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Heights of the Lumbar Intervertebral Discs Related to Age in Turkish Individuals

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Department of Anatomy, School of Medicine, Yüzüncü Yıl University, Van, Turkey, and [1]*Department of Anatomy, School of Medicine, Atatürk University, Erzurum, Turkey*

AYDINLIOĞLU, A., DİYARBAKIRLI, S. and KELEŞ, P. *Heights of the Lumbar Intervertebral Discs Related to Age in Turkish Individuals.* Tohoku J. Exp. Med., 1999, **188** (1), 11-22 —— The present study investigated the changes in the heights and anteroposterior diameters of human intervertebral discs by means of measurements from radiographs, to determine age changes of lumbar intervertebral discs in Turkish people. Measurements of anterior and posterior disc heights and disc depths were made for 200 clinic subjects of different age groups from lateral radiographs. The height of the intervertebral disc increases with aging only in males and the disc depth in both sexes. Our findings generally corroborate previous studies. It is suggested that the different findings from the present study might be peculiar to the society. ———— age; intervertebral disc; x-ray measurement

The intervertebral disc is one of the most important structure in the maintenance of spinal function. Many studies have reported the age changes of the intervertebral disc of the human lumbar spine (Nachemson 1970; Bernick 1982; Higuchi 1982; Oda et al. 1988). Twomey and Taylor (1985) pointed out 72% of the elderly discs examined to become normal not degenerative. Since the intervertebral disc receives incessant stresses for a long period, a process of decomposition and regenesis should be present to maintain the function of the intervertebral disc (Taylor et al. 1981; Oda et al. 1988). Thus the intervertebral discs show the adaptation to alterations in the prevailing mechanical conditions within the vertebral column during aging (Amonoo-Kuofi 1991). The thickness of the discs influenced by histological changes within the intervertebral discs were reported in some studies. The results, however, were different from each other. According to Vernon-Roberts and Pirie (1977), with increasing age the loss in stature occurs, which is due in large part to thinning of the intervertebral disc. On the contrary, some studies reported that aging is associated with a decline in the length of the

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spine which is due to the loss in vertebral height and average disc height is maintained or increased in old age (Nachemson et al. 1979; Twomey and Taylor 1985). Recently, Amonoo-Kuofi (1991) examined the relationships between the lumbar intervertebral disc heights and age by means of measurements from radiograph.

The purpose of the present study is to elucidate the contraversial issue among the previous studies, and also to investigate morphometric changes related to aging in lumbar discs of Turkish people.

Material and Methods

The materials used in the course of this work consist of plain lateral radiographs of lumbar vertebral columns of 200 subjects (107 males and 93 females) from clinic cases. Subjects with a history of trauma or surgery in the spine and the radiograms of the cases with any abnormalities were excluded. The subjects were grouped into five decades (Table 1). Radiographs taken with a standardised technique that had good technical quality and normal appearance according to radiologist's report were selected at radiology department of Yüzüncü Yıl University.

In standardised radiographic technique, lateral roentgenogram of the lumbosacral spine is made with the patient in the lateral recumbent position. The hips and knees are flexed 45 degrees. The central x-ray beam usually passes through the third lumbar vertebra and an anode-film distance of 100 cm is maintained. Radiographs were placed on a viewing box. Distances between adjacent vertebral bodies were determined as disc space. The anterior and posterior heights and the depths of the intervertebral discs at each level of the lumbar spine were measured by the method described by Amonoo-Kuofi (1991). The measurements were made by marking the points shown in Fig. 1 on the radiographs with a pencil and a hand lens, and then using a scale calibrated to 0.1 mm to calculate the required distances between points. The criterion for positioning the landmarks for the discs was that the marks should be on the extreme anterior or posterior margins of the end-plates of the vertebrae (Tibrewal and Pearcy 1985). The disc depth or anteroposterior diameter of each disc was taken as the mean of the superior and inferior disc depth measurements (AB and DC in Fig. 1). The wedge index was calculated by the formula of "(anterior disc height-posterior disc height/disc depth) 100%" (Amonoo-Kuofi 1991; Tibrewal

Table 1. *The age and sex of the subjects in our study*

Sex	Age groups (Decades)				
	10–19	20–29	30–39	40–49	50–59
Male	15	14	18	32	28
Female	10	15	16	30	22

