TABLE 2. (*Continued*)

Factors	%	Crude OR	95% CI	*P*	Adjusted OR	95% CI	*P*
Employment status							
Full-time	95.9	1.00			1.00		
Others	4.1	1.06	0.43–2.65	0.896	0.98	0.38–2.51	0.958
Manual handling at work							
No manual handling (desk work)	78.4	1.00			1.00		
Manual handling of objects <20 kg	10.6	1.40	0.79–2.47	0.250	1.47	0.83–2.63	0.188
Manual handling of objects ≥20-kg objects or working as a caregiver	11.0	1.24	0.69–2.20	0.473	1.34	0.73–2.46	0.351
Bending							
Not frequent	95.0	1.00			1.00		
Frequent	5.0	1.19	0.53–2.66	0.674	1.22	0.54–2.75	0.639
Twisting							
Not frequent	97.0	1.00			1.00		
Frequent	3.0	0.42	0.10–1.81	0.244	0.41	0.09–1.79	0.235
Lifting							
Not frequent	95.7	1.00			1.00		
Frequent	4.3	0.98	0.40–2.44	0.973	1.02	0.41–2.57	0.960
Pushing							
Not frequent	97.7	1.00			1.00		
Frequent	2.3	1.32	0.42–4.12	0.629	1.34	0.43–4.22	0.616
Hours of driving per day							
<4 hr	92.5	1.00			1.00		
≥4 hr	7.5	1.25	0.64–2.45	0.514	1.30	0.66–2.56	0.456
Hours of desk work							
<6 hr per day	45.7	1.00			1.00		
≥6 hr per day	54.3	1.03	0.72–1.50	0.856	1.03	0.71–1.50	0.866
Mental workload (quantitative aspect)							
Not stressed	59.1	1.00			1.00		
Stressed	40.9	0.88	0.60–1.28	0.488	0.91	0.62–1.34	0.642
Mental workload (qualitative aspect)							
Not stressed	60.0	1.00			1.00		
Stressed	40.1	1.36	0.94–1.97	0.104	1.39	0.96–2.02	0.085
Physical workload							
Not stressed	70.7	1.00			1.00		
Stressed	29.3	1.13	0.76–1.69	0.539	1.21	0.80–1.81	0.364
Interpersonal stress at work							
Not stressed	84.2	1.00			1.00		
Stressed	15.8	1.20	0.74–1.95	0.466	1.31	0.80–2.15	0.285

(*Continued*)

TABLE 2. (*Continued*)

Factors	%	Crude OR	95% CI	*P*	Adjusted OR	95% CI	*P*
Work environmental stress							
Not stressed	78.3	1.00			1.00		
Stressed	21.7	1.18	0.77–1.82	0.449	1.28	0.82–1.99	0.276
Job control							
Controlled	31.2	1.00			1.00		
Not controlled	68.8	1.03	0.70–1.51	0.875	1.04	0.71–1.52	0.856
Utilization of skills and expertise							
Utilization of skills and expertise	83.4	1.00			1.00		
No utilization of skills and expertise	16.6	0.97	0.59–1.59	0.906	0.96	0.58–1.59	0.882
Job fitness							
Feeling fit	79.5	1.00			1.00		
Not feeling fit	20.5	1.36	0.88–2.09	0.163	1.37	0.89–2.11	0.154
Reward to work							
Satisfied	80.4	1.00			1.00		
Not satisfied	19.6	1.13	0.72–1.78	0.583	1.14	0.72–1.79	0.578
Vigor							
Vigorous	89.1	1.00			1.00		
Not vigorous	10.9	1.25	0.72–2.19	0.427	1.26	0.72–2.21	0.425
Anger							
Not angry	76.5	1.00			1.00		
Angry	23.5	1.22	0.80–1.86	0.358	1.30	0.84–1.20	0.233
Fatigue							
No fatigue	77.7	1.00			1.00		
Fatigue	22.3	0.93	0.60–1.45	0.750	0.98	0.62–1.55	0.944
Anxiety							
Not anxious	82.8	1.00			1.00		
Anxious	17.2	1.40	0.88–2.21	0.154	1.45	0.91–2.31	0.113
Depressed mood							
Not feeling depressed	76.9	1.00			1.00		
Depressed	23.1	1.26	0.83–1.93	0.278	1.28	0.84–1.97	0.252
Somatic symptoms							
No somatic symptoms	87.8	1.00			1.00		
Somatic symptoms	12.2	1.47	0.87–2.47	0.148	1.48	0.87–2.49	0.145
Support by supervisors							
Supported	78.5	1.00			1.00		
Not supported	21.5	1.12	0.72–1.73	0.627	1.13	0.73–1.76	0.591
Support by coworkers							
Supported	66.7	1.00			1.00		
Not supported	33.3	0.95	0.64–1.41	0.800	0.93	0.63–1.38	0.719

(*Continued*)

TABLE 2. (*Continued*)

