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

Validity, reliability and responsiveness of the Japanese version of the Neck Disability Index

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Abstract
Background The Neck Disability Index (NDI) is one of the most widely used questionnaires for neck pain. The purpose of this study was to validate the Japanese NDI.
Methods We performed two surveys with an 8-week interval in 130 patients with neck pain, radiculopathy and myelopathy. We asked patients to answer two versions of the Japanese NDI: the original NDI, which had been completed by a forward–backward translation procedure, and the modified NDI, which has the phrase "because of neck pain" to the phase "because of neck pain or numbness in the arm." The other parameters examined were the strength of pain and numbness, the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire, the Hospital Anxiety and Depression Scale, and Short Form 36. Attending surgeons judged the symptom severity. Patients were asked to report the patient global impression of change (PGIC) at the second survey. The internal consistency, criterion-related and discriminative validity, and reliability were evaluated.
Results The original NDI and the modified NDI were 26.9 ± 17.1 and 29.9 ± 15.5, respectively. The Cronbach α values of the original NDI and the modified NDI were 0.92 and 0.89, respectively. Both versions of the NDI had good to excellent correlative coefficients with the related domains. The modified NDI had a higher validity for numbness and mental health-related QOL. The symptom severity was significantly correlated with the modified NDI. The intraclass correlation coefficients of the two surveys of the modified and original NDI were comparable. The effect sizes of the modified and the original NDI were 0.64 and 0.55, respectively. Spearman's ρ between the change of the NDI and the PGIC was 0.47 in the original NDI and 0.59 in the modified NDI.
Conclusions We demonstrated the validity, reliability and responsiveness of the Japanese NDI. The modified NDI was more strongly correlated with numbness and mental health-related QOL.

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Introduction

Neck pain is one of the most common complaints in the general population. Patient-reported outcome measures are primary tools used to assess the patients' condition, and the Neck Disability Index (NDI) [1], a symptom-specific questionnaire modified from the Oswestry Disability Index [2] for neck pain by Vernon, has been used extensively to evaluate patients with neck pain and cervical disorders [3].

There has been no report of the Japanese version of the NDI so far. The purpose of this study was to validate the Japanese version of the Neck Disability Index (NDI).

This study was supported by the Japanese Society for Spine Surgery and Related Research, and study approval was given by the institutional review board of the Clinical Research Support Center of the University of Tokyo Hospital.

Materials and methods

Translation of the NDI into Japanese

The NDI has ten questions with numerical responses on a six-point scale (0–5). The questions cover pain, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. The raw total score of the NDI is calculated by summing the scores of the questions. The NDI is usually described as a percentage of raw scores divided by the full scores of answered questions. The final % score ranges from 0 to 100, and lower scores indicate a better state of health.

We translated the English NDI into Japanese by forward translation. The Japanese NDI was then successively translated into English as a back-translation. Finally, the original NDI was completed after we received suggestions from Dr. Vernon, the original developer of the NDI. However, during the preliminary survey at the university hospital, some patients with cervical disorders left comments on the questionnaire sheet indicating that their disability resulted not from neck pain, but from numbness in the arm. Therefore, we made the modified NDI (Supplementary material) by changing the phrase "because of neck pain" to the phase "because of neck pain or numbness in the arm" in the questions. Therefore, we included a comparative study between the two versions of the NDI in this validation study. We asked patients to answer both of the NDIs and then compared the validity between the two versions. The two Japanese versions of the original and modified NDI can be seen by downloading the files in the Supplementary material.

Participants

The first survey was performed in the hospital or in the clinic at six institutions after the institutional review board had approved the study. Signed informed consent was obtained from each patient. We recruited patients who had one of the three diagnoses below: (1) neck pain without neurological symptoms (the neck pain group), (2) cervical radiculopathy or (3) cervical myelopathy. The neck pain group included patients with acute and chronic neck pain without neurological symptoms. Patients who experienced pain after traffic vehicle accidents were included. A diagnosis of cervical radiculopathy (the radiculopathy group) was made when (1) a patient suffered from pain in an upper extremity and (2) arm pain was provoked by a specific head position or with a specific exercise, or a physician found an imaging abnormality related to the arm pain. Patients with pain only around the scapula were excluded. Cervical myelopathy (the myelopathy group) was confirmed from both the neurological and magnetic resonance imaging findings. Patients with rheumatoid arthritis, cerebral palsy and other systemic diseases that might have influenced neck conditions were excluded. Patients who suffered from both radiculopathy and myelopathy (radiculomyelopathy) were also excluded.

Data collection

The questionnaire set of the first survey included questions about patient backgrounds (age, sex, height, weight, occupation, marital status, education, smoking status) and previous treatment. It also included the original and modified versions of the Japanese NDI, the 11-grade strength of pain and numbness using a drawing of the body divided into six parts (Fig. 1), the Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire (JOACMEQ) [4], the Hospital Anxiety and Depression Scale (HADS) [5, 6] and the Short Form 36 (SF-36) [7, 8].

The JOACMEQ is a disease-specific scale for cervical myelopathy proposed by the Japanese Orthopaedic Association. This patient-reported outcome measure has two components. The first component has 24 questions that comprise five domains: (1) cervical function, (2) upper extremity function, (3) lower extremity function, (4) bladder function and (5) quality of life (QOL). Each domain is calculated by a weighted sum of the involved questions, ranging from 0 to 100, with higher scores indicating a better health state. The second component has three visual analog scales for pain and numbness. We adopted only the first component in this study.