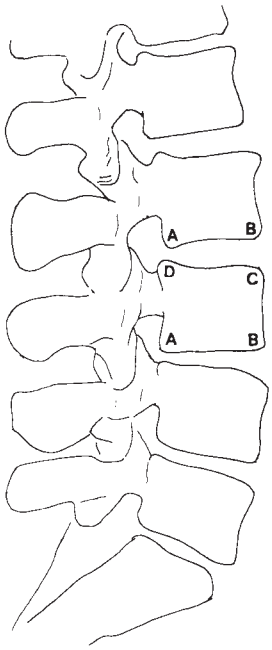

Fig. 1. Method showing the markers for measurements. BC, anterior disc height; AD, posterior disc height; AB and DC, superior and inferior disc depth; CB, anterior vertebra height; DA, posterior vertebra height.

and Pearcy 1985). A relative disc height index used by Taylor (1975) and Amonoo-Kuofi (1991) and the average disc height were also calculated by using the following formulas: Relative disc height index (RI) = disc height/vertebral height, and average disc height (ADH) = anterior disc height + posterior disc height/2. The mean and standard deviations belonging to discs' heights, discs' depths, vertebra heights were calculated. To ensure interobserver reliability, the measurements were made by two different clinicians in different times, and kappa statistic was used. Kappa values higher than 0.75 may be regarded as excellent interobserver agreement, and those below 0.40 as poor agreement (Fleis 1981). The statistical significance of the difference in disc dimensions between the decades were assessed using paired t-test.

Results

Since a standardized radiographic technique was used, magnification error in all lateral radiographs was negligible. Interobserver reliability also showed an excellent agreement (kappa = 0.80).

Anterior disc height

Table 2 shows the changes of anterior disc height between the age groups in males and females. The anterior disc height showed an increasing trend cephalocaudally. Only L5-S1 disc did not show this gradient in the second decade of the males, and the second, third and forth decades of the females. Changes between the age groups were observed as followings: In male, while

TABLE 2. *Quantitative analysis of anterior disc height among the subject by age and sex*

Disc level	Sex	Decades									
		10-19		20-29		30-39		40-49		50-59	
		Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.
L_1-L_2	M	12.7	2.5	11.4	2.2	10.2	2.8	12.6	2.6	11.6	2.1
	F	11.5	0.7	10.7	1.9	11.1	2.3	11.2	3.4	10.8	1.5
L_2-L_3	M	14.3	3.0	13.4	1.8	13.3	1.9	14.8	2.6	13.7	1.4
	F	13.5	0.7	12.5	2.3	13.1	2.5	12.8	3.3	13.6	2.5
L_3-L_4	M	16.7	1.5	14.6	2.4	14.9	2.4	17.5	3.7	16.9	2.4
	F	14.5	0.7	14.5	2.7	15.4	1.4	15.5	4.2	15.3	2.5
L_4-L_5	M	18.0	2.0	16.6	2.8	16.3	1.9	18.5	3.9	19.1	2.3
	F	16.5	0.7	16.1	3.7	16.5	2.4	17.2	4.7	16.1	3.3
L_5-S_1	M	13.3	3.5	16.5	3.6	16.5	2.9	19.0	3.6	21.6	4.7
	F	15.5	0.7	15.9	3.8	15.6	3.1	17.8	3.6	16.8	3.6

M, Males; F, Females; S.D., standard deviation.

L5-S1 disc showed a steady increase with age, the others showed a declining trend between the second and forth decade, and a sharp increase between the forth and fifth decade. In fifth decade, L4-L5 and L5-S1 discs tended to increase, and the others to decrease. Female discs showed little change and seemed to maintain their height with age. Statistically, the changes with age were only found to be significant in male ($p=0.05$).

Posterior disc height

Quantitative analysis of the changes of posterior disc height between the age groups is presented in Table 3. Cephalocaudally, the posterior disc heights showed the changes similar to the anterior disc height. While all discs showed an increasing trend from L1-L2 level to L5-S1 in each decade, L5-S1 disc did not show the same increase in both sexes. Changes between the decades were observed as followings: In male, all discs showed a steady decrease between the second and third decade. While some discs seemed to increase between the third and forth decade, an increase including all disc appeared between the forth and fifth decade. Variations were observed between the fifth and sixth decade, some discs showed an increase, and some a decrease. In female, posterior disc height in all discs generally seemed to maintain their height between the second and forth decade. All discs showing a decreasing trend between the forth and fifth decade increased again between the fifth and sixth decade. Statistically changes of L3/4, L4/5, and L5/S1 discs with age in males were only found to be significant ($p<0.05$).

