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Height of lumbar disc and vertebral body: what is the relation with body mass index, subcutaneous fat thickness, body weight, length and age?

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Aims and objectives

The aim of this study was to determine the correlation between anthropometric (age, body mass index, body weight and length) and morphometric parameters (lumbar disc height, vertebral body height and subcutaneous fat thickness) on MRI of the lumbar spine (Fig. 1 on page 3). To our knowledge, no study has ever reported the correlation between disc height and subcutaneous fat thickness on MR imaging.

Images for this section:

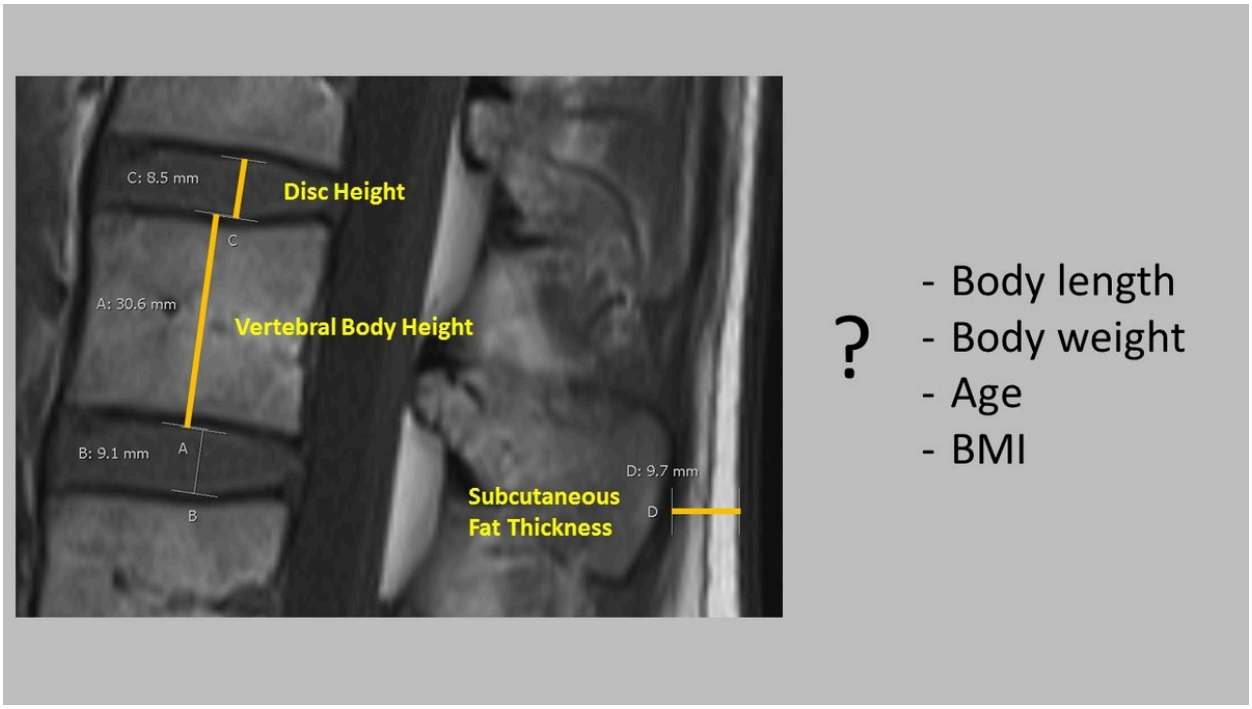

Fig. 1: Overview of all measured parameters: anthropometric parameters (age, body mass index, body weight and length) and morphometric parameters (lumbar disc height, vertebral body height and subcutaneous fat thickness).

Methods and materials

A retrospective study was performed in 50 patients, aged 19 to 72 years old (mean: 46,3 y; median 45,5 y), who underwent an MRI of the lumbar spine. Body weight and length were measured in all subjects.

MRI was performed on two 1,5 T MR units with a specific lumbar spine protocol. For this study only the sagittal T1-weighted images were used (TR: 510 ms; TE: 10 ms).

The following morphometric measurements were performed on the mid-sagittal T1-weighted image after appropriate adjusting of the gray scale:

- the central vertebral body height (VBH) was measured by connecting the centre of upper and lower vertebral end plate of each lumbar vertebra (Fig. 2 on page 5)

- the intervertebral disc height (DH) was measured by assessing the maximum vertical height of the nucleus pulposus of each disc from level T12-L1 to level L5-S1 (Fig. 3 on page 5)

- thickness of the subcutaneous fat layer (SFL) was measured between the superficial skin and the posterior cortex of the spinous process of L3 (Fig. 4 on page 6)

Data from these measurements were correlated with several constitutional parameters: age, body length, body weight and body mass index (BMI).

