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Evaluation Of Changes in Lumbar Intervertebral Foramina Dimensions in Egyptian Adults by Radiological Study

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Abstract:
OBJECTIVES: *Chronic low back pain is a common cause of disability and poor quality of life. Its prevalence increases linearly from the third decade of life until the 60 years of age, being more prevalent in women. Lumbar disc herniation (LDH) is one of the main etiologies seen in 20% of the patients. Although most of the cases can be managed with the conservative treatments, surgery is still needed for those with progressive neurological deficits. Transforaminal percutaneous endoscopic lumbar discectomy (PELD) is done through the Kambin triangle. Morphological changes of lumbar intervertebral foramina are not only important in aiding PELD procedure but also in illustrating stenosis.*
METHODS: *50 healthy adult subjects (17 males and 33 females) aged between 20-60 years were included in the study. The subjects were outpatient individuals checking themselves after simple injuries. All the cases of fractures, disc prolapse, disc herniation, severe vertebral column deformity were excluded. The gross radiological anatomy of the lumbar region was carefully examined to study various patterns of lumbar intervertebral foramina dimensions. Sectional radiological anatomy of these foramina was analyzed using MRI. The sample size calculation was performed using the STATA 10 program.*
RESULTS: *Significant differences were found at all vertical diameter of intervertebral foramina in all lumber levels was more in males than in females, significant differences were found at vertical diameter of the age group (< 35) was more than age group (> 35) at the following levels L2-L3 and L4-L5 and high significant differences in L2-L3 and in L4-L5.*
CONCLUSION: *This study contributes on elucidating the impacts of gender, age, and anatomical symmetry on intervertebral foramina measurements. These findings highlight the importance of personalized assessment in spinal healthcare, as anatomical variations are associated with different clinical outcomes and risk factors.*
Keywords: *Intervertebral foramina; Kambin's-triangle; Percutaneous endoscopic lumbar discectomy (PELD)*

1. INTRODUCTION

Low back pain is a common cause of disability and poor quality of life. Chronic low back pain prevalence increases linearly from the third decade of life until the 60 years of age, being more prevalent in women (Samini et al 2014). It is considered with a radicular component a common ailment in many clinics and is a leading cause of disability and adds a great burden to health care costs globally (Mokdad et al 2018).
Lumbar disc herniation (LDH) is one of the main etiologies seen in 20% of the patients. Although most of the cases can be managed with the conservative treatments, surgery is still needed for those with progressive neurological deficits (Oppenheimer et al 2009).
Transforaminal percutaneous endoscopic lumbar discectomy (PELD) is done through the Kambin triangle (Cong et al 2016). Kambin triangle represents a right triangle over the dorsolateral disc, with inferior border being the rim of the vertebral plate, posteriorly is the lateral edge of the superior articular process of the next inferior vertebra and the third border is the related spinal nerve (Ruetten et al 2008).
Morphological changes of lumbar intervertebral foramina are not only important in aiding PELD procedure but also in illustrating stenosis (Fujiwara et al 2001). Several in vitro and in vivo studies have reported the changes of lumbar intervertebral foramina (Fredericson et al 2001).
The purpose of this study is to describe the topographic anatomy of the lumbar intervertebral foramina (through radiological data) also to provide morphometric data on lumbar intervertebral foramina dimensions in adult normal population.

MATERIALS AND METHOD

50 healthy adult subjects (17 male and 33 female) aged between 20-60 years were included in the present study. Approval of this study was obtained from institutional ethics committee. The subjects were outpatient individuals checking themselves after simple injuries. All the cases of fractures, disc prolapse, disc herniation, severe vertebral column deformity were excluded, inclusion criteria were age (20-60) years old and unremarkable MRI.

The study was conducted in the anatomy and radiology departments on October 6 University Hospitals, Giza, Egypt. MRI images were acquired with participants in the supine position. A total of 100 MRI studies were included.

The gross radiological anatomy of the lumbar region was carefully examined radiological to study various patterns of lumbar intervertebral foramina dimensions. Sectional radiological anatomy of these foramina was analyzed using MRI. The sample size calculation was performed using the STATA 10 program (Nowak & Kubaszewski 2022).

RESULTS

1.Gender-Based Differences in Vertical and Disc Measurements

Statistically significant differences between males and females were found in vertical measurements at multiple levels, with males generally having larger measurements **(Fig. 1) & (Table 1)**.

