of right and left lumbar spine rotations on the extent of lateral flexion of their lower backs. The extent of the lateral flexion at each contiguous lower lumbar vertebrae was measured manually by using image J software and choosing the mid-sagittal magnetic resonance images to applying a saturated pixel percentage of 70 with a magnification power of 300%.

The extent of the lateral flexion angle was measured as the angle between two lines, one of which was fixed and parallel to the inferior endplate of the superior vertebra, and the other was parallel to the superior endplate of the inferior vertebra, as illustrated in Fig 1. This method was based on the landmarks introduced [15].

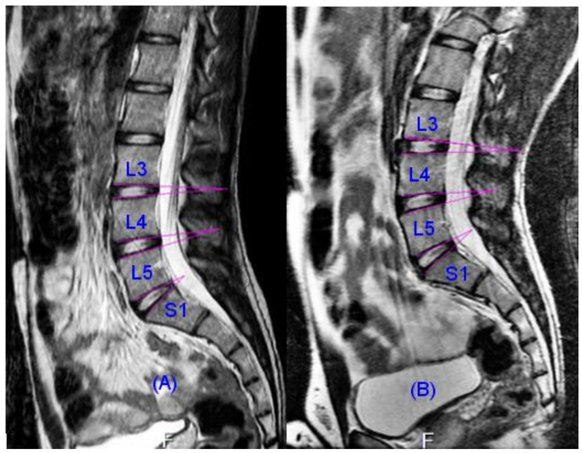

Fig. 1. The measurements of the extent of lateral flexion at last three lower lumbar vertebrae during different lower lumbar spine positions (A) and (B)

The statistical analysis has been done by using SPSS (version 23, IBM Corp.). The mean and the standard error were calculated. After examination the normal distribution by using Shapiro–Wilk test. The mean differences and P-values of lateral flexion degrees at neutral, right, and left twisting of the last three lumbar vertebrae were assessed using the A paired Student's t-test.

3. Results

Using mid-sagittal MRI scans, the extent of lateral flexion of each two adjacent lower segments of the lumbar spine was measured during three various position (neutral and two twisting positions). Table 1 presents the mean of the computed parameters along with their mean standard errors and mean differences at the neutral position (N) and two twisting positions.

Table 1. The degree to which the last three lumbar levels stretch laterally in both the neutral, right and left twisting positions

Intervertebral level	**Lateral flexion degree**		**Mean difference**
	(Mean± standard error)	**Intra class correlation coefficient**	
Third –fourth lumbar level during neutral position	6.7±.3	.98(.95-.99)	-.9(increased)
Third –fourth lumbar level during right twisting without using MRI holder	7.6±.3	.98(.94-.99)	
Third –fourth lumbar level during neutral position	6±.4	.99(.97-1)	-1.5(increased)
Third –fourth lumbar level during right twisting with using MRI holder	7.5±.5	.99(.97-1)	
Third –fourth lumbar level during neutral position	5.8± .6	.99(.98-1)	-2.5 (increased)
Third –fourth lumbar level during left twisting with using MRI holder	8.3± .6	.99(.97-1)	
Fourth- fifth lumbar level during neutral position	8.6±.2	.98(.95-.99)	-2.1 (increased)
Fourth-fifth lumbar level during right twisting without using MRI holder	10.7±.3	.99(.97-.99)	

Fourth- fifth lumbar level during neutral position	8.7±.4	.99(.97-1)	-2.5 (increased)
Fourth-fifth lumbar level during right twisting with using MRI holder	11.2±.5	.99(.97-1)	
Fourth- fifth lumbar level during neutral position	8.6± .4	.98(.94-.99)	-2.9 (increased)
Fourth-fifth lumbar level during left twisting with using MRI holder	11.5± 1	.99(.99-1)	
Fifth lumbar - first sacral level during neutral position	15.7±.6	.99(.99-1)	.3(increased)
Fifth lumbar – first sacral level during right twisting without using MRI holder	16±.8	.97(.90-.99)	
Fifth lumbar - first sacral level during neutral position	17.5±1	.99(.99-1)	-1.3(increased)
Fifth lumbar – first sacral level during right twisting with using MRI holder	18.8±1	.99(.99-1)	
Fifth lumbar - first sacral level during neutral position	14.6± 1	.99(.99-1)	-2.2(increased)
Fifth lumbar – first sacral level during left twisting with using MRI holder	16.8± 1	.99(.99-1)	

A paired t-test was used to measure the P-values and mean differences of the lateral flexion measurements. Depending on the applied twisting forces, the lateral flexion degree of each two adjacent last three lumbar vertebrae increased. At all twisting positions, the lateral flexion angle was greatest between the fourth and fifth vertebral level. However, as Fig. 2 illustrates, the mean differential values were only determined to be significant ($p < 0.005$) for the left twisting position.