Statistical analysis was performed with SPSS 24.0 (SPSS, Chicago, IL, USA). Basic descriptive statistics were performed where appropriate. Correlation was investigated using Pearson's correlation coefficient. The threshold for significance was set at $p = 0,05$.

Images for this section:

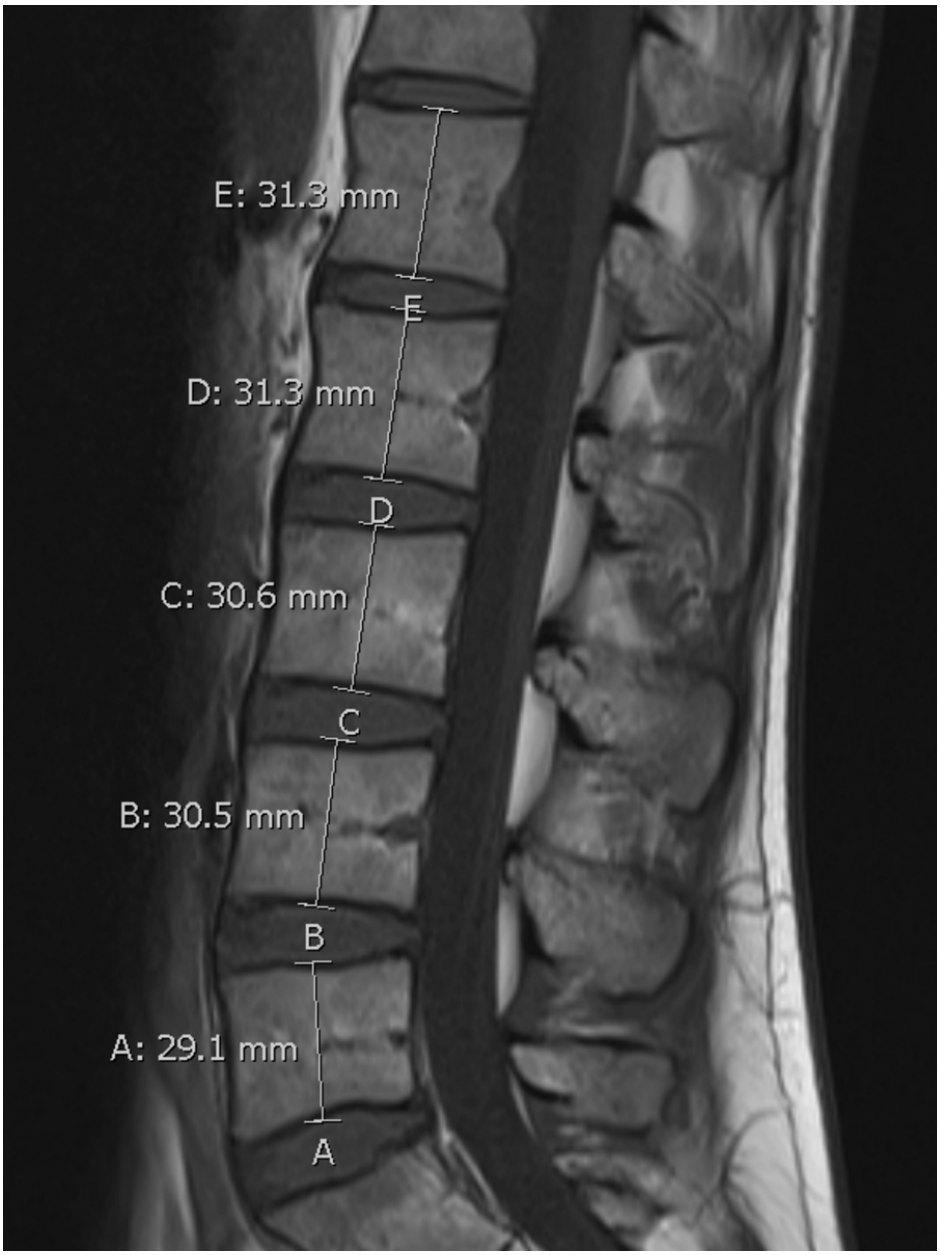

Fig. 2: Mid-sagittal T1-weighted image of the lumbar spine with measurements of the vertebral body height from L1 to L5.