Factors	%	Crude OR	95% CI	*P*	Adjusted OR	95% CI	*P*
Support by family or friends							
Supported	83.6	1.00			1.00		
Not supported	16.4	1.01	0.62–1.66	0.964	1.04	0.63–1.73	0.868
Daily-life satisfaction							
Satisfied	76.4	1.00			1.00		
Not satisfied	23.7	1.04	0.68–1.61	0.844	1.10	0.71–1.70	0.664
Monotonous work							
Not monotonous	84.4	1.00			1.00		
Monotonous	15.6	0.70	0.40–1.21	0.203	0.72	0.41–1.25	0.239
Family history of LBP with disability							
No LBP with disability	86.4	1.00			1.00		
LBP with disability	13.6	1.23	0.73–2.05	0.433	1.27	0.75–2.14	0.368

Data adjusted for age and sex.
Totals may not sum to 100% because of rounding.
BMI indicates body mass index; CI, confidence interval; LBP, low back pain; OR, odds ratio.

intake is encouraged. Despite the small proportion of workers experiencing sciatica during the follow-up period (approximately 18%), economic loss at workplaces because of sciatica cannot be overestimated. Promoting available, accessible, and effective approaches for the management of overweight and obesity may improve overall industrial health by decreasing and preventing obesity and the subsequent risk of cardiovascular disease and diabetes,[38] osteoarthritis,[39] and spine diseases pertaining to obesity.[40]

TABLE 3. Multivariate-Adjusted Odds Ratios for Cases of New-Onset Sciatica

Factors	OR	95% CI	*P*
Age			
<40	1.00		
40–49	1.50	0.93–2.40	0.093
≥50	1.59	1.01–2.52	0.046
Sex			
Male	1.00		
Female	0.99	0.52–1.86	0.969
Obesity			
BMI <25 kg/m²	1.00		
BMI ≥25 kg/m² (obese)	1.77	1.17–2.68	0.007
Mental workload (qualitative aspect)			
Not stressed	1.00		
Stressed	1.40	0.96–2.04	0.082

Data adjusted for age and sex.
CI indicates confidence interval; OR, odds ratio; BMI, body mass index.

Although not significant in multivariate analysis, mental workload in a qualitative aspect approached significance in crude analyses and was statistically significant in adjusted analyses ($P < 0.1$). Manual handling while under mental strain can biomechanically increase spine loads under experimental conditions.[41,42] As a result, the chance for injury, especially disc injury, increases, which may lead to the onset of sciatica. Existing literature on new-onset of sciatica relating to psychosocial factors is still scarce. Moreover, those results often conflict perhaps because different measurements were used to assess psychosocial factors. Further research is needed to elucidate the potential relationship fully between psychosocial factors and cases of new-onset sciatica.

There are some limitations to the study. Generalization of the results is an issue. First, approximately 89% of the study participants were male, and sex was an effect modifier, particularly in males. Although this study indicated that sex can be an effect modifier for obesity and mental workload, the number of females may not be sufficient to investigate effect modification. Further investigation is needed for effect modification in females. Second, there is also a concern that results may not represent workers who left work because of sciatica. Third, results may be influenced by selective drop out because 3194 workers followed-up were entered into the analysis out of 5310 participants. On the basis of the results comparing the baseline characteristics between the follow-up group and non–follow-up group (Table 1), more of the non–follow-up group were younger and engaged in no/less manual handling involved at work than the follow-up group. Although obesity

TABLE 4. Assessment of Effect Modification by Age and Sex on the Association of New-Onset Sciatica

Factor	OR	*P*	95% CI
Obesity (obese *vs.* not obese)			
<40	1.09	0.834	0.47–2.53
40–49	1.38	0.384	0.67–2.82
≥50	3.18	0.001	1.65–6.15
Obesity (obese *vs.* not obese)			
Male	1.93	0.002	1.26–2.95
Female	0.68	0.730	0.08–6.02
Mental workload (stressed *vs.* not stressed)			
<40	1.99	0.043	1.02–3.86
40–49	1.18	0.624	0.61–2.29
≥50	1.16	0.633	0.63–2.16
Mental workload (qualitative aspect) (stressed *vs.* not stressed)			
Male	1.44	0.071	0.97–2.13
Female	0.96	0.950	0.31–3.02

CI indicates confidence interval; OR, odds ratio.

and manual handling at work were statistically significant, the differences were practically small. This is perhaps because the number of both the follow-up and non–follow-up groups was large. Although it was assumed that these differences may not influence interpretation, results of the study may need to be regarded with care. Lastly, this study used the MLHW definition of obesity, unlike the previous literature using the World Health Organization definition of obesity. Although the MLHW definition may be appropriate for obese in Japanese population, not using an internationally-accepted definition of obesity may limit generalizing the findings.

Moreover, this study indicated effect modification by age exists in the association between obesity and new-onset sciatica, and the OR was high especially for those aged 50 or more. This can be explained by degenerated intervertebral discs and spinal canals by age, but further research may be needed for explaining this effect modification. Interpretation of the results regarding age is needed.

Additionally, misclassification at some extent is inevitable. Responses that rely on diagnosis and subjective measurement may be distorted because of the nature of the self-administered questionnaires, whereas retrospective questions may be distorted by recall bias. Future research should consider using both subjective as well as objective measures simultaneously.

Finally, there may be alternative methods for the selection of potential risk factors before conducting multivariate analysis. It should be noted that a more complicated model aside from including well-established potential confounders such as age and sex, may offer a better explanation of the data. Further research is needed to identify a full range of potential risk factors for inclusion in future studies.

