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Evaluation of Anthropometric Characteristics Due to Sex and Age Variables of Lumbar Vertebra and Spinal Canal

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ABSTRACT Anthropometric measurements of the lumbar spinal canal and lumbar vertebra have been done for seventy people with backache and seventy people with L4-L5 lumbar disc herniation diagnosis in this research. Measurement of corpus vertebra height, intervertebral disc height, antero-posterior transvers diameter of disc herniation and sagittal-transvers diameter of spinal canal were done. Measured values were compared due to age and sex, and between the two groups. Sex and age variables were found to be of statistical significance among groups ($p<0.001$). Intervertebral disc height did not have any meaning between the two groups ($p=0.5$). Sagittal diameters of spinal canal were significant in both groups ($p<0.001$), while there was no other meaning attached when considering sexes ($p=0.4$), and it seems that sagittal diameter is the significant diameter in the stenosis of spinal canal. Sex difference of the spine affected by disease seems to be a related weak force for men, and menopausal and postmenopausal periods for women according to age. Anthropometric measurement of the lumbar spinal canal and lumbar vertebra could lead to many medical and anthropological applications related to the spine.

INTRODUCTION

Objective

The anthropometric measurement of the lumbar spinal canal (SC) and lumbar vertebra is of importance to clinical and archaeological researchers. Identification of the SC and the lumbar vertebra structures are of relevance to many medical and anthropological applications related to the spine. Especially with respect to single vertebral measurements, only a rough prediction is possible. Due to their complex geometry, vertebral measurements are possible at various locations (Klein et al. 2015). However, several diseases commonly affect the spine. An anthropological measurement of the related area may define the degree of the diseases, and could lead to the need for a proper medical or surgical treatment.

Sex and Age Importance

Several scientific studies until today have shown that excessive load on the spine, genetic factors and age are the main causes of lumbar disc herniation (LDH) formation (Weinstein 1983), and vertebra degeneration due to age is an important factor of LDH formation (Thompson et al. 1990; Brinjikji et al. 2015). Due to the disc degeneration of these patients, liquid and metabolic excrements are forced out of the disc, then, at the height of it, intervertebral disc (IVD) segment decreases, after the inner pressure of disc decreases, liquid and metabolic excrements again get inside disc, thus, height of disc segment again increases (tumorous disc) (Meray and Alpaslan 2001). Other researches on this issue prove that change in the disc height also causes disruptions in arthrodia and ligament structures (Ohshima et al. 1993). Thus, anatomic knowledge about the area is essential and the determination of structural and anthropological change seems to be important. Sex comparison among various professions, environmental factors such as heavy and repeating mechanic pressure (Videman et al. 1995), smoking (Battie et al. 1991), mechanic stresses, decreased nutritional diffusion (Buckwalker 1995; Horner and Urban 2001), and lifting of heavy weight are shown as the main factors that cause LDH especially in men.

Anthropometric Measurement of Spinal Canal and Lumbar Vertebra

The pathological alterations in the sagittal and transverse diameters of the SC lead to aches in the lumbar region and lower extremity. Therefore, it is important to know the sizes of the SC.

The structural properties of the relevant anatomic region can be revealed with the determination of the diameter values of the SC by using various radiological methods, particularly the MRI. Magnetic resonance visualization is the most important diagnosis method for disc herniation and provides sagittal and transverse plain visualization (Yussen and Swartz 1993; Takada and Takahashi 2001). Especially, maximum visualization level of LDH is L4-L5 and has the most common site of spinal stenosis with the largest flexion-extension motion (Boleaga-Duran and Fiesco-Gomez 2006; Kim et al. 2013; Putzer et al. 2015).

Thus, for LDH patients, determination of radiological anatomic characteristic of related area comes to the forefront. However, there are so few retrospective studies focusing on relations between clinic and radiological anatomy (Amudsen et al. 1995). Therefore, with this research, evaluation of related area's anthropometric characteristics of SC and lumbar vertebra could help scientists and anthropologists in the knowledge of SC diameters and lumbar vertebra body height.