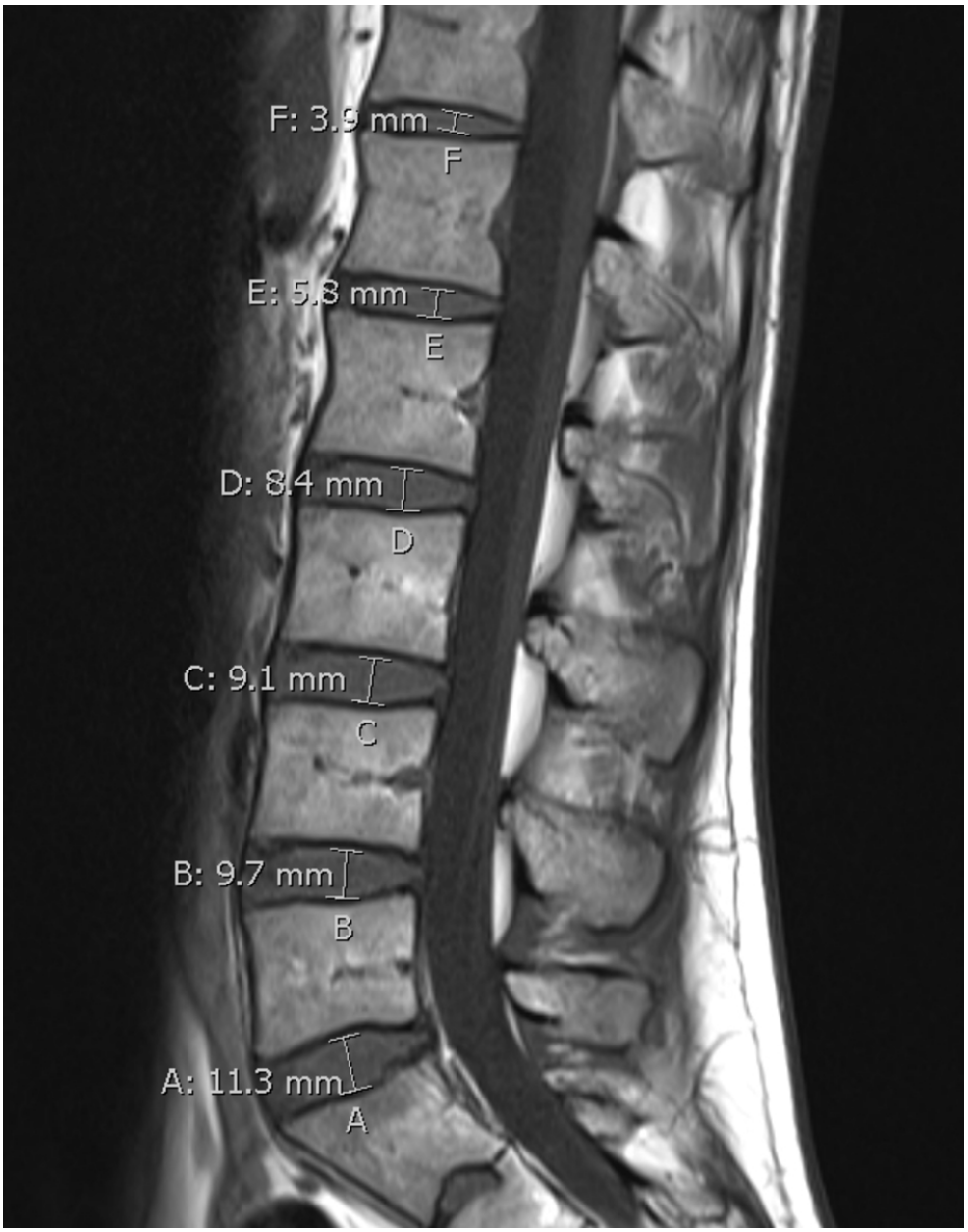

Fig. 3: Mid-sagittal T1-weighted image of the lumbar spine with measurements of the disc height from T12-L1 to L5-S1.