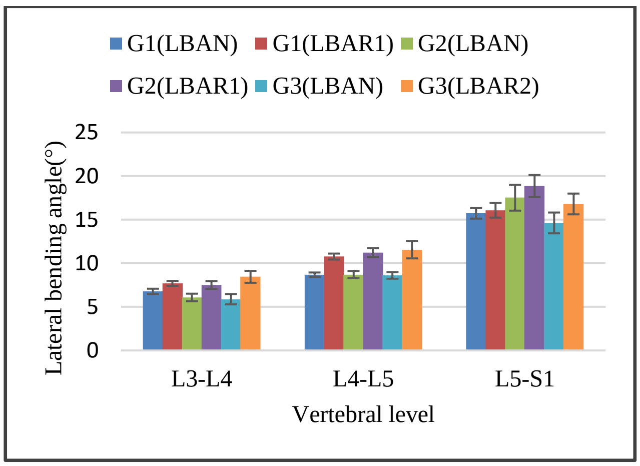

Fig. 2. The degree of the lateral flexion (LBA) during two different twisting positions (right and left) in the first, second and third groups compared with neutral position (N)

4. Discussion

In the present study, a modified method was used to measure the extent of the lateral bending at the last three lumbar spine vertebrae during rotation. Image J was used as an effective method for measuring the angle of lateral flexion by using mid -sagittal MRI scans. In proportion to the lower lumbar twisting positions, the extent of lateral flexion at the last three lumbar levels increased. At all twisting positions, the lateral flexion degree was greatest at fourth- fifth lumbar level. The mean differences of lateral flexion angle were significant only in the left twisting position at the fourth and fifth lumbar levels.

Demonstrated [24] that the prolapsed disc develops in the mid-disc plane when the spinal components are simultaneously compressed and flexed laterally, which could account for these findings. The concave side of the lateral flexion is where this disc bulge is most noticeable, both laterally and postero-laterally. Also [13] were disagree with these findings. However, Pearcy and Tibrewal study indicating that the lateral flexion at the first three lumbar levels was approximately ten degrees, nevertheless the lateral flexion between the fourth-fifth lumbar level and fifth lumbar vertebrae-first sacral vertebrae was six and three degrees, respectively. In contrast [14] indicated that the primary lateral flexion increased from three degrees at T12-L1 to 4.9 degrees at L4-L5, while reduced to 3.4 degrees at L5-S1. The conclusion of [13] could explain these different observations, which indicated that there was no simple mechanical coupling of the spine rotations and the coordination between the shapes of the lumbar lordosis together with muscular actions are the main determining factors that may explain the relationship between the primary and accompanying rotations. However, the degree of the lateral flexion could be influenced by the orientation of the articular facets of the lumbar segments. These results were in agreement with [25] who observed that the articular facets of the human spine lack a uniform shape and orientation.

In turn [26] stated that there are two facet joints in each vertebral level of the spine, extending from the cervical to the lumbar region. Accordingly, the articular spine facet could interfere with extent of the lateral flexion of the whole spine. Moreover, the mechanical impact of the lumbar facets on the intervertebral disc function plays an important role in the different movement of the whole trunk. In other words, the difference between the orientation angle of the right and left superior articular facets can control the applied load on the disc by applying the required opening distance of the facet according to each involved lumbar segment. According to [7] the disc contains annulus which surrounds the nucleus pulposus and possesses two functions: distributing and transferring compressive loads across vertebrae and promoting joint movement. So, annulus fibrosis and nucleus pulposus are structures provide nourishment to the intervertebral disc and can deflect under axial loads between the disc and the vertebral body. However [27] and [28] observations might explain the mechanical relationship between the following structures: the different orientations of the articular facets, the intervertebral discs and the axis of rotation of the vertebral body. The limitation of the current study was the small sample size, which may not reflect the normal population.