MATERIAL AND METHODS

This research started after a preapproval from the human resources ethic council of Kocaeli University. A total of 140 patients who applied to Research and Practice Hospital Brain and Nerve Surgery Clinic with backache complaint were included. After retrospective examination of MR visuals, 70 patients diagnosed with LDH were decided as the fact patient group and 70 people without LDH were decided as fact control group. Deciding on patient group, only cases with L4-L5 posterior disc herniation were chosen. Cases with disc herniation different from L4-L5 level or cases of vertebra degeneration were not included in the research. Age range of patient group is between 30-65 years, and control group is from 33-57 years. T2 based axial and sagittal visions of MRI visualizations of all cases were examined on a computer, and measurements were obtained in millimeters.

Height of vertebral body *(d1)* was measured at L4 herniation level, SC width *(d2)* was measured at L4-L5 IVD herniation level and L4-L5 IVD height *(d3)* was measured in the T2 weighted sagittal image of the patient group. In addition, the heights of IVDs in the upper and lower levels of the herniation level and the width of the SC were measured in order to make a comparison. In these measurements, the SC width as from the rear-midpoint of L3-L4 IVD was *d4,* the height of L3-L4 IVD was *d5*, the SC width as from the rear-midpoint of L5-S1 IVD was *d6* and the height of L5-S1 IVD was *d7*. The same measurements were performed for the control group as well. Due to these reasons, LDH was lacking in the control group, and the measurement of the SC (*d2*) was performed as from the rear-midpoint of L4-L5 IVD.

Since the control group had no LDH, measurements of SC width *(d2)* were done from the back-middle point of L4-L5 IVD. Anterior-posterior herniation length (AB) and the herniation width (CD) as from the midpoint of the AB length were measured in the axial section of the MRI image of the patient group. These measurements were not performed in the control group due to a lack of herniation. Besides, sagittal (EF) and transvers (GH) diameters of SC were measured on the same sections in both groups (Table 3).

An index of herniation (IH) was generated in order to define ratio between SC and herniated disc material. The more there is index of herniation, the more the SC that is being covered by disc material. In order to obtain index of hernia, and as a result of measurements, the formula given below was used (Ozturk et al. 2005).

$$HI = \frac{(AB \times CD)}{(EF \times GH)} \times 1.000$$

Where,

AB: Anterior-posterior herniation length

CD: Herniation width as from the midpoint of the AB length

EF: Sagittal (EF) diameter of spinal canal

GH: Transvers (GH) diameter of spinal canal

In the evaluation process, information on age and sex from patient files were used. Statistics were used for determining whether there was a significant difference between measurement of patient and control groups. For the comparison of data, independent sample t test was used. For distribution of sexes for two groups, square test was applied. All data obtained was evaluated with SPSS: 16 for Windows program ($p<0.001$ accepted as significant).

RESULTS

In this research, 70 out of a total number of 140 patients composed the patient group, while other 70 were considered as control group. Female number was 86 (61.4%) and male number was 54 (38.6%). The distribution by groups was 47 of 86 women in control group and 39 in patients group, 23 of 54 male composed the control group, 31 composed the patient group. Distribution of both patient and control groups according to sex is shown in Table 1.

Table 1: Distribution of control and patient groups according to sex

	Group			
Gender	*Control*	*Patient*	*Total*	*P value*
Female	47	39	86	0.166
Male	23	31	54	
Total	70	70	140	

For the comparison of sexes, square test had been applied and no statistically significant difference could be defined. In the comparison of age and sex between control and patient groups**,** square test was applied and a significant difference had been defined among groups (p<0.001).

For the comparison of T2 sagittal and axial segment measurements of MR images for control and patient group, independent samples t-test had been applied. Average and standard deviation values after the test can be seen in Table 2.

Table 2: Average of age and gender comparisons between groups

Group	*Number*	*Mean*	*Std. deviation*
Control group female	47	41.9	5.141
Control group male	23	43.9	6.646
Patient group female	39	50.9	8.571
Patient group male	31	51.3	9.612

Findings in Table 2, demonstrate that the average of age of patient group is higher than control groups and statistically significant between groups.

Independent sample t-test was conducted for the comparison between the measurements performed on the T2 sagittal and axial sections in the MRI images of the control and patient groups. Accordingly, statistically significant differences were found between width of SC at L4-L5 IVD herniation level, anterior-posterior herniation lengths of L4-L5 IVD and the sagittal diameters of SC at L4-L5 level.