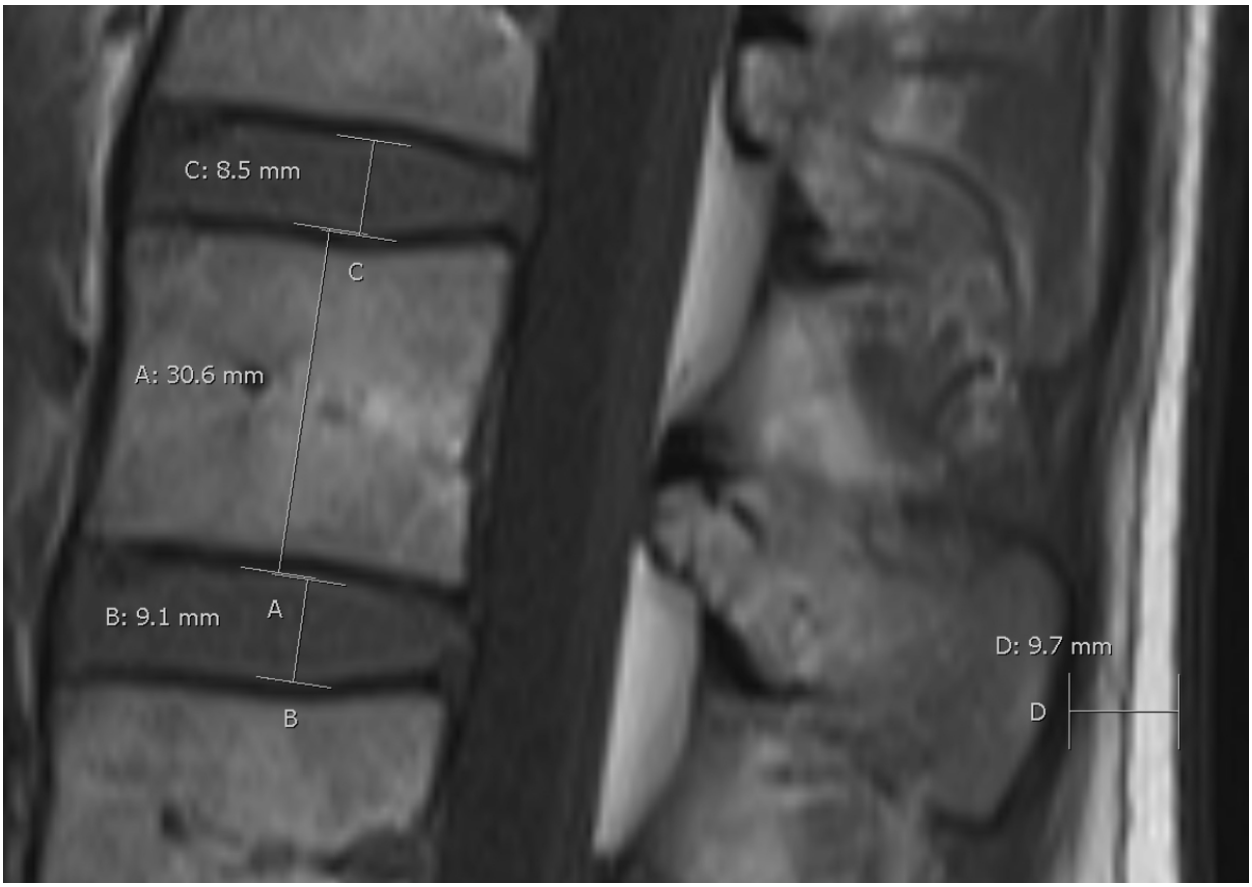

Fig. 4: At each level, vertebral body height and disc height were measured. Thickness of the subcutaneous fat layer was measured at the level of the spinous process of L3.

Results

I. Disc height (Table 1 on page 9)

Disc height was positively correlated with:

+ Body length: at all levels

+ Body weight: at all levels

Disc height was negatively correlated with:

- Age: at levels L3-L4 and L4-L5

II. Vertebral body height (Table 2 on page 9)

Vertebral body height was positively correlated with:

+ Body length: at all levels

+ Body weight: at levels L1 to L3

Vertebral body height was negatively correlated with:

- Age: at all levels except L4

III. BMI and subcutaneous fat layer (Table 3 on page 10 and Table 4 on page 11)

There was no correlation between BMI and vertebral body height nor disc height (except for L1-L2 and L2-L3).

There was no correlation between thickness of the subcutaneous fat layer and vertebral body height nor disc height.