5. Conclusion

With the use of mid-sagittal MRI scans, the lateral flexion angle of each of the two consecutive lower lumbar vertebrae was determined for the three position (neutral and two twisting positions). The extent of lateral flexion at all lower lumbar segments grew in synchrony with the lower lumbar twisting positions. fourth–fifth lumbar level had the largest lateral flexion angle. But only in the left rotational position did the effect become noticeable. Consequently, this level may be the primary target of manipulative therapy during treatment.

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Nomenclature & Symbols			
MRI	Magnetic resonance imaging	SPSS	Statistical Package for the Social Sciences
LBA	The degree of the lateral bending	MD	Mean difference
N	Neutral position	SD	Standard Deviation
RR	Right rotation	SE	Standard Error
LR	Left rotation	ICC	Intra class correlation coefficient
G1(LBAN)	Group1(lateral bending angle at neutral position)	G2(LBAN)	Group 2 (lateral bending angle at neutral position)

References

[1] Allegri, M., Montella, S., Salici, F., Valente, A., Marchesini, M., Compagnone, C., & Fanelli, G. (2016). Mechanisms of low back pain: a guide for diagnosis and therapy. F1000Research, 5. 10.12688/f1000research.8105.2.

[2] Leboeuf-Yde, C., Klougart, N., & Lauritzen, T. (1996). How common is low back pain in the Nordic population? Data from a recent study on a middle-aged general Danish population and four surveys previously conducted in the Nordic countries. Spine, 21(13), 1518-1525.

[3] Jarvik, J. G., & Deyo, R. A. (2002). Diagnostic evaluation of low back pain with emphasis on imaging. Annals of internal medicine, 137(7), 586-597. DOI: 10.7326/0003-4819-137-7-200210010-00010.

[4] Brinjikji, W., Luetmer, P. H., Comstock, B., Bresnahan, B. W., Chen, L. E., Deyo, R. A., & Jarvik, J. G. (2015). Systematic literature review of imaging features of spinal degeneration in asymptomatic populations. American journal of neuroradiology, 36(4), 811-816. doi: https://doi.org/10.3174/ajnr.A4173.

[5] NICE NG59 National Institute for Health and Care Excellence (2017). Available at:http://www.noebackpainprogramme.nhs.uk/wp-content/uploads/2015/05/National-Low-Back-and-Radicular-Pain-Pathway-2017_final.pdf [Accessed: 03-02-2018].

[6] Maniadakis, N., & Gray, A. (2000). The economic burden of back pain in the UK. Pain, 84(1), 95-103. https://doi.org/10.1016/S0304-3959(99)00187-6.

[7] Nazari, J. (2007). The effects of different posture on lumbar spine loading. University of Aberdeen (United Kingdom).

[8] Herzog, W. (2010). The biomechanics of spinal manipulation. Journal of bodywork and movement therapies, 14(3), 280-286. https://doi.org/10.1016/j.jbmt.2010.03.004.

[9] Shekelle, P. G., Adams, A. H., Chassin, M. R., Hurwitz, E. L., & Brook, R. H. (1992). Spinal manipulation for low-back pain. Annals of internal medicine, 117(7), 590-598. https://doi.org/10.7326/0003-4819-117-7-590.

[10] Ferreira, M. L., De Luca, K., Haile, L. M., Steinmetz, J. D., Culbreth, G. T., Cross, M., & Mahmoodpoor, A. (2023). Global, regional, and national burden of low back pain, 1990– 2020, its attributable risk factors, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. The Lancet Rheumatology, 5(6), e316-e329. https://www.thelancet.com/action/showPdf?pii=S2665-9913%2823%2900098-X.

[11] Gill, T. K., Mittinty, M. M., March, L. M., Steinmetz, J. D., Culbreth, G. T., Cross, M., ... & Vasankari, T. J. (2023). Global, regional, and national burden of other musculoskeletal disorders, 1990–2020, and projections to 2050: a systematic analysis of the Global Burden of Disease Study 2021. The Lancet Rheumatology, 5(11), e670-e682. https://www.thelancet.com/action/showPdf?pii=S2665-9913%2823%2900232-1

[12] Fujii, R., Sakaura, H., Mukai, Y., Hosono, N., Ishii, T., Iwasaki, M., ... & Sugamoto, K. (2007). Kinematics of the lumbar spine in trunk rotation: in vivo three-dimensional analysis using magnetic resonance imaging. European spine journal, 16, 1867-1874.]

