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Original article

Comparison of cervical spinal canal diameter between younger and elder generations of Japanese

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Abstract

Background. Cervical myelopathy is more common among Japanese than Westerners. The shorter anteroposterior diameter of the cervical spinal canals (AP diameter) is its probable cause. In recent years, builds of younger Japanese have become larger and been approaching those of Westerners. The purpose of this study was to investigate whether the cervical spinal canal had enlarged in the younger Japanese as well as any cross-sectional improvement in their builds.

Methods. The subjects included 300 men and 300 women who were healthy and without symptoms related to the cervical spine. They were divided into six age groups at 10-year intervals from the twenties to the seventies. Height, body weight, and arm span were measured as physical factors. Using lateral dynamic radiographs of the cervical spine, the AP diameter from C3 to C6 in the neutral position and Penning's jaw diameter in extension (jaw diameter) from C2/3 to C5/6 were measured. The number of trapezoid-shaped vertebral bodies with a thickened posterior margin were also counted as such thickening might be one of the causes of spinal canal narrowing. Statistical analysis was performed for the following associations in both sexes: (1) age and physical factors; (2) age and the AP diameter; (3) age and jaw diameter; and (4) the difference of the AP diameter of the canal within and outside the trapezoid-shaped deformity of the vertebral body.

Results. In both men and women, the younger generations statistically had a larger height, arm span, and AP diameter. Older generations showed a significantly narrower jaw diameter at all measured spinal levels in both sexes. Trapezoid-shaped vertebral bodies were found in 3.5% of the men and in 1.3% of the women in their fifties, sixties, and seventies, which statistically had no effect on the AP diameter being wider in the younger generations.

Conclusions. Younger generations had larger builds and a wider canal of the cervical spine. A narrow spinal canal is a fundamental risk factor for cervical myelopathy. Therefore, cervical myelopathy might be expected to decrease in Japan in the near future when the present younger generations have aged.

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Introduction

Cervical myelopathy, which is common in persons ≥50 years of age, results from compression of the spinal cord by various degenerative processes of the spine.[1,2] Among them, the anteroposterior diameter of the cervical spinal canal (AP diameter) is a basic determinant of myelopathy. A number of studies on the AP diameter have been conducted in Japan.[2–10] Murone[6] reported in 1974 that the average AP diameters at the C4 to C7 levels were smaller by 3 mm in Japanese patients with myelopathy than in the control group. Furthermore, it was noted that they were smaller by 2.25 mm in the normal Japanese than in the normal Westerner.[6] Taking into consideration the large number of surgeries for it in Japan, the incidence of cervical myelopathy has been thought to be higher in the Japanese than in Westerners.[1,4,6,7,11] It might be caused most often by the narrower AP diameter in the former.

The builds of the Japanese have been smaller than those of Westerners, which may be a cause of the narrower AP diameter in the Japanese. In recent years, however, the builds of younger Japanese are becoming larger owing to the nutritional and environmental improvements, thereby approaching those of Westerners.[12–14] There is a possibility that the spinal canal of the younger Japanese has been also improved in proportion to their builds. The size of the spinal canal is closely related to the etiology of the cervical myelopathy. Therefore, in this study, we investigated whether the cervical spinal canal had enlarged in the younger Japanese and the improvement of their builds cross-sectionally.

Materials and methods

The subjects were 300 men and 300 women who agreed to be enrolled in this study. They had undergone health screening at Senboku Kumiai General Hospital with no

symptoms related to the cervical spine, or they had been admitted for treatment of disorders other than those of the cervical spine between April 2002 and March 2003. They were divided into six age groups in each six at 10-year intervals from the twenties to the seventies. Each group was composed of 50 individuals. Those who had a history of injury or surgical treatment or who had a congenital anomaly or ossification of the posterior longitudinal ligament in the cervical spine were excluded. The study design was approved by the ethics committee in Senboku Kumiai General Hospital. The participants of this study were informed that their data would be submitted for publication and gave their consent.