CONCLUSION

The aim of this study was to examine risk factors, including psychosocial factors, for the development of sciatica in Japanese workers. In the study, individual factors such as age and obesity were identified as risk factors for the development of new-onset sciatica in previously asymptomatic individuals. Our findings suggest that the management of obesity is key to preventing new-onset sciatica. Japanese occupational health departments should encourage preventative strategies, including exercise, weight control, and control of dietary intake. Further research is needed to assess the effectiveness of obesity management in preventing new-onset sciatica.

➢ Key Points

- ❑ Significant associations between development of new-onset sciatica and age and obesity were found in both univariate and multivariate analyses.
- ❑ The relationship between individual and occupational factors and cases of new-onset sciatica is established, but the involvement of psychosocial factors in its development remains unclear. This study suggests that individual factors (*e.g.*, obesity) are the potential risk factors for new-onset sciatica in previously symptom-free workers.
- ❑ Our results suggest that reducing or preventing obesity may lower the risk of new-onset sciatica. Promoting available, accessible, and effective sources of weight management for workers should be encouraged in industrial health.

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ORIGINAL ARTICLE

An outcome measure for patients with cervical myelopathy: the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ): an average score of healthy volunteers

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Abstract
Background An outcome measure to evaluate the neurological function of patients with cervical myelopathy was proposed by the Japanese Orthopaedic Association (JOA score) and has been widely used in Japan. However, the JOA score does not include patients' satisfaction, disability, handicaps, or general health, which can be affected by cervical myelopathy. In 2007, a new outcome measure, the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ), which is a self-administered questionnaire, was developed. However, the influence of age and gender on the scores has not been fully examined. The purpose of this study was to establish the standard value of the JOACMEQ by age using healthy volunteers.
Methods This study was conducted in 23 university hospitals and their affiliated hospitals from September to December 2011. The questionnaire included 24 questions for evaluation of physical function of the cervical spine and

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spinal cord. A total of 1,629 healthy volunteers were recruited for the study. The ages ranged from 20 to 89 years old.
Results The volunteers comprised 798 men and 831 women. In the elderly healthy volunteers, the JOACMEQ scores decreased with age. In general, the scores for cervical spine function and upper/lower extremity function were retained up to the 60s, then decreased in the 70s and 80s. The scores for quality of life were retained up to the 70s; however, the score for bladder function was retained up to the 40s, then declined with age from the 50s to 80s.
Conclusion The standard values of the JOACMEQ by age were established. Differences in the scores were found among different generations. Patients with cervical myelopathy should be evaluated with this new self-administered questionnaire taking into account the standard values according to different ages.

Introduction

The members of the Subcommittee on the Evaluation of Low Back Pain and Cervical Myelopathy, who belong to the Clinical Outcomes Committee of the Japanese Orthopaedic Association, have composed a new self-administered questionnaire, the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ), as a new outcome measure for patients with cervical myelopathy [1] to solve problems associated with the Japanese Orthopaedic Association score (JOA score), which was established by the Japanese Orthopaedic Association in 1975 [2] and was revised in 1994 [3]. The JOACMEQ provides specific outcome measures including patients' disability, handicaps, and general health, which are necessary to evaluate severity and treatment results in patients with cervical myelopathy. It has been used in many institutions nationwide. However, the influence of age and gender on the scores has not been fully examined, and there is a concern that the age-related decline in scores may influence the evaluation. Therefore, standard values according to age using the data of physically unimpaired persons are needed to validate this new self-administered questionnaire. The purpose of the current study was to establish the standard values of the JOACMEQ according to different ages using the results of healthy volunteers in their 20s up to 80s.

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Materials and methods

This study was conducted in 23 university hospitals and their affiliated hospitals from September to December in 2011. A total of 1,644 healthy volunteers were recruited for the study. They were self-supporting and required no medical assistance for orthopedic diseases. Subjects with cognitive impairment who could not understand the questionnaires and those who were under treatment for orthopedic disorders and/or had a history of operation for spinal disorders including the cervical spine were excluded from the study. Medical professionals were also excluded from the subjects. The healthy volunteers were grouped by gender and decade from 20 to 80 years of age. Five healthy individuals within each age group and from both genders were surveyed at each institution. This study was reviewed and approved by the institutional review board of each institution, and all subjects provided informed consent prior to the inclusion to the study.

The questionnaire included 24 questions in five domains, cervical spine function, upper extremity function, lower extremity function, bladder function, and quality of life. Visual analog (VAS) scales were used to evaluate the degree of pain or stiffness in the neck or shoulders, tightness in the chest, pain or numbness in the arms or hands, and pain or numbness from the chest to toes (Table 1). A respondent recalled his or her physical condition during the previous 1 week and circled the number of an answer for each question that best fit his or her condition. If a respondent's condition changed depending on the day or the time, he or she circled the number representing "the worst condition." The JOACMEQ score was calculated as: cervical spine function: Q1-1 × 20 + Q1-2 × 10 + Q1-3 × 15 + Q1-4 × 5 − 50; upper extremity function: (Q1-4 × 5 + Q2-1 × 10 + Q2-2 × 15 + Q2-3 × 5 + Q3-1 × 5 − 40) × 100 ÷ 95; lower extremity function: Q3-1 × 10 + Q3-2 × 10 + Q3-3 × 15 + Q3-4 × 5 + Q3-5 × 5 − 45) × 100 ÷ 110; bladder function: (Q4-1 × 10 +

Table 1 The JOA Cervical Myelopathy Evaluation Questionnaire (JOACMEQ)

With regard to your health condition during the last week, please circle the one item number of the answer for the following questions that best applies. If your condition varies depending on the day or the time, circle the item number of your condition at its worst.

