Age Related Changes in Height and Shape of The Lumbar Intervertebral Discus

Ismail Malkoc[1], Sener Atif Aydinlioglu[2], Fatih Alper[3], Fatih Kaciroglu[1], Yasemin Yuksel[4], Ramazan Yuksel[5], Asli Kara[1], Senol Dane[5], Muhsin Toktas[6]

[1]Department of Anatomy, Medical School, Ataturk University, Erzurum, Turkey.

[2]Department of Anatomy, Medical School, Yuzuncu Yil University, Van, Turkey.

[3]Department of Radiology, Medical School, Ataturk University, Erzurum, Turkey.

[4]Department of Histology and Embryology, Medical School, Fatih University, Ankara, Turkey.

[5]Department of Physiology, Medical School, Fatih University, Ankara, Turkey.

[6]Department of Anatomy, Medical School, Fatih University, Ankara, Turkey.

Eur J Basic Med Sci 2012;2(3):68-73

Received: 11-06-2012

Accepted: 06-10-2012

Correspondence (Yazışma Adresi):
Dr. Ramazan YUKSEL, School of Medicine, Department of Physiology, Fatih University, Ankara, Turkey
e-mail: ryuksel38@hotmail.com

ABSTRACT

There was no agreement on intervertebral disc changes by age in human lumbar spine in the previous studies. The present study aimed the re-examination of the possible changes in intervertebral lumbar discs by age in healthy subjects. Normal lumbar spine magnetic resonance imaging (MRI) scans were obtained from 171 individuals (84 men, 87 women; 12-80 years old). The anterior and posterior heights and the depths of the intervertebral discs at each level of the lumbar spine were measured. The gender and age-related changes were not significant for heights. The depths of the intervertebral discs changed with age significantly in both sexes. The average disc height and shape index increased with age significantly in some disks individually. The disk depths showed only gender difference. The present study did not find clear increases in all dimensions and the shape of the discs of both sexes with age and differed from the previous studies. Our findings needed to be confirmed by the further MRI studies.

Key words: *Lumbar intervertebral disc, disc height, disc shape*

Lumbal İntervertebral Disklerin Yükseklik ve Şekillerinde Yaşa Bağlı Değişiklikler

ÖZET

Önceki çalışmalarda insan lomber intervertebral disklerin yaşa bağlı değişiklikleri hakkında herhangi bir fikir birliği yoktu. Bu çalışmada sağlıklı bireylerde yaş ile birlikte lomber intervertebral disklerde olası değişikliklerin yeniden incelenmesi amaçlanmıştır. Normal lomber vertebra Manyetik Rezonans Görüntülemeye (MRG) 171 kişi (12-80 yaş arasında 84 erkek ve 87 kadın) alındı. Vertebrae lumbalesler'in discus intervertebralis'lerinin her seviyesinde anterior ve posterior yükseklik ve derinlikleri ölçüldü. Yükseklik bakımından cinsiyet ve yaşa bağlı değişimler anlamlı değildi. Her iki cinsiyette de discus intervertebralis derinliklerinin yaşa bağlı değişiklikleri anlamlıydı. Ortalama discus intervertebralis yüksekliği ve şekil indeksi bazı kişilerde yaş ilerledikçe anlamlı bir biçimde artmaktaydı. Discus intervertebralis derinlikleri ise sadece cinsiyet bakımından farklılık gösterdi.

Bu çalışma diğer çalışmalardan farklı olarak her iki cinsiyette disklerin tüm boyutlarının ve şekillerinin yaşa bağlı değişikliklerinde net bir artış tespit edemedi. Bulgularımızın daha fazla MRG çalışmaları ile teyit edilmesi gerekebilir.