TABLE 3. *Quantitative analysis of posterior disc height among the subject by age and sex*

Disc level	Sex	Decades									
		10–19		20–29		30–39		40–49		50–59	
		Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.
L_1-L_2	M	7.3	2.5	5.1	1.4	4.9	1.4	5.5	1.2	5.4	1.3
	F	5.0	0.0	5.1	1.4	5.0	1.1	4.5	1.4	5.2	1.6
L_2-L_3	M	8.0	3.0	6.4	1.1	6.2	1.6	7.3	2.1	6.5	1.7
	F	6.0	1.4	5.9	1.9	6.1	1.3	5.0	1.3	6.3	1.5
L_3-L_4	M	9.7	2.5	6.8	1.2	7.3	1.3	8.9	2.5	8.0	1.5
	F	6.0	1.4	7.6	1.9	6.9	1.4	5.7	1.2	6.8	2.1
L_4-L_5	M	10.3	2.1	7.1	1.3	7.4	1.5	8.9	2.4	9.3	2.3
	F	7.5	0.7	8.0	2.5	7.6	1.5	6.2	1.9	7.3	2.5
L_5-S_1	M	6.7	0.6	5.9	1.6	6.3	1.9	7.9	1.1	8.1	2.2
	F	5.5	0.7	6.0	1.7	5.8	1.8	5.7	1.5	7.3	2.8

M, Males; F, Females; S.D., standard deviation.

Average disc height

Fig. 2A, 2B and Table 4 show an average disc height (ADH) in both males and females. Excluding L5/S1 disc, all discs showed an increasing gradient from L1/2 level to L5/S1 in both sexes. Changes with aging between age groups were found as follows: In male, L5/S1 disc seemed to continue its increase from the second to sixth decade. The others generally continued to decrease by the forth decade and then sharply increased by the fifth decade, and after the fifth decade decreased steadily (L4/5 excluded). In female, L5/S1 disc slightly continued to increase during the decades. The others seemed to maintain their height with aging. The changes with age for ADH were statistically found to be significant in only male L3/4, L4/5, L5/S1 discs ($p<0.05$).

Disc depth or anteroposterior diameter

Changes with aging for the mean depths of the discs are presented in Fig. 3A, 3B and Table 5. Lumbosacral disc did not show a cephalocaudal increase, i.e., from L1/2 level to L5/S1 in male. The other discs showed a steady increase cephalocaudally for all decades except for the second decade in that variations were observed. In female except for the L5/S1 disc, all discs cephalocaudally showed an increasing trend. The mean depth of the discs showed the changes between age groups as follows: In male, a decreasing trend was observed at L1/L2, L2/L3, L3/L4 discs and an increasing trend at L4/L5, L5/S1 discs between the second and third decade. The values continued to decrease at all discs, L5/S1 excluded, between the third and forth decades. All discs showed a sharp