The height, body weight, and arm span were measured as physical factors. The arm span was defined as the distance between the tips of the middle fingers with 90° abduction of the shoulders and the entire back and arms touching the room wall. Among these physical factors, the height and body weight were compared with a control data from the National Nutrition Survey in Japan.[12]

Lateral radiographs of the cervical spine in the neutral position, in flexion, and in extension were taken at a distance of 1.8 m between the X-ray tube and the film.[1] The AP diameter was measured from C3 to C6 in the neutral position. This diameter was defined as a distance between the middle of the posterior margin of the vertebral body and a line parallel to the posterior margin of the vertebral body and tangent to the base of the spinous process, according to the method described by Higo et al.[8] (Fig. 1a). The jaw diameter was measured from C2/3 to C5/6 in extension (Fig. 1b). This diameter was defined as the distance between the posteroinferior corner of the body of the superjacent vertebra without the posterior bony spur and the base of the spinous process of the subjacent vertebra according to the method described by Penning.[15] Measurements were directly taken from the films using a ruler with a minimum scale of 1 mm. The interobserver reliabilities tested by Pearson's correlation coefficient were 0.9 agreement ($P = 0.316$) between observers A and B for the AP and jaw diameters at the four spinal levels of 100 randomly selected cases.

In this study, the age-related effects on the AP and jaw diameters had to be eliminated. The vertebral bodies in the degenerative spine usually have a bony spur that is more often detected at the antero- and posteroinferior corners of the body in lateral radiographs. (In individuals with osteophyte formation, it is of interest that the smallest AP measurement is usually between a spur on the inferior posterior aspect of a cervical vertebra and the base of the spinous process of the vertebra below.[16]) As mentioned above, the AP diameter was measured from the middle of the vertebral body, and the jaw diameter did not involve the bony spur so the spur itself might not affect these measurements. However, the vertebral body occasionally shows a trapezoid-shape deformity, which is possibly due to spur formation at its posteroinferior corner and subsequent thickening of its posterior cortex. In these cases, the AP and jaw diameters should narrow, affected by the shape of the vertebral body. Thus, we also examined the frequency of the trapezoidal change and its effects on the AP and jaw diameters. The trapezoid-shaped body of the cervical vertebra was defined as follows: (1) The protuberance of the posteroinferior corner is ≥2 mm than the posterosuperior corner of the lower vertebral body; (2) the posterosuperior angle of the vertebral body is >90°; and (3) the AP diameter of its canal is 1 mm shorter than that of the superjacent or subjacent vertebra (Fig. 2).

Statistical analyses were performed using one-way analysis of variance (ANOVA) for the following asso-

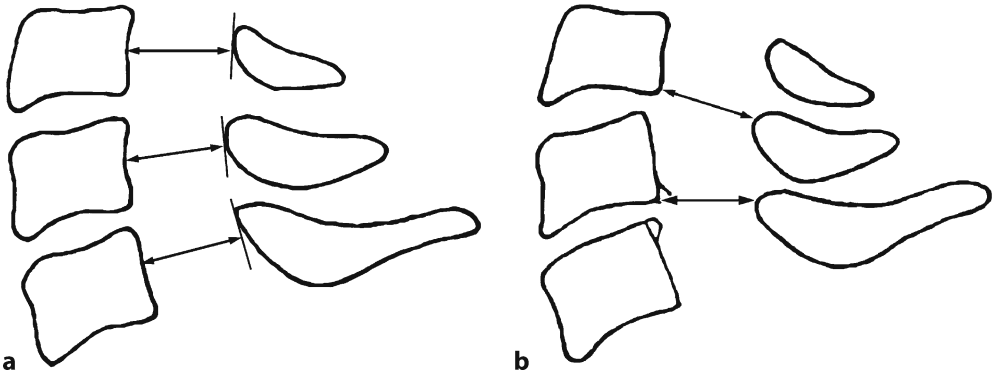


Fig. 1. Measurements of the anteroposterior (AP) diameter and jaw diameter of the cervical spinal canal. **a** AP diameter, which is defined as the distance between the middle of the posterior margin of the vertebral body and a line parallel to the posterior margin of the vertebral body and tangential to the anterior margin of the base of the spinous process. **b** Jaw diameter, which is defined as the shortest distance between the posteroinferior corner of the vertebral body without the posterior bony spur and the anterior margin of the base of the spinous process with the cervical spine in extension