Q1-1 While in the sitting position, can you look up at the ceiling by tilting your head upward?

1) Impossible 2) Possible to some degree (with some efforts)

3) Possible without difficulty

Q1-2 Can you drink a glass of water without stopping despite the neck symptoms?

1) Impossible 2) Possible to some degree

3) Possible without difficulty

Q1-3 While in the sitting position, can you turn your head toward the person who is seated to the side but behind you and speak to that person while looking at his/her face?

Table 1 continued

1) Impossible 2) Possible to some degree

3) Possible without difficulty

Q1-4 Can you look at your feet when you go down the stairs?

1) Impossible 2) Possible to some degree

3) Possible without difficulty

Q2-1 Can you fasten the front buttons of your blouse or shirt with both hands?

1) Impossible 2) Possible if I spend time.

3) Possible without difficulty

Q2-2 Can you eat a meal with your dominant hand using a spoon or a fork?

1) Impossible 2) Possible if I spend time.

3) Possible without difficulty

Q2-3 Can you raise your arm? (Answer for the weaker side.)

1) Impossible

2) Possible up to shoulder level

3) Possible though the elbow and/or wrist is a little flexed

4) I can raise it straight upward

Q3-1 Can you walk on a flat surface?

1) Impossible

Table 1 continued

2) Possible but slowly even with support

3) Possible only with the support of a handrail, a cane, or a walker

4) Possible but slowly without any support

5) Possible without difficulty

Q3-2 Can you stand on either leg without the support of your hand? (the need to support yourself)

1) Impossible with either leg

2) Possible on either leg for more than ten seconds

3) Possible on both legs individually for more than ten seconds

Q3-3 Do you have difficulty in going up the stairs?

1) I have great difficulty. 2) I have some difficulty.

3) I have no difficulty.

Q3-4 Do you have difficulty in one of the following motions; bending forward, kneeling or stooping?

1) I have great difficulty. 2) I have some difficulty.

3) I have no difficulty.

Q3-5 Do you have difficulty in walking more than 15 minutes?

1) I have great difficulty. 2) I have some difficulty.

Table 1 continued

3) I have no difficulty.

Q4-1 Do you have urinary incontinence?

1) Always

2) Frequently

3) When retaining urine over a period of more than 2 hours

4) When sneezing or straining

5) No

Q4-2 How often do you go to the bathroom at night?

1) Three times or more 2) Once or twice 3) Rarely

Q4-3 Do you have a feeling of residual urine in your bladder after voiding?

1) Most of the time 2) Sometimes 3) Rarely

Q4-4 Can you initiate (start) your urine stream immediately when you want to void?

1) Usually not 2) Sometimes 3) Most of the time

Q5-1 How is your present health condition?

1) Poor 2) Fair 3) Good 4) Very good 5) Excellent

Q5-2 Have you been unable to do your work or ordinary activities as well as you would like?

Table 1 continued

1) I have not been able to do them at all.

2) I have been unable to do them most of the time.

3) I have sometimes been unable to do them.

4) I have been able to do them most of the time.

5) I have always been able to do them.

Q5-3 Has your work routine been hindered because of the pain?

1) Greatly 2) Moderately 3) Slightly (somewhat)

4) Little (minimally) 5) Not at all

Q5-4 Have you been discouraged and depressed?

1) Always 2) Frequently 3) Sometimes 4) Rarely 5) Never

Q5-5 Do you feel exhausted?

1) Always 2) Frequently 3) Sometimes 4) Rarely 5) Never

Q5-6 Have you felt happy?

1) Never 2) Rarely 3) Sometimes 4) Almost always 5) Always

Q5-7 Do you think you are in decent health?

1) Not at all (my health is very poor)

2) Barely (my health is poor)

3) Not very much (my health is average health)

Table 1 continued

4) Fairly (my health is better than average)

5) Yes (I am healthy)

Q5-8 Do you feel your health will get worse?

1) Very much so 2) A little bit at a time

3) Sometimes yes and sometimes no 4) Not very much 5) Not at all

Regarding 0 as "no pain (numbness) at all" and 10 as "the most intense pain (numbness) imaginable," mark a point between 0 and 10 on the lines below to show the degree of your pain (numbness) when your symptom was at its worst during the last week.

If you feel pain or stiffness in your neck or shoulders, mark the degree

0 10

If you feel tightness in your chest, mark the degree

0 10

If you feel pain or numbness in your arms or hands, mark the degree (If there is pain in both limbs, then the worse of the two)

Table 1 continued

0 10

If you feel pain or numbness from chest to toe, mark the degree

0 10

0 : No pain (numbness) at all

10 : The worst state imaginable

Q4-2 × 5 + Q4-3 × 10 + Q4-4 × 5 − 30) × 100 ÷ 80; quality of life: (Q5-1 × 3 + Q5-2 × 2 + Q5-3 × 2 + Q5-4 × 5 + Q5-5 × 4 + Q5-6 × 3 + Q5-7 × 2 + Q5-8 × 3 − 24) × 100 ÷ 96. The score of each domain ranges from 0 to 100 points, which is proportional to the patients' clinical conditions [4–6].