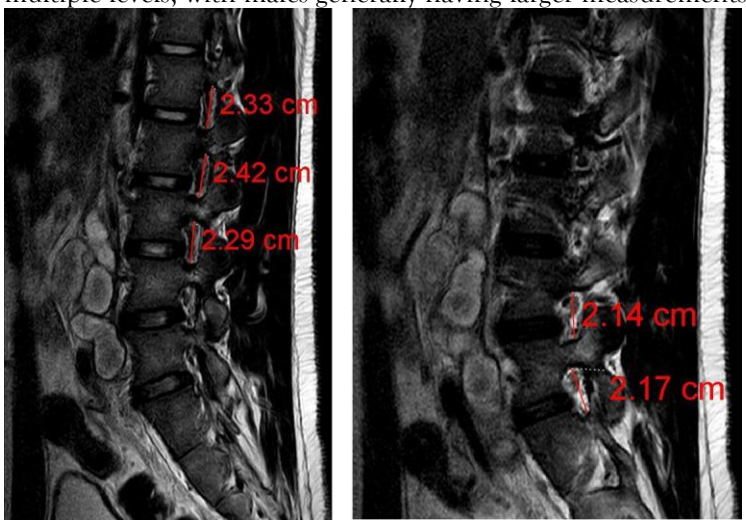

FIG 1: MRI of the lumber spine sagittal view T2 sequence right paramedian at the level of neural exit foramen showing vertical measurements of intervertebral foramen of all lumber level of an adult male the measurement as follows

Table 1: Comparison between females and males regarding different vertical levels using independent t-test (P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant).

Vertical		Sex Female No. = 34	 Male No. = 66	Test value	P-value	Sig.
L1-12	Mean ± SD Range	1.67 ± 0.16 1.34 – 1.94	1.76 ± 0.16 1.34 – 2.31	-2.641 •	0.010	S
L2-L3	Mean ± SD Range	1.77 ± 0.18 1.48 – 2.2	1.87 ± 0.16 1.54 – 2.47	-2.947 •	0.004	HS
L3-L4	Mean ± SD Range	1.75 ± 0.2 1.14 – 2	1.88 ± 0.18 1.49 – 2.42	-3.338 •	0.001	HS
L4-L5	Mean ± SD Range	1.64 ± 0.16 1.11 – 1.92	1.83 ± 0.19 1.44 – 2.28	-4.862 •	0.000	HS
L5-S1	Mean ± SD Range	1.41 ± 0.2 0.97 – 1.77	1.62 ± 0.27 1.13 – 2.55	-4.102 •	0.000	HS

2. Age-Related Changes

The younger age group (<35 years) demonstrated higher mean measurements at certain levels compared to the older group, indicating potential age-related spinal degeneration **(Fig. 2, 3, 4) & (Table 2)**.

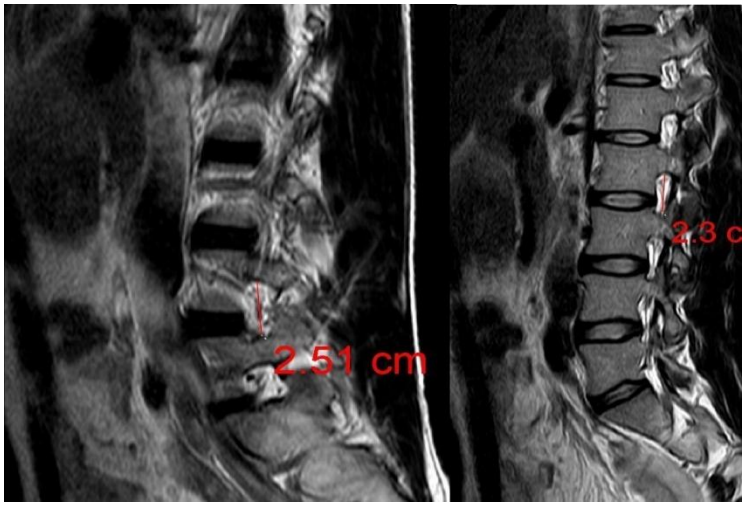

FIG 2: MRI of the lumber spine sagittal view T2 sequence right paramedian at the level of neural exit foramen showing vertical measurements of intervertebral foramen of adult male his age below 35 at

FIG 3: MRI of the lumber spine sagittal view T2 sequence right paramedian at the level of neural exit foramen showing vertical measurements of intervertebral foramen of adult male his age below 35 at L3 - L4 and L5 -S1 as follows