A value was obtained by subtracting the anterior-posterior disc herniation length (AB) from

Table 3: Mean values of the spinal canal and lumbar vertebra between groups

	Group	*N*	*Mean*	*Standard deviation*	*P value*
Mean Age	Control	70	42.3	5.709	**<0.001**
	Patient	70	51.1	8.891	
Height of L4 Spinal Canal Body (d1)	Control	70	21.4	2.482	0.37
	Patient	70	21.3	1.91	
Spinal Canal Width at L4-L5 Level (d2)	Control	70	11	1.245	**<0.001**
	Patient	70	8.4	2.133	
L4-L5 IVD Height (d3)	Control	70	11.2	1.681	0.49
	Patient	70	10.6	2.077	
Spinal Canal Width of L3-L4 IVD (d4)	Control	70	11.5	1.401	0.68
	Patient	70	11.7	2.551	
Height of L3-L4 IVD (d5)	Control	70	11.1	1.653	0.66
	Patient	70	11.3	2.348	
Spinal Canal Width at L5-S1 Level (d6)	Control	70	12.1	1.887	0.12
	Patient	70	12.6	2.735	
Height of L5-S1 IVD (d7)	Control	70	11.3	2.438	0.09
	Patient	70	11.2	3.299	
L4-L5 Anterior-Posterior Herniation Length (AB)	Control	70	0.00	0.000	**< 0.001**
	Patient	70	8.9	2.661	
Sagittal Diameter of L4-L5 Spinal Canal (EF)	Control	70	18.9	2.201	**< 0.001**
	Patient	70	17.4	2.408	
Transvers Diameter of L4-L5 Spinal Canal (GH)	Control	70	26.3	2.996	0.63
	Patient	70	26	3.840	
Visual Analog Scale	Control	70	4.8	0.722	**< 0.001**
	Patient	70	7.2	1.426	

the sagittal diameter of SC (EF), in order to analyze whether there is a correlation between the spinal canal and VAS at the level of IVD hernia. This value is the distance between the IVD herniation and the SC. Researchers obtained the correlation between this value, and VAS was evaluated. Accordingly, a negative correlation was determined between them. A significant difference was not found between the comparison made between females and males in terms of the EF value (Table 3). P values that belong to these comparisons are defined in Table 3 ($p<0.001$ defined significant).

DISCUSSION

Morphological changes in human skeleton can be important indicators of age and have been used extensively in forensic anthropology. However, degenerative changes in the vertebral column like osteophytes or bony lipping on the margins of the vertebral have been shown to be useful indicators of age (Stewart 1958; Snodgrass 2004). Furthermore, many studies on LDH states that this disease is more often in men than in women, and the frequency of disease varies between sixty five and eighty percent (Kuday 1993; Celik 1997; Omidi-Kashani et al. 2016).

Due to studies based on sex comparison among various professions, environmental factors such as heavy and repeating mechanic pressure (Videman et al. 1995), smoking (Battie et al. 1991), mechanic stresses, decreased nutritional diffusion (Buckwalker 1995; Horner and Urban 2001) and lifting heavy weight are shown as the main factors to cause LDH especially in men. The research of Michael and friends also claims without the factor of heavy weight, for both sexes, that genetic predisposition also affect LDH and collagen structure, vitamin D receptors and some proteins effect tension of tissues, thus, causing disc degeneration (Adams and Roughley 2006). In this research, both in patient group with LDH diagnosis and in control group with backache complaints, the number of women was more than men. 23 of 39 women's age was above 50, and researchers believe that this fact might have affected this result. High average of age for women and since it is known that there have been degenerative changes in vertebra and disc structure due to postmenopausal period, support this paper (Fahrni and Trueman 1965).