The data of those over 90 years old were extracted from the study; then the answers of 1,629 volunteers were used for the analysis. Irrelevant data where subjects did not respond to all the questions or clearly inappropriate answers in which subjects did not follow instructions were excluded from the analyses for each domain. The Steel–Dwass test was used for multiple comparisons among different generations, and the Jonckheere-Terpstra test was used to determine age trends in each gender by domain. $P < 0.05$ was considered significant.

Table 2 Gender and age distribution of volunteers

Age groups (years)	Male	Female	Total
20–29	115	120	235
30–39	122	117	239
40–49	117	120	237
50–59	113	123	236
60–69	118	122	240
70–79	109	117	226
80–89	104	112	216
Total	798	831	1,629

Results

The volunteers comprised 798 men and 831 women. The gender and age distributions of the volunteers are shown in Table 2. The distribution of the scores for each domain in the JOACMEQ (from 10th to 90th percentile) are shown in Tables 3, 4, 5, 6, and 7. In the elderly healthy volunteers, the JOACMEQ scores decreased with age. The average score for cervical spine function was more than 90 points in the younger generation from the 20s to 60s, and in those in their 70s and 80s, the average score decreased to 80 points and 70 points, respectively (Table 3). There were significant differences in the average scores between the younger generation in their 20s to 60s and the elderly generation in their 80s in both genders. The average score for upper extremity function was more than 95 points in those in their 20s to 70s and decreased to 80 points for those in their 80s in both genders (Table 4). There were also significant differences in the average scores between the younger generations and elderly in their 80s in both genders. The average lower extremity function score was more than 95 points in those in their 20s to 60s in males and decreased to 70 points in their 80s. In females, the average score was more than 95 points in those in their 20s to 40s and decreased to <95 points in their 50s and 60s; in 70s and 80s, the average score further decreased to 80 points and 60 points, respectively (Table 5). There were significant differences in the average scores between the younger generation below 70 years of age and elderly generation above 70 in both genders. The average bladder function score was more than 90 points in the young generations in their 20s to

Table 3 Distribution of scores for domains in the JOACMEQ; cervical spine function

Cervical spine function	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	115	120	117	113	118	106	102	Valid	119	115	118	121	121	115	109
	Invalid	0	2	0	0	0	3	2	Invalid	1	2	2	2	1	2	3
Average		96.9	98.4	97.0	93.8	95.0	86.9	74.9*		98.1	97.6	97.1	94.9	93.1	87.4	79.7*
Median		100.0	100.0	100.0	100.0	100.0	100.0	85.0		100.0	100.0	100.0	100.0	100.0	100.0	90.0
Standard deviation		12.2	6.7	8.5	12.6	10.0	21.5	27.7		6.3	5.6	8.1	10.3	15.6	21.5	22.6
Percentile	10.0	90.0	100.0	85.0	80.0	75.0	57.0	31.5	10.0	90.0	88.0	85.0	80.0	75.0	58.0	40.0
	25.0	100.0	100.0	100.0	87.5	97.5	85.0	55.0	25.0	100.0	100.0	100.0	95.0	90.0	80.0	65.0
	50.0	100.0	100.0	100.0	100.0	100.0	100.0	85.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0	90.0
	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* $p < 0.05$; the average scores were significantly lower than those in the young generations in their 20s to 60s in both genders

Table 4 Distribution of scores for domains in the JOACMEQ; upper extremity function

Upper extremity function	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	115	121	116	113	117	107	103	Valid	120	114	120	122	122	117	109
	Invalid	0	1	1	0	1	2	1	Invalid	0	3	0	1	0	0	3
Average		99.0	99.7	99.6	99.2	99.0	96.9	88.4*		100.0	99.8	99.9	98.9	98.5	96.3	88.1*
Median		100.0	100.0	100.0	100.0	100.0	100.0	95.0		100.0	100.0	100.0	100.0	100.0	100.0	95.0
Standard deviation		6.3	1.6	1.7	2.6	3.9	9.2	16.4		0.5	1.6	0.6	3.1	5.3	10.6	16.0
Percentile	10.0	100.0	100.0	100.0	95.0	100.0	89.0	65.0	10.0	100.0	100.0	100.0	95.0	95.0	89.0	68.0
	25.0	100.0	100.0	100.0	100.0	100.0	100.0	84.0	25.0	100.0	100.0	100.0	100.0	100.0	95.0	81.5
	50.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0	50.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0
	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	75.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

* $p < 0.05$; the average scores were significantly lower than those in the young generations in their 20s to 70s in both genders

Table 5 Distribution of scores for domains in the JOACMEQ; lower extremity function