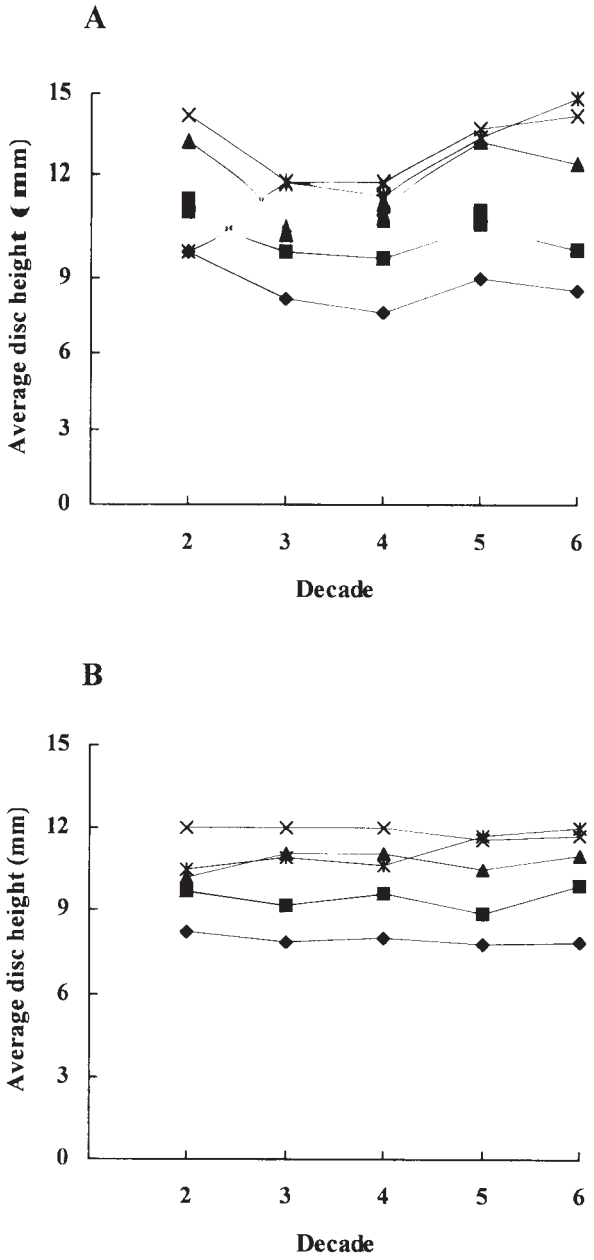

Fig. 2. Changes with age in average height of male (A) and female (B) discs. $L_{1/2}$ (◆); $L_{2/3}$ (■); $L_{3/4}$ (▲); $L_{4/5}$ (×); $L_{5/}S_1$ (✳).

increase by the fifth decade and then except for the L1/L2, this increase steadily continued for all discs by the sixth decade. In female, generally a sharp increase for all discs was found by the forth decade. Except for the L4/L5, the discs showing a decrease between the forth and the fifth decade showed again a sharp increase by the sixth decade. Statistically, the changes with age for all male discs were insignificant ($p > 0.05$) and for all females significant ($p < 0.05$).

Wedge index

Table 6 shows the values of wedge index. Except for the L3/L4 and lumbosacral discs in the second and the L3/L4 in the fifth decade, the wedging of the male discs cephalocaudally increased from L1/L2 level to L5/S1. In female,

TABLE 4. *Quantitative analysis of average disc height among the subject by age and sex*

Disc level	Sex	Decades									
		10-19		20-29		30-39		40-49		50-59	
		Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.
L_1-L_2	M	10.0	1.5	8.2	1.7	7.6	1.6	9.1	1.3	8.5	1.3
	F	8.3	0.4	7.9	1.3	8.1	1.6	7.8	2.3	7.9	1.4
L_2-L_3	M	11.2	3.0	9.9	1.2	9.8	1.5	11.0	1.7	10.1	1.2
	F	9.8	1.1	9.2	1.7	9.6	1.7	8.9	2.1	9.9	1.7
L_3-L_4	M	13.2	2.0	10.7	1.7	11.1	1.7	13.2	2.2	12.4	1.6
	F	10.3	1.1	11.1	1.7	11.1	1.2	10.1	2.7	11.0	1.8
L_4-L_5	M	14.2	1.6	11.9	1.9	11.9	1.4	13.6	2.5	14.2	1.9
	F	12.0	0.7	12.1	2.7	12.1	1.7	11.7	3.1	11.7	2.6
L_5-S_1	M	10.0	1.5	11.8	2.2	11.4	2.1	13.4	1.6	14.9	3.1
	F	10.5	0.7	11.0	2.6	10.7	2.1	11.8	2.4	12.0	2.9

M, Males; F, Females; S.D., standard deviation.

while the L4/L5 disc generally did not show a cephalocaudal increase, the others showed a cephalocaudal gradient of increasing from L1/L2 to L5/S1 level. Changes with ageing observed in age groups was found as follows: In male, an increasing trend between the second and third decade and between the forth and fifth decade was observed in the degree of wedging with age. The variations were found between the other age groups. The degree of lumbosacral disc wedging seemed to tend with ageing. In female, the values showing a steady increase between the forth and fifth decade were observed to be of a decreasing trend between the second and third decade and between the fifth and sixth decade. While the L3/L4 and L4/L5 discs slightly increased, the others showed no change between the third and forth decade. The changes with age for wedge index were statistically insignificant in both males and females ($p > 0.05$).