Images for this section:

Level	DH and length		DH and weight		DH and age	
	p	R^2	*p*	R^2	*p*	R^2
T12-L1	**0,005**	**0,391**	**0,029**	**0,309**	0,752	0,046
L1-L2	**0,003**	**0,409**	**0,001**	**0,459**	0,697	-0,057
L2-L3	**<0,001**	**0,520**	**<0,001**	**0,515**	0,055	-0,273
L3-L4	**<0,001**	**0,643**	**<0,001**	**0,479**	**0,004**	**-0,401**
L4-L5	**0,001**	**0,452**	**0,027**	**0,313**	**0,004**	**-0,400**
L5-S1	**0,046**	**0,482**	**0,043**	**0,287**	0,218	-0,177

Table 1: Correlation of disc height with body length, body weight and age using Pearson's correlation coefficient. The threshold for significance was set at p = 0,05.

Level	VBH and length		VBH and weight		VBH and age	
	p	R^2	*p*	R^2	*p*	R^2
L1	**<0,001**	**0,755**	**0,031**	**0,306**	**0,002**	**-0,424**
L2	**<0,001**	**0,669**	**0,017**	**0,335**	**0,001**	**-0,447**
L3	**<0,001**	**0,682**	**0,049**	**0,280**	**0,010**	**-0,361**
L4	**<0,001**	**0,532**	0,089	0,243	0,053	-0,267
L5	**<0,001**	**0,628**	0,083	0,248	**0,022**	**-0,323**

Table 2: Correlation of vertebral body height with body length, body weight and age using Pearson's correlation coefficient. The threshold for significance was set at p = 0,05.

Level	DH and BMI		DH and SFL	
	p	R^2	*p*	R^2
T12-L1	0,468	0,105	0,411	-0,119
L1-L2	**0,043**	**0,287**	0,704	0,055
L2-L3	**0,038**	**0,294**	0,804	0,036
L3-L4	0,269	0,159	0,860	-0,026
L4-L5	0,560	0,084	0,819	-0,033
L5-S1	0,246	0,167	0,671	-0,062

Table 3: Correlation of disc height with body mass index (BMI) and thickness of the subcutaneous fat layer (SFL) using Pearson's correlation coefficient. The threshold for significance was set at p = 0,05.

Level	VBH and BMI		VBH and SFL	
	p	R^2	*p*	R^2
L1	0,279	-0,156	0,055	-0,273
L2	0,690	-0,058	0,224	-0,175
L3	0,352	-0,134	0,075	-0,254
L4	0,589	-0,078	0,175	-0,195
L5	0,364	-0,131	0,063	-0,265

Table 4: Correlation of vertebral body height with body mass index (BMI) and thickness of the subcutaneous fat layer (SFL) using Pearson's correlation coefficient. The threshold for significance was set at p = 0,05.

Conclusion

1. *Disc height was positively correlated with body length and weight at all levels.*

It's logical that when someone is larger, vertebral body height and disc height will also be higher, since body length and weight are constitutional determinants of the human body. The positive correlation of weight with disc height reflects higher body length.

2. *Disc height was negatively correlated with age at levels L3-L4 and L4-L5.*

It's well known in the literature that intervertebral discs decrease in height with age due to increasing disc degeneration and disc ageing [1,2,3]. In our study, there was a significant negative correlation between disc height and age at levels L3-L4 and L4-L5, which are the levels that degenerate first due to high load. This is confirmed by the study of Miller et al. which reported the highest prevalence of disc degeneration at these levels [4].

3. *Vertebral body height was positively correlated with body length at all levels and body weight at levels L1 to L3.*

Similar to disc height, it's also logical that vertebral body height increases with increasing body length and weight [5].

4. *Vertebral body height was negatively correlated with age at all levels except L4.*

It's well known that at an older age, vertebral body height decreases due to senile or post-menopausal osteoporosis or other causes of age-related decrease of bone density [5,6].

5. *There was no correlation between BMI and vertebral body height nor disc height.*

There was no correlation between thickness of the subcutaneous fat layer and vertebral body height nor disc height.

Thickness of the subcutaneous fat layer and BMI, both reflecting the grade of excess body fat, do not seem to have a direct short-term influence on disc height: the intervertebral disc is capable of withstanding increased loads and forces in younger individuals. However, when the disc has been exposed to excess weight for several years to decades, it will dehydrate and decrease in height [2,7].

In conclusion, disc height and vertebral body height are mainly determined by body length and body weight (constitutional determinants) and decrease with ageing (dehydration and senile osteoporosis).

The thickness of the subcutaneous fat layer and BMI do not correlate with disc height and vertebral body height (no direct influence).

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