Lower extremity function	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	115	121	117	112	116	109	103	Valid	119	113	118	121	120	114	111
	Invalid	0	1	0	1	2	0	1	Invalid	1	4	2	2	2	3	1
Average		98.6	97.8	97.9	96.3	95.8	90.4*	73.2*		97.0	97.9	96.9	94.4	94.5	88.0*	63.7*
Median		100.0	100.0	100.0	100.0	100.0	100.0	77.0		100.0	100.0	100.0	100.0	100.0	95.0	68.0
Standard deviation		4.1	6.7	5.5	8.0	10.0	15.6	25.6		7.0	6.1	7.6	9.9	11.2	17.4	27.0
Percentile	10.0	95.0	95.0	91.0	83.2	80.5	68.0	27.0	10.0	86.0	92.6	82.0	77.0	77.0	66.0	23.0
	25.0	100.0	100.0	100.0	96.3	95.0	86.0	59.0	25.0	100.0	100.0	100.0	95.0	95.0	82.0	45.0
	50.0	100.0	100.0	100.0	100.0	100.0	100.0	77.0	50.0	100.0	100.0	100.0	100.0	100.0	95.0	68.0
	75.0	100.0	100.0	100.0	100.0	100.0	100.0	95.0	75.0	100.0	100.0	100.0	100.0	100.0	100.0	86.0
	90.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	99.0

* $p < 0.05$; the average scores were significantly lower than those in young generations in their 20s to 60s in both genders

Table 6 Distribution of scores for domains in the JOACMEQ; bladder function

Bladder function	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	113	120	114	112	117	108	102	Valid	118	116	120	120	120	113	106
	Invalid	2	2	3	1	1	1	2	Invalid	2	1	0	3	2	4	6
Average		97.1	94.9	94.1	90.1*	87.5*	83.2*	72.1*		97.5	97.5	95.2	91.2*	89.6*	84.2*	75.1*
Median		100.0	100.0	100.0	94.0	94.0	88.0	75.0		100.0	100.0	100.0	94.0	94.0	88.0	81.0
Standard deviation		6.5	8.0	9.2	10.3	12.9	15.5	22.2		6.7	5.3	6.8	9.4	10.2	13.8	20.0
Percentile	10.0	88.0	81.0	81.0	75.0	69.0	62.0	38.0	10.0	88.0	88.0	88.0	81.0	75.0	64.8	44.0
	25.0	100.0	88.0	94.0	82.8	81.0	75.0	62.0	25.0	100.0	100.0	88.0	88.0	81.0	81.0	62.0
	50.0	100.0	100.0	100.0	94.0	94.0	88.0	75.0	50.0	100.0	100.0	100.0	94.0	94.0	88.0	81.0
	75.0	100.0	100.0	100.0	100.0	97.0	94.0	94.0	75.0	100.0	100.0	100.0	100.0	100.0	94.0	94.0
	90.0	100.0	100.0	100.0	100.0	100.0	100.0	94.0	90.0	100.0	100.0	100.0	100.0	100.0	100.0	94.0

* $p < 0.05$; the average scores were significantly lower than those in young generations in their 20s to 40s in both genders

Table 7 Distribution of scores for domains in the JOACMEQ; quality of life

Quality of life	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	113	121	116	112	117	106	103	Valid	114	114	117	120	118	112	108
	Invalid	2	1	1	1	1	3	1	Invalid	6	3	3	3	4	5	4
Average		75.7	70.6	68.5	66.2	70.3	68.5	60.2*		73.0	70.5	65.7	64.2	67.5	64.3	58.9*
Median		77.0	70.0	69.5	65.5	72.0	72.0	61.0		73.5	69.0	64.0	65.0	67.5	63.0	57.0
Standard deviation		16.0	14.6	13.2	16.3	14.0	15.9	18.5		15.8	13.0	13.4	13.6	14.4	16.3	17.2
Percentile	10.0	51.4	53.0	52.0	46.0	49.8	46.7	38.4	10.0	54.0	55.0	49.0	49.1	48.0	45.0	38.9
	25.0	65.5	62.0	60.0	56.3	60.5	57.8	46.0	25.0	64.0	61.0	57.5	54.0	57.8	52.0	47.0
	50.0	77.0	70.0	69.5	65.5	72.0	72.0	61.0	50.0	73.5	69.0	64.0	65.0	67.5	63.0	57.0
	75.0	86.0	82.0	76.0	77.0	80.5	79.3	74.0	75.0	83.3	79.3	74.5	73.0	77.0	77.0	71.0
	90.0	97.0	88.8	84.0	88.7	89.0	89.3	83.0	90.0	95.5	89.0	83.2	80.9	88.0	85.7	82.0

* $p < 0.05$; the average scores were significantly lower than those in young generations in their 20s to 60s in both genders

50s in both genders; the average score decreased to 80 points in those in their 60s and 70s and to 70 points in their 80s in both genders (Table 6). There were significant differences in the average scores between the younger generations in their 20s to 40s and elderly generations in their 50s to 80s in both genders. The average quality of life score of each generation was approximately 70 points in the generations in their 20s to 60s in both genders and decreased to the 60–70 points in their 70s in males and at 70s and 80s in females (Table 7). There were significant differences in the average scores between the younger generations and elderly generation in their 80s in both genders. With regard to the age trend on the Jonckheere–Terpstra test, scores tended to decrease in the five domains as age increased in both genders.