Relative height index (RI)

Changes with aging for this index are presented in Fig. 4A, 4B and Table 7. In both males and females, the values showed a cephalocaudal increase from L1/L2 to L5/S1 level except for lumbosacral disc. Lumbosacral disc, in both sexes, showed a cephalocaudal increase only in the last two age groups. Changes observed with ageing were found in both sexes as follows: In males, lumbosacral disc seemed to increase constantly during the decades. The others showed a decreasing trend between the second and the third decades, variations between the third and the forth decades, an increasing trend between the forth and the fifth decades, and a decreasing trend between the fifth and the sixth decades except for

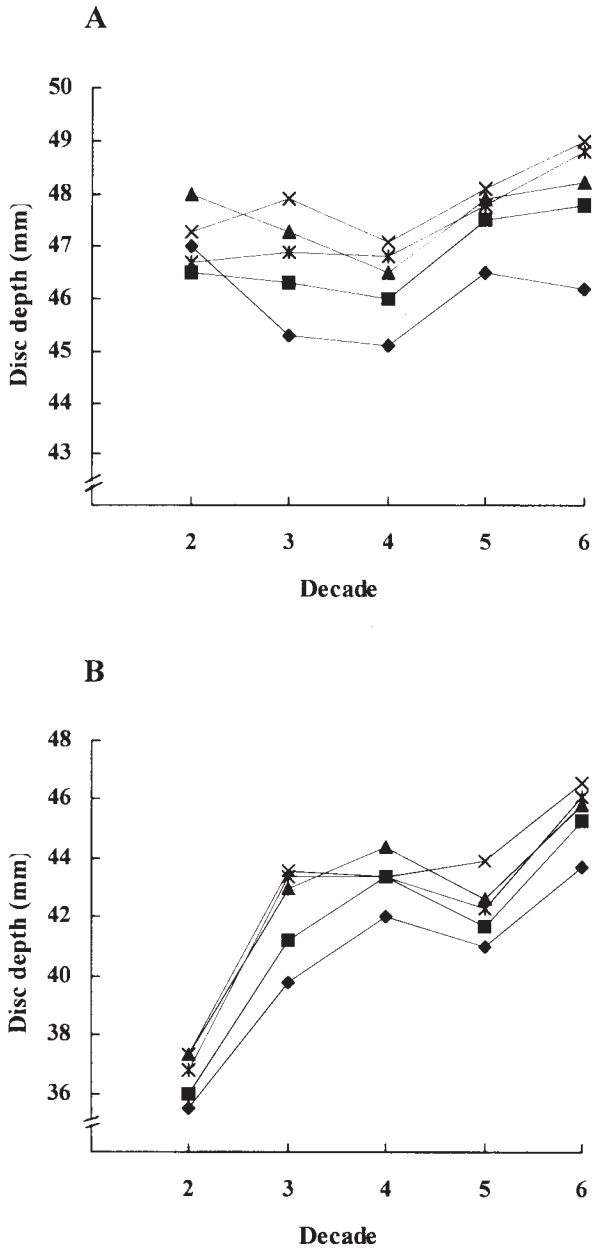

Fig. 3. Changes with age in the depth of male (A) and female (B) discs. $L_{1/2}$ (◆); $L_{2/3}$ (■); $L_{3/4}$ (▲); $L_{4/5}$ (×); $L_{5/}S1$ (✳).

L4/L5. In females, lumbosacral disc seemed to increase slightly by the fifth decade. The others showed no change with age. Statistically the changes were found to be insignificant in females ($p > 0.05$) and significant in the lower three lumbar discs of males ($p < 0.05$).

Discussion

Our study demonstrated that the height of the intervertebral disc increases with aging only in males and the disc depth in both sexes. Changes with aging for intervertebral disc height have been discussed in previous studies (Vernon-Roberts and Pirie 1977; Nachemson et al. 1979; Twomey and Taylor 1985; Amonoo-Kuofi 1991). That the loss in stature occurs with increasing age is a