Anahtar kelimeler: *Lumbal intervertebral disk, disk yüksekliği, disk şekli*

INTRODUCTION

The intervertebral discs are the most important structure in the maintenance of spinal function. The age changes of the intervertebral disc in human lumbar spine have been studied (1-4). The intervertebral disc shows the adaptation to the changes in the current mechanical conditions within the vertebral column with age (2). The disk changes with age were reported to be different from each other in the studies with autopsy (5) and cadaver (4). Vernon-Roberts and Prie (5) proposed that the thinning in most of the intervertebral and the loss in stature occurs with increasing age. On the other hand, Twomey and Taylor (4) reported that the loss of disc height is unusual in a normal, aging population.

Changes in the dimensions of human lumbar intervertebral discs have been also studied by using plain radiographs. The results were found to be different in them as the previous reports. While overall increase was observed in the various dimensions of the disc with age in the study by Amonoo-Kuofi (1), Aydinlioglu et al. (2) indicated that the height of the intervertebral disc increases with aging only in males. Therefore, it has not already been come to an agreement on the intervertebral disk changes with age by the previous studies. Since the magnification errors resulting from non-standardized film-tube distances is possible in the studies using the plain films, the magnetic resonance imaging is a more reliable in the measurement of the intervertebral disk (6). Therefore, we aimed to re-examine the age changes of intervertebral lumbar disks by using MR scans obtained from healthy subjects from eastern Anatolian individuals.

MATERIAL and METHODS

Normal lumbar spine MRI scans obtained from 171 individuals (84 male, 87 female; 12–80 years old) were evaluated. Subjects with a history of trauma, surgery in the spine, spinal tumours, congenital anomalies, radiotherapy and scoliosis were excluded from the study. The MRI scanner had 1.5-T field strength (Intera Nova; Philips Medical Systems, Best, The Netherlands). The sagittal slice thickness was 4 mm and the interslice gap was 1 mm. Distances between adjacent vertebral bodies were determined as disc space. The landmarks for the measurements were taken as the extreme anterior or posterior margins of the end-plates of the vertebrae (2). The anterior and posterior height and the depths of the intervertebral discs at each level of the lumbar spine were measured. The disc depth or antero-posterior diameter of each disc was taken as the distance between the midpoints of the anterior and posterior heights (Figure 1).

The shape or wedge index (SI) was calculated by the formula of "Anterior height–Posterior height / Depth of the intervertebral disc" (1,2). The average disc height was also calculated by using the following formulas: "anterior disc height + posterior disc height / 2" (2). Two measurements were made in different times and the average values of all measurements were calculated for the statistical analyses.

Magnification error in all lateral MR images was negligible due to the standardized technique used. Height/dept ratio or shape index also was confirmed to be unaffected by magnification in our study.

Data Analysis

Descriptive statistics are presented as mean and standard deviation for the variables in Tables. Factorial Variance Analysis was used to determine differences

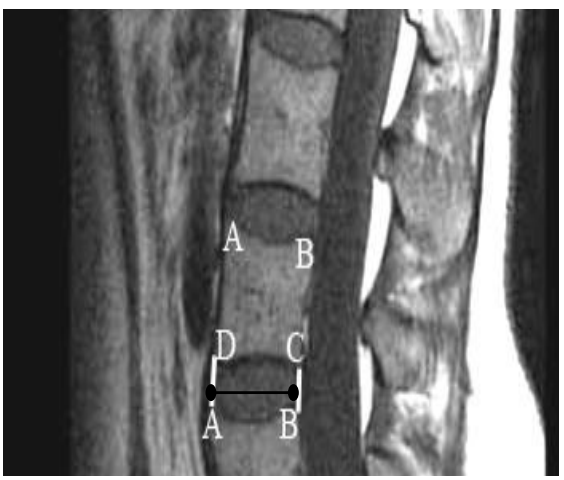

Figure 1*. The disc depth or antero-posterior diameter was taken as the distance between the midpoints of the anterior and posterior heights.*