The scores for each domain in the VAS for pain or stiffness in the neck or shoulders, tightness in the chest, pain or numbness in the arms or hands, and pain or numbness from the chest to toe are shown in Tables 8, 9, 10, and 11. The volunteers recorded the VAS scores as a mark on the bar scale as a value according to the instructions in the attached document. However, if both a mark on the bar scale and a numerical value on the sheet were present, the former was used for the analysis. The VAS scores for all domains increased with age; however, the score for pain or stiffness in the neck or shoulders in females tended to decrease with age (Table 8). The scores of the generation in their 40s and 50s for females were significantly higher than those of the elderly in their 70s and 80s. Tightness in the chest was not a frequent complaint in either gender (Table 9), and there were no significant differences in the scores among different generations in either gender. The VAS score for pain or numbness in the arms or hands was more frequent in males in those who were in their 60s and above and in their 50s and above in females, and it was a common complaint in the 80s in both genders (Table 10). There were significant differences in the scores between the younger generation and elderly in their 80s in both genders. Also, the score for pain or numbness from the chest to toe was more frequent in those over 60 years in males and over 50 years in females, with a particularly high incidence in those in their 80s in both genders (Table 11). In male volunteers, there were significant differences in the scores between the younger generations in their 20s to 50s and elderly generations in their 60s to 80s, and in females, there were significant differences in the scores between the younger generations in their 20s to 60s and elderly in their 70s and 80s. Regarding age trends among the VAS scores, the scores tended to increase with age in both genders across all domains, except neck stiffness in women, which showed a tendency to decrease with an increase in age.

Table 8 Distribution of scores in VAS scales for pain or stiffness in the neck or shoulders

Pain or stiffness in the neck or shoulders	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	106	119	111	106	106	101	91	Valid	118	113	115	117	114	105	109
	Invalid	9	3	6	7	12	8	13	Invalid	2	4	5	6	8	12	3
Average		17.2	23.4	28.5	27.2	20.1	21.5	29.2		28.1	33.0	36.1*	41.2*	31.0	22.2	24.6
Median		9.5	15.0	20.0	17.5	15.5	11.0	26.0		20.0	28.0	31.0	39.0	24.0	13.0	15.0
Standard deviation		21.6	25.3	27.8	27.0	22.0	26.4	28.3		28.0	27.8	25.1	30.6	26.2	24.9	27.5
Percentile	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	6.2	0.0	0.0	0.0	0.0
	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	3.8	11.0	15.0	13.5	9.5	0.0	0.0
	50.0	9.5	15.0	20.0	17.5	15.5	11.0	26.0	50.0	20.0	28.0	31.0	39.0	24.0	13.0	15.0
	75.0	25.0	35.0	50.0	49.3	31.3	35.5	49.0	75.0	49.3	50.0	57.0	68.0	51.0	41.5	44.0
	90.0	54.6	65.0	74.8	70.3	49.3	63.6	72.2	90.0	75.0	74.4	72.8	80.0	72.0	61.4	69.0

* $p < 0.05$; the average scores were significantly higher than those in the elderly in their 70s and 80s in females

Table 9 Distribution of scores in VAS scales for tightness in the chest

Tightness in the chest	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	108	120	114	107	105	101	94	Valid	120	115	119	117	111	106	110
	Invalid	7	2	3	6	13	8	10	Invalid	0	2	1	6	11	11	2
Average		3.7	3.1	5.9	5.1	2.4	4.9	8.1		2.4	3.1	2.9	3.9	3.8	3.2	7.9
Median		0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Standard deviation		8.6	10.7	14.8	10.2	7.2	12.6	17.1		9.4	10.0	9.8	12.5	11.9	11.0	16.8
Percentile	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	75.0	0.0	0.0	3.0	6.0	0.0	0.0	8.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	8.0
	90.0	18.0	7.9	19.0	21.0	8.0	19.8	36.0	90.0	8.0	10.0	10.0	11.6	12.6	5.3	28.5

Table 10 Distribution of scores in VAS scales for pain or numbness in the arms or hands

Pain or numbness in the arms or hands	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	106	121	112	106	102	102	92	Valid	118	116	120	121	112	108	108
	Invalid	9	1	5	7	16	7	12	Invalid	2	1	0	2	10	9	4
Average		3.5	4.3	6.6	6.8	9.9	12.7	20.4*		3.1	4.3	6.4	10.5	10.7	11.3	16.7*
Median		0.0	0.0	0.0	0.0	0.0	0.0	5.0		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Standard deviation		10.8	12.0	17.8	13.3	17.7	22.3	29.0		8.2	12.9	13.6	18.8	18.6	23.0	25.7
Percentile	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	50.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	75.0	0.0	0.0	5.0	9.0	10.8	17.8	30.0	75.0	0.0	0.0	4.8	11.5	15.0	9.3	29.0
	90.0	11.0	17.4	19.4	26.0	39.0	46.0	68.8	90.0	12.1	12.6	26.6	44.4	38.5	53.1	50.1

* $p < 0.05$; the average scores were significantly larger than those in young generations in their 20s to 40s in both genders

Table 11 Distribution of scores in VAS scales for pain or numbness from chest to toe