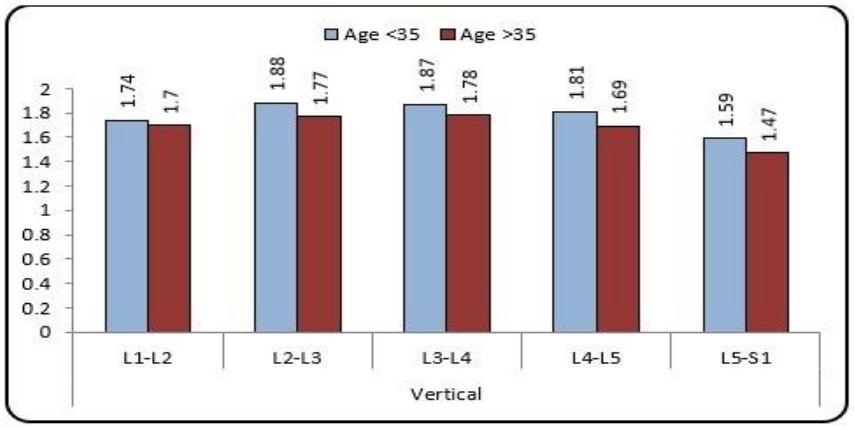

FIG 4: Comparison between age groups regarding different vertical levels

Table (2): Comparison between age groups regarding different vertical levels using independent t-test (P-value > 0.05: Non significant; P-value < 0.05: Significant; P-value < 0.01: Highly significant).

Vertical		Age <35 No. = 60	>35 No. = 40	Test value	P-value	Sig.
L1-12	Mean ± SD	1.74 ± 0.17	1.7 ± 0.16	1.180 •	0.241	NS
	Range	1.34 – 2.31	1.34 – 1.96			
L2-L3	Mean ± SD	1.88 ± 0.16	1.77 ± 0.17	3.227 •	0.002	HS
	Range	1.54 – 2.47	1.48 – 2.2			
L3-L4	Mean ± SD	1.87 ± 0.17	1.78 ± 0.22	2.207 •	0.030	S

L4-L5	Range	1.49 – 2.42	1.14 – 2.28			
	Mean ± SD	1.81 ± 0.16	1.69 ± 0.22	3.347•	0.001	HS
	Range	1.45 – 2.28	1.11 – 2.16			
L5-S1	Mean ± SD	1.59 ± 0.26	1.47 ± 0.25	2.271•	0.025	S
	Range	1.17 – 2.55	0.97 – 1.88			

3. No Significant Differences in horizontal Levels

Horizontal level comparisons showed no significant differences between right and left sides.

4- Asymmetry in Intervertebral Spaces:

Observed asymmetry at specific intervertebral levels in patients, often attributed to asymmetric loading or postural adaptations over time. This supports the idea that certain levels, like L2-L3 and L4-L5, are more susceptible to functional or structural asymmetry.

Implications of Findings

Clinical Practice: The identified asymmetry and gender differences suggest a need for tailored therapeutic strategies. For instance, younger patients may benefit from preventative measures to maintain disc health, while older patients might require interventions targeting age-related spinal changes.

Future Research: These results highlight the importance of further studies on the impact of asymmetry at the L2-L3 and L4-L5 levels, especially in populations exposed to physical labor or sports. Additionally, research focusing on how these anatomical variations affect pain and mobility could enhance treatment protocols.

Medical Imaging Standards: Given the differences observed, MRI protocols could be optimized to account for these anatomical variations, especially in planning surgical or therapeutic interventions for different age groups and genders

DICCUSION:

The present study provides insights into anatomical variations in the lumbar intervertebral foramina dimensions at vertical levels measurements across gender and age groups. The findings demonstrate significant asymmetry at specific lumbar spine levels (notably L2-L3 and L4-L5) and reveal measurable differences between genders and age groups. These results have potential implications for both clinical practice and further research, as discussed below.

MRI measurements were employed to analyze intervertebral space dimensions at multiple spinal levels. This non-invasive method has been highlighted in research, as effective for accurately assessing intervertebral foramen size, especially for investigating age and gender variations in spinal anatomy.

Gender-Based Differences in Intervertebral foramina Measurements

A key finding of this study is the statistically significant differences between males and females in vertical measurements at multiple lumbar levels, with males generally having larger values. This observation is consistent with findings from Endo, K. et al (2012) who reported that men typically exhibit greater vertebral height and intervertebral space, likely due to increased muscle mass and load-bearing capacity.