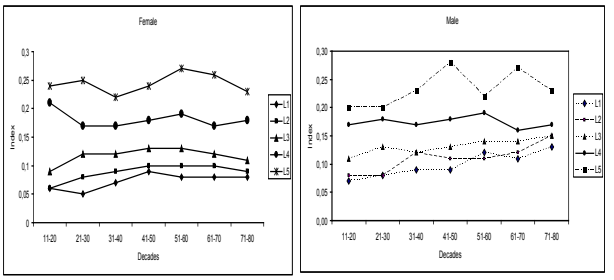

***Figure 2**.Changes of the shape index with age in female and male.*

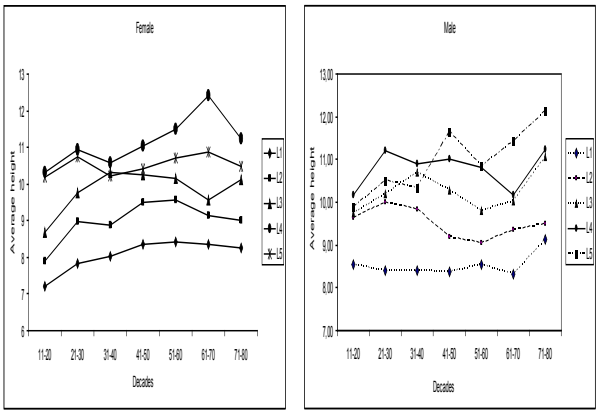

***Figure 3**. Changes of the average height of the disc with age in female and male.*

means of decades and gender. Duncan (multiple comparisons) test was then used. p value of 0.05 and less was considered as statistically significant for all analyses and comparisons. MINITAB 14 for Windows was used for all statistical calculations.

RESULTS

In our study, apart from variations in some level and decade, the anterior and posterior heights showed insignificant gender and age changes (Table 1, 2). However, the disc depth changed with age significantly in both sexes and showed sex difference by 6th decade, in favour of male (Table 3). Shape index of the L1 and L2 disk changed with age only in males. But, shape index did not show sex differences generally (Table 4, Figure 2).

Changes of average disk height by sex and age groups

Female average height was found between 7.21-12.42 in mm, L1 disk of first decade and L4 disk of 6th decade respectively. Average height was found in male as 8.32 (L1 disk of 6th decade) - 12, 14 (L5 disk of 7th decade) in mm (Table 5, Figure 3).

Changes found from the present study are given in detail at the following:

L1 (L1/L2): During the decades, it continued with a lowest value than the other levels and stably to the last decade in both sexes.

L2 (L2/L3): In male, it showed over than L1 value and insignificant increase and decrease trends throughout the decades. In female, however, it showed significant increase trend initially and decrease in last decade.

L3 (L3/L4): Female value showed a significant increase initially and then steady course along the fourth and

***Table 1**. Changes of anterior height of the lumbar intervertebral discs of both sexes (mm) by age groups (decades). F=female, M=male. The varied lower case in the decades indicates the differences between the age groups (a, b, c →).*