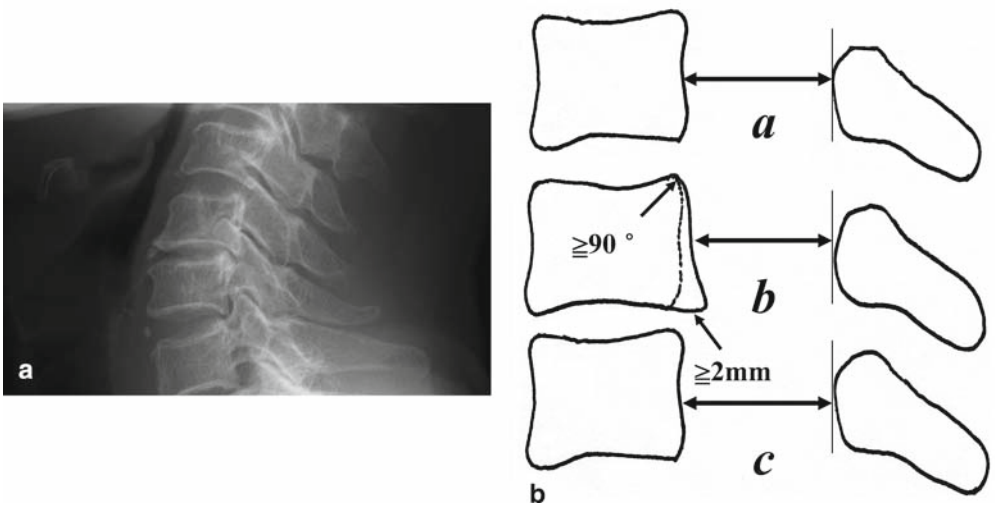


Fig. 2. Trapezoid-shaped vertebral body. **a** Representative radiograph. **b** The deformity is defined by (a or c) – b > 1 mm

ciations: (1) age and physical factors; (2) age and the AP diameter; (3) age and jaw diameter; and (4) the difference of the AP diameter of the canal within and without the trapezoid-shaped deformity of the vertebral body. In addition, multiple regression analysis was performed with the AP diameter and jaw diameter used as an independent variable and with age, height, weight, and arm span as dependent variables. In all the statistical analyses, $P < 0.05$ was considered significant.

Results

There were no significant differences in the mean and standard deviation of the height and weight between the subjects in each generation group and the control from the National Nutrition Survey in Japan[12] ($P = 0.15$). Younger generations were of a taller height in both sexes ($P < 0.05$) (Fig. 3a). Younger male generations indicated a heavier weight ($P < 0.05$), whereas all female generations showed no significantly different weight ($P = 0.09$) (Fig. 3b). Younger generations also indicated a longer arm span in both sexes ($P < 0.05$) (Fig. 3c).

The AP diameter tended to be wider at C3 and C6 than at C4 and C5 in all generations of both sexes. The generations <40 years in both sexes had a wider spinal canal at every spinal level ($P < 0.05$) (Fig. 4). The men and women in their twenties had a larger AP diameter by 1.1 mm and 1.0 mm on average, respectively, than those in their seventies. The jaw diameter at C2/3 was significantly wider than those at the other spinal levels, and the lower cervical spine had a narrower jaw diameter in both sexes in every generation group. The generations <40 years indicated a significantly wider jaw diameter at all spinal levels in both sexes ($P < 0.05$) (Fig. 5). As a result of the multiple regression analysis, the AP diameter and jaw diameter were significantly correlated with age ($R^2 = 0.06$, $P < 0.05$).

A trapezoid-shaped body was found in 3.5% and 1.3% of the men and women, respectively, in their fifties, sixties, and seventies, whereas no such deformed vertebrae were found in the other generations (Table 1). There was no significant difference of the AP diameter between the three elderly generation groups from the fifties to the seventies and the same age groups, excluding those with the trapezoid-shaped bodies in both sexes ($P = 0.16$).