Pain or numbness from chest to toe	Male	20–29	30–39	40–49	50–59	60–69	70–79	80–89	Female	20–29	30–39	40–49	50–59	60–69	70–79	80–89
Number	Valid	105	122	115	106	105	99	94	Valid	119	115	120	119	111	108	107
	Invalid	10	0	2	7	13	10	10	Invalid	1	2	0	4	11	9	5
Average		2.3	3.3	6.1	5.5	11.0*	11.9*	24.4*		1.9	3.6	4.7	10.2	9.8	14.0*	19.1*
Median		0.0	0.0	0.0	0.0	0.0	0.0	14.5		0.0	0.0	0.0	0.0	0.0	0.0	1.0
Standard deviation		9.5	10.0	16.9	13.9	19.7	21.2	29.1		9.0	10.6	14.1	19.3	18.9	25.2	25.3
Percentile	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	50.0	0.0	0.0	0.0	0.0	0.0	0.0	14.5	50.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
	75.0	0.0	0.0	2.0	4.5	18.5	13.0	43.5	75.0	0.0	0.0	0.0	16.0	11.0	19.8	38.0
	90.0	4.0	11.7	20.4	17.0	34.2	46.0	74.5	90.0	0.0	14.0	17.9	50.0	33.6	64.3	56.2

* $p < 0.05$; the average scores were significantly larger than those in young generations in their 20s to 50s in males and in their 20s to 60s in females

Discussion

Spinal cord function related to cervical myelopathy was assessed by the JOA (Japanese Orthopaedic Association) score, which was established in 1975 [2] and revised in 1994 [3]. The original JOA score was used as a functional assessment for cervical myelopathy worldwide, and the high inter- and intraobserver reliability of the score was demonstrated [7]. Although the JOA score attaches importance to the physical function of the upper and lower extremities and bladder dysfunction, the score does not include cervical spine function, including neck pain, a stiff neck, patient satisfaction, disability, or QOL.

The JOACMEQ was developed as a new self-administered questionnaire to measure outcomes in patients with cervical myelopathy [1] to solve problems of the original JOA score. With this new score, specific outcome measures of patient satisfaction, disability, handicaps, and general health, which are necessary information to evaluate patients with cervical myelopathy, are obtained. However, the influence of age and gender on the score has not been examined, and concern exists that the age-related decline may influence the evaluation.

In the current study, 1,629 healthy volunteers were recruited in 23 institutions to establish the standard values of the JOACMEQ by age using data obtained from healthy volunteers in their 20s to 80s.

In the elderly healthy volunteers, the JOACMEQ scores decreased with age. As for upper and lower extremity function, there was a relatively weak influence of age and gender; however, there was a strong influence of aging on bladder function. The bladder function scores were retained only up to 40 years of age, then declined significantly after 50 years. Also in the QOL score, even in the younger volunteers, the average score did not reach the full score of 100.

The authors believe that the standard scores for cervical spine function, upper extremity function, and lower extremity function should be regarded as 95 points for relatively young patients under the age of 60, and for bladder function, the lower limits of the score for healthy subjects should be regarded as 80 points. The QOL scores may not be altered with age or gender, and the standard value should be regarded as over 70 points. There was a significant decrease in the JOACMEQ score in those in their 80s in the current study. These results indicate that persons older than 80 years of age might have accompanying age-related degeneration of the central and/or peripheral nervous systems, impairment of motor functions, and other general complications even if they look healthy.

As for the VAS, an influence of age was also found in the healthy volunteers. Most domains in the VAS were influenced by age-related degenerative diseases of the cervical spine. In the domain of pain or numbness in the arms or hands, the scores in the elderly generation were significantly higher than those in the younger generations. These results may be induced by peripheral arterial diseases or neuropathy that may exist in the elderly population. The VAS in most domains tended to increase with age; however, in females, the VAS for pain or stiffness in the neck or shoulders decreased with age. These findings suggest that pain or stiffness in the neck or shoulders may not be affected by age-related degenerative conditions of the cervical spine, but may be caused by muscular or posture distress related to office work or household work in relatively younger female generations.

The JOACMEQ was designed as a self-administered questionnaire to evaluate spinal functions in myelopathy patients and may be suitable for a relative evaluation in each case and may not be suitable for direct comparison with other patients. We can judge that a treatment is "effective" for a patient if: (1) the patient answers all questions necessary to calculate the score of a domain and an increase of $\geq$20 points is obtained for that score, or (2) the functional score after treatment is >90 points even if the answers for the unanswered questions were supposed to be the worst possible choice. The effectiveness of the treatment can be evaluated based only on the two above-mentioned conditions [8]. Although these criteria were chosen based on the extensive analysis of a considerable amount of data, which was obtained in a series of previous studies, by the statistics expert, a revision may be necessary for the elderly populations. According to our results, the average functional scores of most domains in normal healthy volunteers were <90 points in the elderly population in the 70s and 80s. In the JOACMEQ, exceptional attention to judgment about the treatment or relative evaluation in the assessment for elderly individuals over 70 years old might be needed.

As for limitations of this study, the detailed medical history and general health of the volunteers were not fully assessed; therefore, potentially unhealthy subjects might have been included in the study group, especially in the elderly generations. Also, the mental status was not investigated to exclude psychiatric diseases. These physical and mental conditions may have affected the score.

In conclusion, the standard values for the five domains of the JOACMEQ were established using healthy volunteers. Physicians should be aware that there are differences in the scores among different generations. Patients with cervical myelopathy should be evaluated with this new self-administered questionnaire, JOACMEQ, taking the standard value in each generation into account. This new self-administered questionnaire can be used to evaluate the outcomes in patients with cervical myelopathy more efficiently and will be helpful to identify the most appropriate