	Sex	DECADES						
		10-19	20-29	30-39	40-49	50-59	60-69	70-79
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
L1	F	7.94±1.75^{b}	8.56±1.08$^{\#ab}$	9.04±1,2$^{\#ab}$	9.76±1.14^{a}	9.64±.93^{a}	9.59±1,33^{a}	9.6±1.58^{a}
	M	9.68±1.17^{b}	9.83±1.61^{b}	9.89±.96^{b}	9.92±1.15^{b}	10.53±1.5^{ab}	10.16±1.1^{b}	11.46±1.9^{a}
L2	F	8.81±2.26^{b}	10.28±1.3^{ab}	10.4±1,5$^{\#ab}$	11.21±1.6^{a}	11.21±1,19^{a}	10.8±2.2^{a}	10.61±2.5^{a}
	M	10.97±1.5^{a}	11.47±2.6^{a}	11.84±1.3^{a}	11.19±1.5^{a}	10.95±1.15^{a}	11.59±1.6^{a}	12.28±1.2^{a}
L3	F	9.95±2.6^{b}	11.59±1.3^{ab}	12.35±1.19^{a}	12.49±1.51^{a}	12.45±2.22^{a}	11.57±1.8^{ab}	12.24±2.05^{a}
	M	11.66±2.14^{b}	12.41±2.42^{ab}	12.86 ±1.85^{ab}	12.79±1.93^{ab}	12.34±2.08^{ab}	12.55±1.88^{ab}	14.06±2.35^{a}
L4	F	13.33±2.97^{a}	13.6±1.36^{a}	13.49±1.99^{a}	14.09±2.01^{a}	14.80±2.27^{a}	13.72±2.41^{a}	14.53±3.35^{a}
	M	12.98±1.97^{a}	14.33±2.06^{a}	13.84±1.66^{a}	14.44±1.67^{a}	14.29 ±2.59^{a}	13.21 ±3.23^{a}	14.47±1.79^{a}
L5	F	13.55±3.24^{a}	14.45±1.6^{a}	13.74±3.96^{a}	14.38 ±3.18^{a}	16.6±3.39^{a}	15.01 ±4.32^{a}	14.4±4.82^{a}
	M	13.06±1.62^{b}	13.92±3.53^{ab}	14.17±3.32^{ab}	16.58±2.89^{a}	14.75±2.93^{ab}	16.13±3.08^{a}	16.39±4.46^{a}

: male> female is significant (p<0.05)

***Table 2**. Changes of posterior height of the lumbar intervertebral discs of both sexes (mm) by age groups (decades). F=female, M=male. The varied lower case in the decades indicates the differences between the age groups (a, b, c →).*

	Sex	DECADES						
		10-19	20-29	30-39	40-49	50-59	60-69	70-79
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
L1	F	6.48 ±2.52^{a}	7.1 ±1.32^{a}	6.99 ±1.06^{a}	6.91±1.06^{a}	7.19±1.08^{a}	7.1±1.68^{a}	6.94±2.01^{a}
	M	7.39±1.1^{a}	6.94±1.41^{a}	6.89±1.65^{a}	6.82±1.24^{a}	6.58±1.11^{a}	6.48±0.67^{a}	6.8±1.4^{a}
L2	F	6.98±2.22^{a}	7.67±1.12^{a}	7.37±0.63^{a}	7.78±1.04^{a}	7.91±1.07^{a}	7.45±1.56^{a}	7.41±1.11^{a}
	M	8.28±0.8^{ab}	8.50±3.21^{a}	7.81±1.69^{ab}	7.2±1.03^{ab}	7.16±1.1^{ab}	7.1±0.94^{ab}	6.7±1.2^{b}
L3	F	7.43±2.05^{a}	7.91±1.23^{a}	8.32±1.15^{a}	8.01±1.35^{a}	7.82±1.25^{a}	7.57±0.67^{a}	7.97±1.42^{a}
	M	7.86±1.37^{ab}	7.97±1.29^{ab}	8.54±1.19^{a}	7.77±1.29^{ab}	7.29±1.33^{b}	7.51±1.08^{ab}	8.06±1.36^{ab}
L4	F	7.3±0.67^{a}	8.29±1.19^{a}	7.68±1.11^{a}	8.00±1.47^{a}	8.18±0.96$^{\#a}$	11.11±11.19^{a}	7.92±2.88^{a}
	M	7.35±1.12^{a}	8.08±0.95^{a}	7.94±1.66^{a}	7.57±1.31^{a}	7.35±0.76^{a}	7.1±1.3^{a}	7.98±1.61^{a}
L5	F	6.83±1.41^{a}	7.04±1.36^{a}	6.69±1.88^{a}	6.48±1.04^{a}	7.46±1.31^{a}	6.7±1.03^{a}	6.59±1.63^{a}
	M	6.73±1.50^{ab}	7.08±1.18^{ab}	6.51±1.16^{b}	6.72±0.93^{ab}	6.93±1.45^{ab}	6.72±1.18^{ab}	7.89±1.6^{a}

: male> female is significant (p<0.05)

fifth decades. Its diagram increased in 6th decade and increased in the 7th decade significantly. With a value over than L2, the diagram of male average height coursed similar to L2 during the decades.