According to Zhou, S. et al (2020) gender based anatomical differences have clinical implications, as they may influence spinal stability and predisposition to injury. For example, males with larger vertebral dimensions may be more resistant to certain types of spinal compression, while females with smaller spaces might be more prone to conditions such as spinal stenosis or nerve impingement.

The implications of these gender differences underscore the importance of personalized assessment in clinical practice. For physiotherapists and orthopedic specialists, understanding that males and females may have structurally different spines can guide diagnostic and therapeutic decisions. Gender-specific data should be integrated into spinal assessments, ensuring that both male and female patients receive tailored care that considers these anatomical variations. Zhou, S. et al (2020).

Age-Related Changes in Intervertebral foramina Measurements

Our study found that younger patients (<35 years) had higher mean values in certain disc levels compared to the older group. There is significant difference at vertical levels between L3-L4 and L5-S1, and highly significant difference at vertical levels between L2-L3 and L4-L5.

This decrease in intervertebral dimensions with age aligns with established evidence that intervertebral disc height and foramen size diminish over time, primarily due to degenerative processes according to Yan, S. et al. 2018. These changes are often linked to biochemical alterations in the disc matrix, which reduce disc hydration and elasticity, contributing to height loss and foraminal narrowing.

Such age-related changes highlight the value of preventative care in younger populations to delay or mitigate the progression of spinal degeneration. Sun Z. et al. 2022 referred that early intervention strategies, including core strengthening exercises and ergonomic adjustments, may preserve disc height and structural integrity, potentially delaying the onset of age-related spinal conditions. Moreover, the longitudinal nature of spinal degeneration underscores the need for continued research on therapeutic interventions that target these age-related changes at both the cellular and structural levels.

Clinical and Imaging Implications

The findings from MRI measurements employed in this study support MRI's efficacy as a reliable method for assessing intervertebral foramen size and structural differences across populations. MRI is widely recognized as the gold standard for evaluating spinal anatomy due to its non-invasive nature and high resolution. Liu, M. et al. (2020) pointed to that MRI effectively captured subtle anatomical differences, providing a comprehensive understanding of variations in the lumbar spine.

Future imaging protocols might consider incorporating gender- and age-specific reference values to optimize the diagnostic process, particularly for conditions such as herniation, stenosis, and foraminal narrowing, which are sensitive to structural variability.

MRI also allows for real-time assessment of spinal stability and the identification of specific areas vulnerable to degeneration. Hey, H.W.D. et al. (2017) said that given the observed differences in intervertebral dimensions, MRI could be particularly beneficial in monitoring high-risk groups, such as older adults or individuals with a history of spinal injury. As our understanding of spinal variability improves, imaging protocols can be refined to incorporate these variations, potentially enhancing diagnostic accuracy and patient outcomes.

Limitations and Future Directions

While this study provides valuable insights, several limitations warrant consideration. The cross-sectional design limits our ability to draw causal inferences about the progression of age-related changes or the impact of physical activity on spinal dimensions. Additionally, while our sample size is sufficient for detecting significant differences, larger longitudinal studies could provide a more comprehensive understanding of these anatomical variations over time.

Future research should focus on longitudinal analysis of spinal changes in diverse populations, examining how lifestyle factors, such as occupation and physical activity level, influence the progression of spinal degeneration. Investigating the efficacy of preventative measures targeting younger individuals could also contribute to evidence-based strategies for mitigating age-related spinal decline.

CONCLUSION

In conclusion, this study contributes to the existing literature on anatomical variations in the lumbar spine by elucidating the impacts of gender, age, and anatomical symmetry on intervertebral foramina measurements. This study highlights the importance of personalized assessment in spinal healthcare, as anatomical variations of the intervertebral foramina measurement are associated with different clinical outcomes and risk factors. Continued research on spinal structure and its implications for musculoskeletal health will be essential in refining diagnostic practices and developing targeted interventions for spinal disorders.

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Conflict of interest:

There are no conflicts of interest.

Ethical Approval:

The study was approved by the Research Ethics Committee at October 6 University from the ethical point of view. The O6U REC is organized and operated according to guidelines of the International Council on Harmonization (ICH) and the Islamic Organization for Medical Sciences (IOMS), the United States Office for Human Research Protections and the United States Code of Federal Regulations and operates under Federal Wide Assurance No.
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Authors contributions:

Radwa M. El Sabban: writing, revising, and editing. Kamal A. Ibrahim: designing and supervision of the

work, Ahmed M. Desouky: vision of the work, methodology and writing. Basem A. Dawam: collecting data, statistical analysis, and writing. Mahmoud M. Assem: methodology of the research and analysis.

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