Discussion

The pathogeneses of cervical myelopathy caused by the degenerative processes of the spine have been usually divided into seven spinal factors as follows: developmental stenosis, dynamic stenosis, disc herniation, segmental ossification of the posterior longitudinal ligament, continuous ossification of the posterior longitudinal ligament, posterior spur, calcification of the ligamentum flavum.[1,2,9,10] Kokubun et al.[1] noted that their 306 Japanese who had undergone surgery for myelopathy had an AP diameter of 12.8 mm on average (range 9–17 mm) at the symptomatic level and that 40% of them had developmental canal stenosis with an AP diameter of ≤12 mm. This indicates that the wider the spinal canal is the less frequently the other factors compress the spinal cord and induce myelopathy.

There have been several studies on the AP diameter in age brackets in the Japanese, in which the tendency that the younger the patient the wider the canal.[9–11] Regrettably, those studies had a small number of patients, less than one-third of the number in this study.[9–11] Here, we first compared the AP diameter among generations consisting of the same and a larger

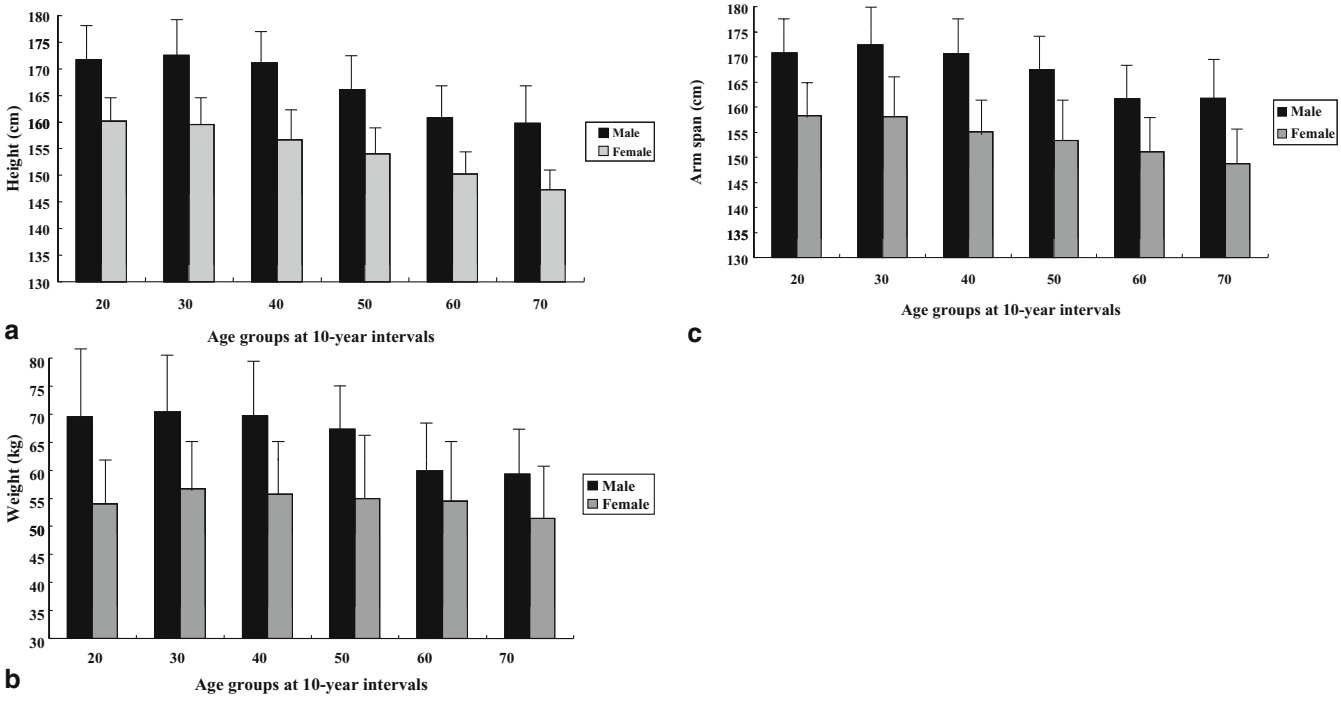


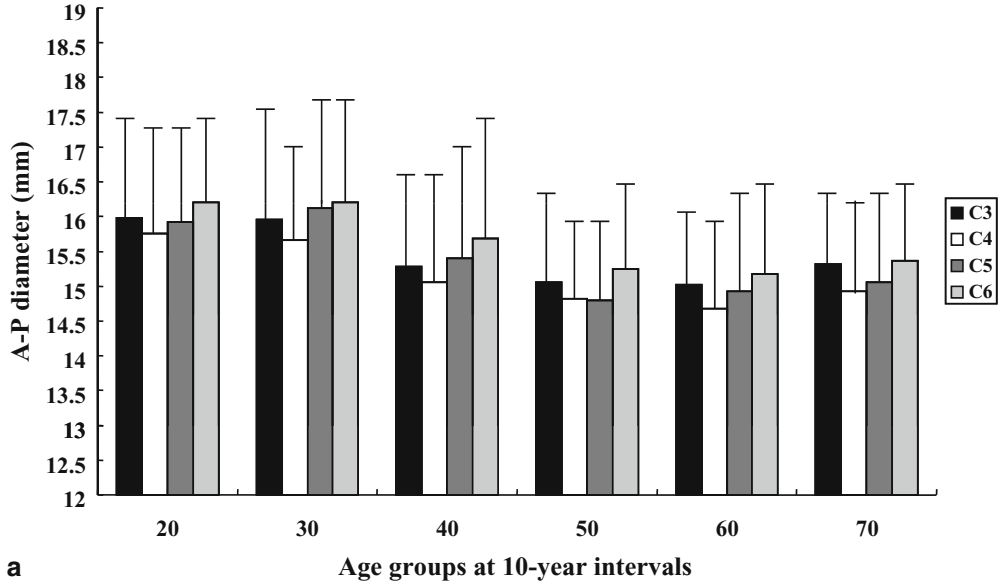