L4 (L4/L5): In both sexes, it showed insignificant rise and fall trends throughout the decades in female. Female average height coursed steadily with a highest value.

L5 (L5/S1): It showed generally significant upward trend in male and a horizontal course in female.

DISCUSSION

The results related to lumbar intervertebral disk height from the present study were found to be different from the previous reports.

Age changes

In our study, average height increased with age significantly in some disk individually, i.e. L2 and L3 disk in female as well as L5 disk in male. A general assumption is that the loss in stature occurs with increasing age, which was attributed to the reduction in the height of the intervertebral discs by Vernon-Roberts and Pirie (5). Degenerative intradiscal vacuum phenomena are commonly detected in radiologic studies of the aging spine, and are considered to be clinically insignificant (7,8). This hypothesis was denied, and proposed that disc height does not decrease with ageing (4). On the other hand, the following studies indicated the rising in the disk height with age for all disks in both sexes (1). However, Aydinlioglu et al (2) reported the disk growth merely in male, which was attributed to physical activity. According to Twomey and Taylor (4), aver-

***Table 3**. Changes of anteroposterior diameter of the lumbar intervertebral discs of both sexes (mm) by age groups (decades). F=female, M=male. The varied lower case in the decades indicates the differences between the age groups (a, b, c →).*

	Sex	DECADES						
		10-19	20-29	30-39	40-49	50-59	60-69	70-79
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
L1	F	27.06±1.21$^{\#c}$	29.86±1.73$^{\#bc}$	30.92±2.09$^{\#ab}$	31.64±1.94$^{\#ab}$	31.45±4.26^{ab}	31.36±4.7^{ab}	33.44±3.71^{a}
	M	32.43±2.94^{b}	33.38±3.75^{b}	33.4±2.4^{b}	34.74±2.16^{ab}	34.17±2.28^{ab}	34.45±3.07^{ab}	36.84±3.97^{a}
L2	F	28.61±1.5$^{\#c}$	31.08±1.86$^{\#b}$	32.37±1.95$^{\#bc}$	33.45±1.86$^{\#bc}$	33.97±2.38^{b}	33.82±4.23^{b}	36.14±2.84^{a}
	M	33.34±2.62^{c}	34.95±2.84^{bc}	34.29±2.57^{bc}	36.49±2.63^{ab}	35.48±2.43^{bc}	36.29±2.25^{ab}	38.51±4.44^{a}
L3	F	29.73±2.41$^{\#d}$	31.65±2.01$^{\#cd}$	33.42±1.77^{bc}	34.31±2.71$^{\#b}$	35.32±2.06^{ab}	33.8±3.3$^{\#bc}$	37.16±2.08$^{\#a}$
	M	33.48±2.35^{d}	35.1±2.68^{bcd}	34.53±3.14^{cd}	37.57±2.91^{b}	35.93±2.72^{bcd}	37.04±1.87^{bc}	40.91±3.77^{a}
L4	F	28.71±1.08$^{\#d}$	31.98±1.67$^{\#c}$	33.71±1$^{\#bc}$	34.39±2.84$^{\#b}$	35.38±2.28^{ab}	34.32±3.24$^{\#b}$	37.29±1.17^{a}
	M	33.78±2.73^{c}	35.7±2.74^{bc}	35.76±2.95^{bc}	38.17±2.54^{ab}	36.78±2.92^{b}	36.98±1.95^{b}	39.64±3.3^{a}
L5	F	28.2±1.64$^{\#d}$	30.11±1.79$^{\#cd}$	31.56±1.96^{bc}	32.43±3.36$^{\#abc}$	33.36±3.02^{ab}	31.96±3.75^{abc}	34.57±1.63^{a}
	M	31.54±2.61^{c}	33.21±2.88^{bc}	32.87±2.94^{bc}	35.69±2.16^{a}	35.12±2.66^{ab}	34.12±1.53^{ab}	36.36±2.51^{a}