Several studies prove that age is an important factor especially for disc degeneration. According to these studies, average age of patients with LDH diagnosis changes is 32.8, 42 and 54.5, 55.5 (Takada and Takahashi 2001; Mullan and Kelly 2005; Eguchi et al. 2016). In this research, average age of control group is 42.57 and average age of patient group is 51.06. This situation underlines the results of other studies, claiming that increasing vertebra degeneration due to age is an important factor of LDH formation (Thompson et al. 1990; Yazgan et al. 2008; Brinjikji et al. 2015). Various alterations occur in the shapes, structures and compositions of discs depending on age and these alterations change the mechanical properties of the vertebral column. The function disorder in the vertebral column and the frequency of the relevant pains vary by age. Due to these reasons, many researchers defined disc degeneration as the common reason for the lumbar pain in adults (Buckwalker 1995). According to Miller and friends, a significant degeneration is being observed in ninety percent of lumbar IVD of people above the age of 50 (Miller et al. 1988). Weak forces produce tears in discs and the histochemical structure of discs must be previously corrupted. This lesion may occur depending on age and genetic susceptibility. For this purpose, researchers analyzed first of all the vertebral body structures upper and under the level of herniation (Table 3). It was seen that the anatomic structures were normal and that there was not any sign of fracture or crack. This makes the researchers think that age and concomitant degenerative alterations were important factors in the development of hernia, considering the mean age of the patient group. In a different paper, researchers measured the antero-posterior diameter of the SC at the mid-portion of the vertebral body and mid-vertebra body height at L4 and L5. Consequently, they demonstrate that vertebral height decreased with age, but SC diameter did not change in patients with either lumbal spinal stenosis or disc herniation (Kim et al. 2013). Parallel with this paper, other researchers reported that age is not associated with spinal canal width and length variation in the thoracic and lumbar vertebrae in normal people (Masharawi and Salame 2011).

Furthermore, according to the values obtained in Table 3, in the comparison made between the groups, the mean sagittal diameter in the group was 17.4 ± 2.4 mm, while it was $18.9 \pm$

2.2 mm in the patient group and a significant difference was found between them. However, a difference was not found in the comparison of transverse diameter comparison. In a similar research, in the result of the measurements performed on BT, the sagittal diameter was found to be 17.1 ± 2.5 mm in females and as 17.5 ± 2.9 mm in males, and the transverse diameter was found to be 25.5 ± 3.4 mm in females and as 25.8 ±3.1 mm in males on the average (Basaloglu et al. 2002). In another research performed by Marchesi et al., the mean sagittal diameter was found to be 16.9 mm and the mean transverse diameter as 24.3 mm in the measurements made directly on bone, and the mean sagittal diameter was found to be 17.2 mm and the mean transverse diameter as 25.1 mm in the radiological measurements (Marchesi et al. 1988).

A value was obtained by subtracting the anterior-posterior disc herniation length (AB) from the sagittal diameter of SC (EF) in order to analyze whether there is a correlation between the SC and VAS at the level of IVD hernia. This value is the distance between the IVD herniation and the SC. The correlation between this obtained value and VAS was evaluated. Accordingly, a negative correlation was determined between them. A significant difference was not found between the comparison made between females and males in terms of the EF value (Table 3). Also, as the HI increases, VAS value rises, because as the disc area with herniation increases, the SC diameters decrease.

CONCLUSION

According to these results, researchers think that anthropometric measurement of the lumbar spinal canal and lumbar vertebra could lead to many medical and anthropological applications, which are related to the spine. Therefore, according to the comparison of spinal canal diameter, it seems that sagittal diameter is the significant diameter in the stenosis of spinal canal. Sex difference of the spine affected by disease seems to be a related weak force for men, and menopausal and postmenopausal periods for women according to age. Also, as well as age is an important factor for disc degeneration, vertebral height decreased with age, but spinal canal diameter did not change. According to this paper therefore, sagittal diameter seems to be the main factor in narrowing the spinal canal and antero-posterior diameter of disc herniation seems to be the reason of increasing pain.

RECOMMENDATIONS

It is important to know the sizes of spinal canal and lumbar vertebra so that structural properties and anthropological measurement of the relevant anatomic region can be revealed in the research of the human spine structure, and in determining the appropriate treatment relating to spine. Furthermore, it seems that further research is needed to enforce age and sex variables according to anthropological measurement.

LIMITATIONS

All the vertebral body structures of upper and under the level of herniation were analyzed in the T2 sagittal and axial images of the control and patient groups. It was seen that the anatomic structures were normal and that there was not any sign of fracture or crack. Patients with lumbar vertebra fracture or crack were removed from this research.

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