Fig. 3. Relation between age and physical factors. **a** Relation between age and height. The younger generation groups showed a taller body height in both men and women ($P < 0.05$). **b** Relation between age and body weight. The younger male generations had a heavier weight ($P < 0.05$), whereas all of the female generations had similar weights ($P = 0.09$). **c** Relation between age and arm span. The younger generations had a longer arm span in both sexes ($P < 0.05$)

number of subjects without symptoms related to the cervical spine during a specific period. We clearly demonstrated that the generations <40 years of age had a statistically wider cervical spinal canal.

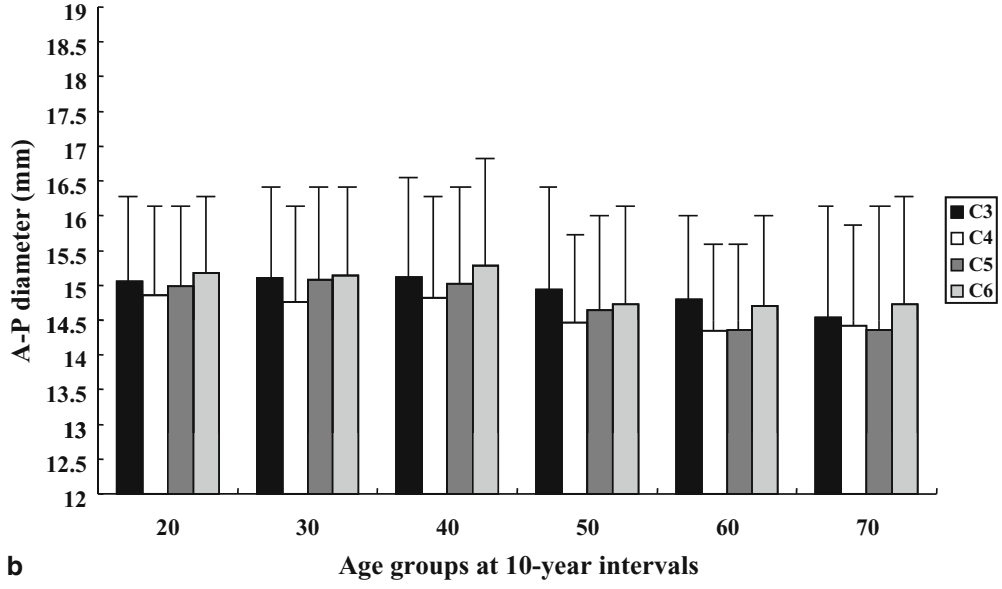
Penning[15] stressed the importance of backward slipping of the superjacent vertebral body upon extension of the cervical spine as the pincers mechanism of spinal cord compression and introduced the concept of jaw diameter. Dynamic canal stenosis, which is defined as a jaw diameter of ≤12 mm in extension, is another common risk factor of cervical myelopathy.[1,17,18] The jaw diameter is shortened by age-related changes such as a backward slipping.[5] This study clearly demonstrated that younger generations had a wider jaw diameter at every spinal level in both sexes. The wider jaw diameter in the younger generations reflects not only less age-related change but also a developmentally wider canal. The wider the spinal canal in both the AP and jaw diameters may be responsible for inducing cervical myelopathy less frequently. Thus, this myelopathy might be expected to decrease in Japan in the near future when the present younger generations have aged.