TABLE 5. *Quantitative analysis of disc depth among the subject by age and sex*

Disc level	Sex	Decades									
		10–19		20–29		30–39		40–49		50–59	
		Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.	Mean (mm)	S.D.
L_1-L_2	M	47.0	1.3	45.3	4.7	45.1	2.9	46.5	2.2	46.2	2.6
	F	35.5	1.4	39.8	3.4	42.1	3.6	40.5	3.2	43.7	4.4
L_2-L_3	M	46.5	0.9	46.3	5.2	46.0	3.4	47.6	2.2	47.8	2.2
	F	36.0	1.4	41.2	3.5	43.4	3.2	41.7	4.5	45.3	4.9
L_3-L_4	M	48.0	2.2	47.3	5.4	46.6	3.7	47.9	2.7	48.2	2.4
	F	37.3	1.8	43.0	3.5	44.3	2.9	42.6	3.7	45.8	4.5
L_4-L_5	M	47.3	2.4	47.9	5.7	47.1	3.4	48.1	1.9	49.0	1.9
	F	37.3	1.8	43.6	2.9	43.4	5.6	43.8	2.9	46.7	3.3
L_5-S_1	M	46.7	3.0	46.9	4.5	46.8	3.7	47.8	2.8	48.8	2.5
	F	36.8	1.1	43.5	2.8	43.4	3.1	42.3	2.6	46.1	3.0

M, Males; F, Females; S.D., standard deviation.

TABLE 6. *Quantitative analysis of wedge index among the subject by age and sex*

Disc level	Sex	Decades				
		10–19	20–29	30–39	40–49	50–59
		WI	WI	WI	WI	WI
L_1-L_2	M	0.11	0.13	0.11	0.15	0.13
	F	0.18	0.14	0.14	0.16	0.12
L_2-L_3	M	0.13	0.15	0.15	0.15	0.14
	F	0.20	0.15	0.15	0.18	0.16
L_3-L_4	M	0.18	0.17	0.18	0.21	0.21
	F	0.22	0.20	0.20	0.24	0.19
L_4-L_5	M	0.16	0.19	0.18	0.20	0.20
	F	0.24	0.18	0.20	0.27	0.19
L_5-S_1	M	0.13	0.22	0.21	0.23	0.27
	F	0.27	0.22	0.22	0.28	0.20

M, Males; F, Females; WI, Wedge index.

general assumption. According to Vernon-Roberts and Pirie (1977), reduction in the height of the intervertebral discs contributes in large part to this shortening of the spine. On the other hand, Twomey and Taylor (1985) reported that average disc height is maintained or increased in old age. The results from their study revealed a clear trend of increase in disc height for both sexes with increasing age. Loss in vertebral height is the principal reason for loss in stature

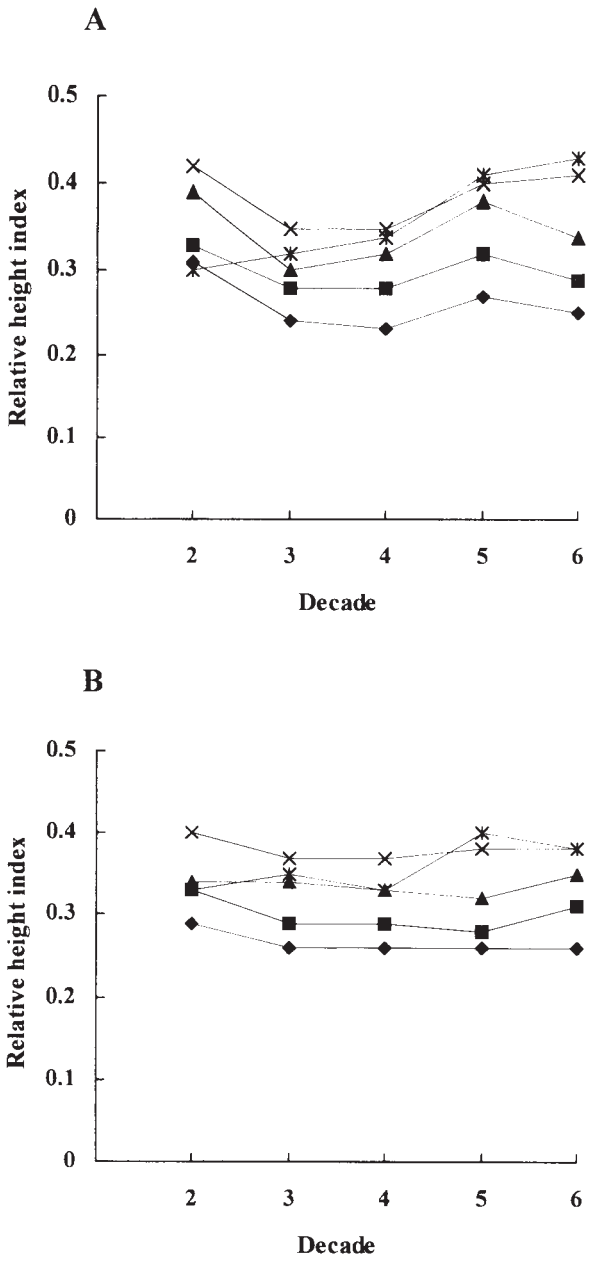

Fig. 4. Changes with age in relative index of male (A) and female (B) discs. $L_{1/2}$ (◆); $L_{2/3}$ (■); $L_{3/4}$ (▲); $L_{4/5}$ (×); $L_{5/}S_1$ (✳).