[13] Pearcy, M. J., & Tibrewal, S. B. (1984). Axial rotation and lateral bending in the normal lumbar spine measured by three-dimensional radiography. Spine, 9(6), 582-587.

[14] Barnes, D., Stemper, B. D., Yoganandan, N., Baisden, J. L., & Pintar, F. A. (2009). Normal coupling behavior between axial rotation and lateral bending in the lumbar spine-biomed 2009. Biomedical sciences instrumentation, 45, 131-136. https://europepmc.org/article/med/19369752.

[15] Suri, A., Jones, B. C., Ng, G., Anabaraonye, N., Beyrer, P., Domi, A., & Rajapakse, C. S. (2021). Vertebral deformity measurements at MRI, CT, and radiography using deep learning. Radiology: Artificial Intelligence, 4(1), e210015. https://doi.org/10.1148/ryai.2021210015.

[16] Gram, M. C., & Hasan, Z. (1999). The spinal curve in standing and sitting postures in children with idiopathic scoliosis. Spine, 24(2), 169-177.

[17] BRYANT, J. T., Reid, J. G., SMITH, B. L., & STEVENSON, J. M. (1989). Method for determining vertebral body positions in the sagittal plane using skin markers. Spine, 14(3), 258-265.

[18] Chen, Y. L., & Lee, Y. H. (1997). A non-invasive protocol for the determination of lumbosacral vertebral angle. Clinical Biomechanics, 12(3), 185-189. https://doi.org/10.1016/S0268-0033(97)00076-4.

[19] Cerveri, P., Pedotti, A., & Ferrigno, G. (2004). Non-invasive approach towards the in vivo estimation of 3D inter-vertebral movements: methods and preliminary results. Medical engineering & physics, 26(10), 841-853. https://doi.org/10.1016/j.medengphy.2004.08.005.

[20] Gracovetsky, S., Newman, N., Pawlowsky, M., Lanzo, V., Davey, B., & Robinson, L. (1995). A database for estimating normal spinal motion derived from noninvasive measurements. Spine, 20(9), 1036-1046.

[21] Mörl, F., & Blickhan, R. (2006). Three-dimensional relation of skin markers to lumbar vertebrae of healthy subjects in different postures measured by open MRI. European Spine Journal, 15, 742-751. https://doi.org/10.1007/s00586-005-0960-0.

[22] Gould, S. L., Davico, G., Liebsch, C., Wilke, H. J., Cristofolini, L., & Viceconti, M. (2024). Variability of intervertebral joint stiffness between specimens and spine levels. Frontiers in Bioengineering and Biotechnology, 12, 1372088. https://doi.org/10.3389/fbioe.2024.1372088

[23] Chastain, K., Gepner, B., Moreau, D., Koerber, B., Forman, J., Hallman, J., & Kerrigan, J. (2023). Effect of axial compression on stiffness and deformation of human lumbar spine in flexion-extension. Traffic injury prevention, 24(sup1), S55-S61. https://doi.org/10.1080/15389588.2023.2198627.

[24] White, A. A. P. M. (1990). Clinical biomechanics of the spine. Clinical biomechanics of the spine.

[25] Bogduk, N. (2005). Clinical anatomy of the lumbar spine and sacrum. Elsevier Health Sciences.

[26] Jaumard, N. V., Welch, W. C., & Winkelstein, B. A. (2011). Spinal facet joint biomechanics and mechanotransduction in normal, injury and degenerative conditions. Journal of biomechanical engineering, 133(7), 071010. https://doi.org/10.1115/1.4004493.

[27] Shin, J. H., Wang, S., Yao, Q., Wood, K. B., & Li, G. (2013). Investigation of coupled bending of the lumbar spine during dynamic axial rotation of the body. European Spine Journal, 22, 2671-2677. https://doi.org/10.1007/s00586-013-2777-6.

[28] Toyone, T., Ozawa, T., Kamikawa, K., Watanabe, A., Matsuki, K., Yamashita, T., & Wada, Y. (2009). Facet joint orientation difference between cephalad and caudad portions: a possible cause of degenerative spondylolisthesis. Spine, 34(21), 2259-2262. DOI: 10.1097/BRS.0b013e3181b20158.