The trapezoid-shaped body of the cervical vertebra has never been described before. The anterior measurement point for the spinal canal in this study is the middle of the posterior cortex of the vertebral body, where generally no osteophyte is found in spondylosis, unlike ossification of the posterior longitudinal ligament.[15–23] Occasionally, with age, the vertebral body tends to deform to a trapezoidal shape. This deformity reduces the AP diameter of the spinal canal. However, it was found only in 3.5% of the men and in 1.3% of the women in their fifties to seventies in this study. The statistical analysis proved that these low rates of the deformity do not affect the conclusion that there has been a recent enlargement of the spinal canal in younger Japanese.

Why do the younger generations have a statistically wider spinal canal than the elderly generations? The body builds, including the height, body weight, and arm span, were significantly larger in the younger generations than in the elderly ones except for body weight in women. For example, the height of the group in their twenties was greater than that in the group in their seventies among the men and women by 7.5% and 9.7%, respectively. In addition, the trapezoid-shaped deformity of the vertebral body had no obvious effect on the diameter of the spinal canal. Therefore, the development of the builds in the Japanese mostly affects the wider spinal canal. The builds of the younger generations of the Japanese have been closer to the



a



b

Fig. 4. Relation between age and the AP (*A-P*) diameter of the cervical spinal canal. **a** Men. **b** Women. The AP diameter was larger by 1.1 mm and 1.0 mm on average in the men and women in their twenties than in those in their seventies, respectively. The younger generations of both sexes had a wider spinal canal at every spinal level ($P < 0.05$)

Westerners, although the spinal canal diameter of the former is still much smaller than that of the latter.[16,19] It might also depend on racial differences as well as the development of the builds.

There are several limitations of the present study. First, this was a cross-sectional study and, thus, different from a longitudinal study; we compared the spinal canal diameter of the every generation at a single point in time. Those data did not indicate the actual change of the canal size of a certain generation. Second, a measurement bias cannot be excluded from this type of study. In addition, we used the trapezoid-shaped body to represent degenerative change of the vertebral body. This was our first trial, and there might be several other radiological findings indicating the degeneration.

Conclusions

Younger Japanese generations had a wider cervical spine canal than did the older Japanese generations. The development of their builds might affect the wider spinal canal. A narrow spinal canal is a fundamental risk factor for cervical myelopathy. Therefore, cervical myelopathy might be expected to decrease in Japan in the near future when the present younger generations have aged.