(Nachemson et al. 1979; Twomey and Taylor 1985). The results reported by Amonoo-Kuofi (1991) also demonstrated that after some initial loss, disc heights increase steadily in both sexes. In males, the findings from our study confirmed last reports, namely average disc height increased with age. The evidence corroborating this finding was also observed by us in the values of relative height index that increased with age from the third to the fifth decade (the lower two discs also continued to increase between the fifth and the sixth decades). The same values, however, showed a decreasing trend both from the second to the third and from the fifth to sixth decades, which also supported the findings of Vernon-Roberts and Pirie (1977). Amonoo-Kuofi (1991) reported that the relative height index did not change with age in both sexes. This clearly suggested that the

TABLE 7. *The values of relative height index among the subject by age and sex*

Disc level	Sex	Decades				
		10-19	20-29	30-39	40-49	50-59
		RI	RI	RI	RI	RI
L_1-L_2	M	0.31	0.24	0.22	0.26	0.25
	F	0.28	0.25	0.25	0.26	0.26
L_2-L_3	M	0.33	0.28	0.28	0.32	0.28
	F	0.33	0.28	0.29	0.27	0.31
L_3-L_4	M	0.38	0.30	0.32	0.37	0.34
	F	0.34	0.33	0.34	0.32	0.34
L_4-L_5	M	0.42	0.34	0.35	0.39	0.40
	F	0.39	0.37	0.37	0.37	0.37
L_5-S_1	M	0.30	0.32	0.34	0.40	0.43
	F	0.33	0.35	0.33	0.40	0.37

M, Males; F, Females; RI, Relative height index.

growth changes taking place in the discs are coordinated with changes in the heights of the vertebral bodies. The author also stated that disc height increased by the fifth decade and decreased after the fifth decade. In females, our findings that both disc height and RI did not change with age are different from those of the studies previously reported. Tibrewal and Pearcy (1985) reported that the intervertebral discs were not bounded by parallel, flat endplates. Thus, any two-dimensional measures are necessarily only indexes of some aspect of disc height.

In our study, the depths of the female discs showed a sharp increase with age except for a decreasing trend between the forth and the fifth decades. The male discs showed a steady increase between the forth and the sixth decades but variations from the second to the forth. Our findings for disc depth generally agree with those of previous studies in which they continued to increase steadily with age (Twomey and Taylor 1985; Amonoo-Kuofi 1991). In this parameter, however, some findings from the present study were found to be different from those studies mentioned above. Both male discs showing variations between the second and the forth decades and female discs showing a decreasing trend between the forth and the fifth decades more probably reflect the changes taking place in the discs. Oda et al. (1988) described the presence of maximum cellular activities in the region near the surface of the cartilaginous end-plate, which might be responsible for regeneration and remodelling. Since the intervertebral disc receives incessant stress for a long period, a process of the decomposition and regenesis in the disc should be present to maintain its function. This cycle of events within the disc explains the decline or deceleration of the growth of disc

heights noted between the decades (Amonoo-Kuofi 1991). Taylor (1975) stated that vertical growth of lumbar intervertebral discs and anteroposterior growth of lumbar vertebral bodies and discs are dependent on the activity associated with weight-bearing in the erect posture. Mechanical study by Porter et al. (1989) demonstrated that physical activity strengthens both the vertebrae and the discs.

The wedged shape values from the present study appeared to be of an increasing trend with age in male discs and showed variations in female discs. In our study, the decline of the growth of female disc depths noted between the forth and fifth decade seemed to have been resulted from a deceleration in hormonal activity. The fact from the present study that the heights and depths of male discs increased with age seemed to have depended on physical activity as well as the activity associated with weight-bearing.

Our findings generally confirmed previous studies in which there are clear increases in the heights, depths, and wedged shape of the discs of both sexes as well as no change in RI. Our different findings that male RI increases with age but female disc height and RI do not change might be peculiar to the society.

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