: male> female is significant (p<0.05)

***Table 4**. Changes of shape index of the lumbar intervertebral discs of both sexes (mm) by age groups (decades). F=female, M=male. The varied lower case in the decades indicates the differences between the age groups (a, b, c →).*

	Sex	DECADES						
		10-19	20-29	30-39	40-49	50-59	60-69	70-79
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
L1	F	0.06±0.04^{a}	0.05±0.04$^{\#a}$	0.07±0.04a	0.09±0.03^{a}	0.08±0.03$^{\#a}$	0.08±0.05^{a}	0.08±0.05^{a}
	M	0.07±0.04^{c}	0.08±0.03^{bc}	0.09±0.05^{abc}	0.09±0.03^{bc}	0.12±0.05^{ab}	0.11±0.03^{ab}	0.13±0.04^{a}
L2	F	0.06±0^{a}	0.08±0.03^{a}	0.09±0.04^{a}	0.10±0.04^{a}	0.1±0.04^{a}	0.1±0.07^{a}	0.09±0.07^{a}
	M	0.08±0.05^{b}	0.08±0.12^{b}	0.12±0.05^{ab}	0.11±0.04^{ab}	0.11±0.04^{ab}	0.12±0.04^{ab}	0.15±0.04^{a}
L3	F	0.09±0.05^{a}	0.12±0.03^{a}	0,12±0.04^{a}	0.13±0.05^{a}	0.13±0.05^{a}	0.12±0.05^{a}	0.11±0.07^{a}
	M	0.11±0.07^{a}	0.13±0.06^{a}	0.12±0.05^{a}	0.13±0.04^{a}	0.14±0.06^{a}	0.14±0.03^{a}	0.15±0.08^{a}
L4	F	0.21±0.12^{a}	0.17±0.03^{a}	0.17±0.05^{a}	0.18±0.07^{a}	0.19±0.05^{a}	0.17±0.32^{a}	0.18±0.07^{a}
	M	0.17±0.06^{a}	0.18±0.07^{a}	0.17±0.05^{a}	0.18±0.04^{a}	0.19±0.09^{a}	0.16±0.07^{a}	0.17±0.04^{a}
L5	F	0.24±0.1^{a}	0.25±0.07^{a}	0.22±0.09^{a}	0.24±0.08^{a}	0.27±0.08^{a}	0.26±0.12^{a}	0.23±0.1^{a}
	M	0.2±0.04^{a}	0.2±0.08^{a}	0.23±0.09^{a}	0.28±0.07^{a}	0.22±0.08^{a}	0.27±0.08^{a}	0.23±0.11^{a}

: male> female is significant (p<0.05)

age height increases with age and that the shortening of the spine is due to the loss of height of the vertebral bodies [4]. Maximum cellular activities responsible for regeneration and remodelling in disks were shown (3). In fact, in the intervertebral disc receiving continuous stress for a long period, a process of the decomposition and regenesis should be available to sustain its function. The vertical growth of lumbar intervertebral discs and antero-posterior growth of lumbar vertebral bodies and discs are found to be dependent on the activity associated with weight-bearing in the erect posture (9). The conclusion from a mechanical study suggested that physical activity strengthens both the vertebrae and the discs (10). The risk factors for low back pain have been widely explored within the biomechanical literature and found to be associated with high mechanical stresses on the lower back (11). If so, it is suggested that our subjects selected for the present study might have not been engaged in physical activity as well as the activity associated with weight-bearing. On the other hand, the evidence supporting the disk growth was also found in L2, L3, and L5 disks by the present study. The changes within age groups were related to low back pain. Since clinical evidence shows that the majority of cases of idiopathic low back pain begin around the age of 25 years (12,13), this could result from the variety of changes activated by the temporary loss of disc height (1).