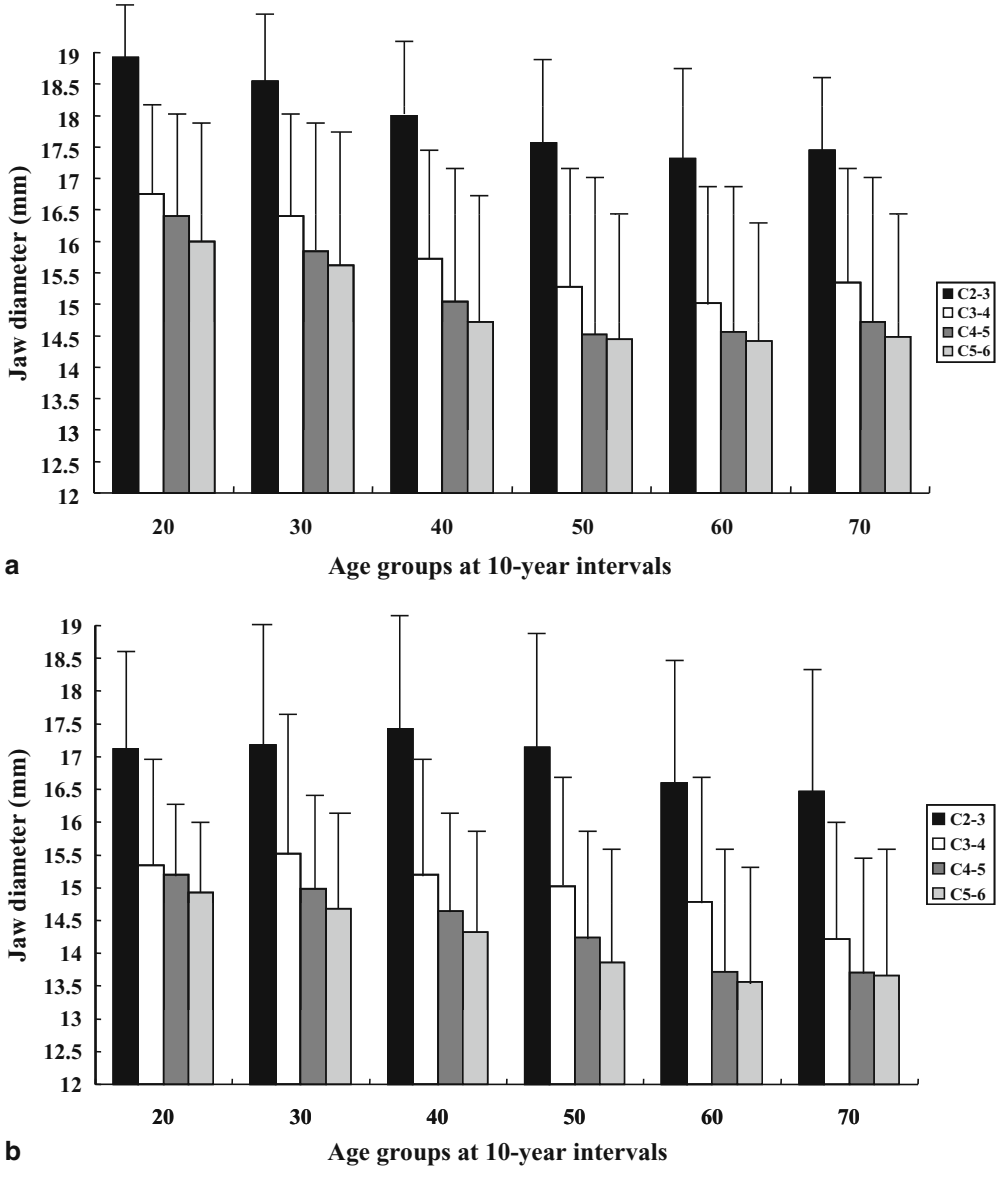


Fig. 5. Relation between the age and the jaw diameter of the cervical spinal canal. **a** Men. **b** Women. The younger generations had a significantly wider jaw diameter at all spinal levels in both sexes ($P < 0.05$)

Table 1. Frequency of the trapezoid-shaped body

	C3		C4		C5		C6	
Age (years)	Men	Women	Men	Women	Men	Women	Men	Women
20–29								
30–39								
40–49								
50–59					4		1	
60–69			1		6	2	2	2
70–79			1		4	3	2	1

References

1. Kokubun S, Sato T, Ishii Y, Tanaka Y. Cervical myelopathy in the Japanese. Clin Orthop 1996;323:129–38.
2. Hayashi H, Okada K, Hamada M, Tada K, Ueno R. Etiologic factors of myelopathy. Clin Orthop 1987;214:200–9.
3. Imai K. Cervical spondylotic myelopathy and sagittal diameter of the cervical spinal canal. J Jpn Orthop Assoc 1970;44:429–38 (in Japanese).
4. Nagashima C. Cervical myelopathy due to developmental stenosis of the cervical spinal canal. Part 1. The sagittal diameter of the

spinal canal. Noushinkeigeka (Neurosurgery) 1973;1:161–71 (in Japanese).
5. Hayashi K, Suzuki T. Measurement of the cervical spine and nerves and its clinical significance. Shinkeinaika 1974;1:175–9 (in Japanese).
6. Murone I. The importance of sagittal diameters of the cervical spinal canal in relation to spondylosis and myelopathy. J Bone Joint Surg Br 1974;56:30–6.
7. Sasaki A. Radiology of normal cervical spine. J Jpn Orthop Assoc 1980;54:615–31 (in Japanese).
8. Higo M, Sakou T, Suzuki S, Matumoto R, Ito H, Kozakura H, et al. Roentgenological study of the antero-posterior diameter in cervical developmental canal stenosis. Rinshou Seikeigeka (Clinical Orthopaedic Surgery) 1984;19:361–6 (in Japanese).
9. Hashimoto I, Tak YK. The true sagittal diameter of the cervical spinal canal and its diagnostic significance in cervical myelopathy. J Neurosurg 1977;47:912–6.
10. Sasaki T, Kadoya S, Iizuka H. Roentgenological study of the cervical spinal canal in normal adult Japanese. Neurol Med Chir 1998;38:83–9.
11. Tanaka Y. Morphological changes of the cervical spinal canal and cord due to aging. J Jpn Orthop Assoc 1984;58:873–86 (in Japanese).
12. Ministry of Health, Labor, and Welfare, Japan. The national nutrition survey in Japan, 2002. p. 113–5 (in Japanese).
13. Kaichi I. Radiographic observation of sagittal diameter of cervical spinal canal in normal children. Arch Jpn Chir 1980;49:436–53 (in Japanese).
14. Hinck VC, Hopkins CE, Savara BS. Sagittal diameter of the cervical spinal canal in children. Radiology 1962;79:97–108.
15. Penning L. Some aspects of plain radiography of the cervical spine in chronic myelopathy. Neurology 1962;12:513–9.
16. Wolf BS, Khilnani M, Malis L. The sagittal diameter of the bony cervical spinal canal and its significance in cervical spondylosis. J Mt Sinai Hosp 1956;23:283–91.
17. Kataoka O, Kurihara A, Maruo S. Dynamic canal stenosis in cervical spondylotic myelopathy. Rinsho Seikeigeka 1975;10:1133–43 (in Japanese).
18. Kokubun S, Sakurai M, Suzuki T, Tanaka Y, Matuda N, Ishikawa T, et al. Clinical importance of posterolisthesis in cervical spine lesion. Rinshou Seikeigeka (Clinical Orthopaedic Surgery) 1989;24:397–403 (in Japanese).
19. Boijsen E. The cervical spinal canal in intraspinal expansive process. Acta Radiol 1954;42:101–15.
20. Payne EE, Spillane JD. The cervical spine, an anatomico-pathological study of 70 specimens with particular reference of the problem of cervical spondylosis. Brain 1957;80:571–96.
21. Hinck VC, Gordy PD, Storino HE. Developmental stenosis of the cervical spinal canal: radiological considerations. Neurology 1964;14:864–8.
22. Gore DR, Sepic SB, Gardner GM. Roentgenographic findings of the cervical spine in asymptomatic people. Spine 1986;11:521–4.
23. Nurick S. The pathogenesis of the spinal cord disorder associated with cervical spondylosis. Brain 1972;95:87–100.