As awaited, we found a cephalocaudal (L1-L5) gradient of increase in the wedging of the lumbar discs in all age groups (1,2) in both sexes. In our study, shape index was also changed with age for male L1 and L2 disks. The wedged shape values from the previous study was reported as increasing trend with age in both male and female discs at all levels (2).

***Table 5**. Changes of average disk height of the lumbar intervertebral discs of both sexes (mm) by age groups (decades). F=female, M=male. The varied lower case in the decades indicates the differences between the age groups (a, b, c →).*

	Sex	DECADES						
		10-19	20-29	30-39	40-49	50-59	60-69	70-79
		Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
L1	F	7.21±2.09^{a}	7.83±1.06^{a}	8.02±0.96^{a}	8.34±1.01^{a}	8.41±0.87^{a}	8.35±1.31^{a}	8.27±1.6^{a}
	M	8.53±0.85^{a}	8.39±1.37^{a}	8.39±1.1^{a}	8.37±1.03^{a}	8.55±1.11^{a}	8.32±0.76^{a}	9.13±1.44^{a}
L2	F	7.89±2.24^{b}	8.97±1.07^{ab}	8.89±0.99$^{\#ab}$	9.5±1.14^{a}	9.56±0.94^{a}	9.13±1.42^{a}	9.01±1.47^{ab}
	M	9.63±0.84^{a}	9.99±2.15^{a}	9.83±1.21^{a}	9.2±0.97^{a}	9.05±0.85^{a}	9.35±1.15^{a}	9.49±0.89^{a}
L3	F	8.69±2.24^{b}	9.75±1.18^{ab}	10.33±0.96^{a}	10.25±1.18^{a}	10.14±1.59^{a}	9.57±1.05^{ab}	10.11±1.13^{a}
	M	9.76±1.35^{a}	10.19±1.6^{a}	10.7±1.31^{a}	10.28±1.47^{a}	9.81±1.38^{a}	10.03±1.36^{a}	11.06±1.19^{a}
L4	F	10.31±1.38^{a}	10.95±1.13^{a}	10.59±1.34^{a}	11.05±1.35^{a}	11.49±1.44^{a}	12.42±5.17^{a}	11.23±2.8^{a}
	M	10.16±1.32^{a}	11.21±1.25^{a}	10.89±1.45^{a}	11±1.34^{a}	10.82±1.19^{a}	10.16±2.1^{a}	11.23±1.62^{a}
L5	F	10.19±2.16^{a}	10.74±1.12^{a}	10.21±2.71^{a}	10.43±1.84^{a}	10.7±2.16^{a}	10.86±2.52^{a}	10.49±3.14^{a}
	M	9.9±1.4^{b}	10.5±2.22^{ab}	10.34±2.05^{ab}	11.65±1.75^{ab}	10.84±1.76^{ab}	11.42±1.86^{ab}	12.14±2.69^{a}

: male> female is significant (p<0.05)

Gender difference

Apart from a few finding individually in L1 and L2 decades, gender differences for average height and SI were found to be insignificant (Tables 4, 5). However, posterior height was differed significantly between the first and the fifth decades (Table 3). According to our knowledge, statistical sex difference for the lumbar disks is given here at first.

Conclusion

Our findings generally did not confirm previous studies, in which there are not clear increases in all dimensions and the shape of the discs of both sexes with age. The heights and the shapes of the disks did not show the sex difference, but the disk depths only changed with gender. However, our findings are from a new subject group and therefore not directly transferable to other samples. The findings from the present study need to be confirmed by the further MRI studies.

The authors declare that they have no conflict of interest.

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