The HADS is a self-reported questionnaire for anxiety and depression. The HADS has 14 questions, and its total score ranges from 0 to 21 for each scale of anxiety and depression. A higher score indicates higher stress.

The SF-36 is a generic health-related QOL measure with 36 questions. The SF-36 consists of eight domains from the weighted sum of specific questions: physical functioning

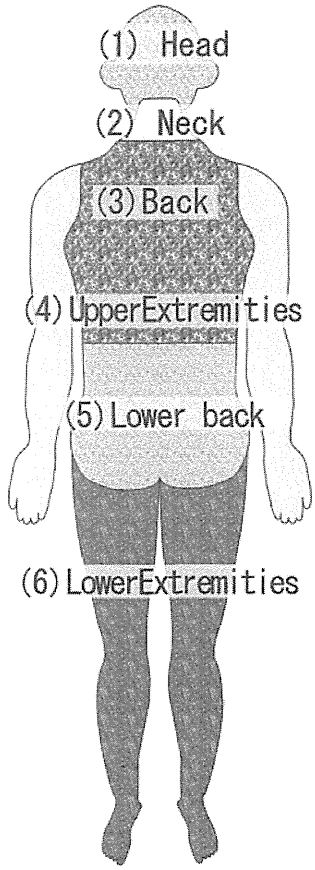

Fig. 1 The body part figure used for the question about the intensity of the pain and numbness

(PF), role physical (RP), bodily pain (BP), general health (GH), vitality (VT), social role (SF), role emotional (RE) and mental health (MH). The raw score of each domain ranges from 0 to 100, with higher scores indicating better health. Two representative scores are also calculated: the Physical Component Score (PCS) and the Mental Component Score (MCS), which are expressed in norm-based scoring. Each component score has the same mean and standard deviation (50 and 10, respectively) in a normal population.

We asked the attending surgeons to report diagnoses of the cervical disorders, symptom severity, comorbidities and treatment. The symptom severity judged by surgeons had three grades: severe, moderate and slight. The surveyed comorbidities were diabetic mellitus, shoulder disorder and peripheral nerve disorders.

The second survey for repeatability/responsiveness was performed by mail 8 weeks after the first survey. A question about the patient global impression of change (PGIC) was added in the questionnaire set. The PGIC was composed of seven answers: much better, better, slightly better, unchanged, slightly worse, worse and much worse.

Table 1 Patient characteristics ($n = 130$)

	N	*N %*	Mean	SD
Height (cm)	129		163.0	8.5
Weight (kg)	129		64.4	12.7
BMI	129		24.2	3.8
Occupation				
Full-time job	59	46.9		
Part-time job	9	7.0		
Housemaker	20	15.6		
Retired	20	15.6		
Other	19	14.8		
Marital status				
Married	95	74.2		
Single	33	25.8		
Education				
Middle-school	8	6.3		
High school	53	41.4		
Training college	16	12.5		
University	42	32.8		
Graduate-school	4	3.1		
Other	5	3.9		
Smoking				
Never	50	38.5		
History of smoking	51	39.2		
Present smoker	29	22.3		
Related comorbidities				
Worker's compensation	1	0.8		
Diabetes mellitus	7	5.4		
Other	2	1.5		

Numbers do not always add up to the total number because of missing values

SD standard deviation, *BMI* body mass index

Statistical analysis

Internal consistency, criterion-related validity and discriminative validity

The internal consistency was evaluated by the Cronbach α. In general, $\alpha \geq 0.9$ is regarded as excellent, $\alpha \geq 0.8$ as good and $\alpha \geq 0.7$ as acceptable [9]. The criterion-related validity was evaluated by calculating the correlation coefficients (Spearman's ρ) between two NDIs and other outcomes: the 11-grade severity of pain and numbness in body parts, JOACMEQ, HADS and the SF-36. In general, $\rho = 0.1$ is regarded as a weak association, $\rho = 0.3$ as a moderate association and $\rho = 0.5$ as a strong association [10]. The discriminative validity was evaluated by performing analysis of variance (ANOVA) between two versions of the NDI and the symptom severity.

Table 2 The outcomes of the first survey

	N	Mean	SD	Min	Median	Max
Japanese NDI (0–100)						
Original	118	26.9	17.1	0	26	72
Modified	118	29.9	15.5	0	28	70
Pain (0–10)						
Head	130	1.6	2.3	0	1	8
Neck	130	4.2	2.8	0	4	10
Back	128	3.0	2.7	0	2	10
Upper ext	128	3.5	2.9	0	3	10
Lower back	129	2.8	2.9	0	2	10
Lower ext	128	2.4	3.0	0	1	10
Numbness (0–10)						
Head	129	1.0	2.0	0	0	9
Neck	129	1.8	2.5	0	0	9
Back	126	1.7	2.4	0	0	10
Upper ext	128	3.9	2.8	0	4	10
Lower back	128	1.7	2.7	0	0	10
Lower ext	129	2.7	3.1	0	1	10
JOACMEQ (0–100)						
Cervical	127	60.0	27.8	0	62.5	100
Upper ext	129	84.3	19.1	0	85.7	100
Lower ext	126	74.6	22.8	16.7	75	100
Bladder	128	76.9	19.8	20	80	100
QOL	124	49.1	16.0	6.5	51.6	90.3
HADS (0–21)						
Anxiety	128	6.3	3.9	0	6	18
Depression	127	6.1	4.0	0	6	19
SF-36						
PF (0–100)	129	70.7	22.8	10	80	100
RP (0–100)	129	61.4	27.8	0	62.5	100
BP (0–100)	129	45.9	20.4	0	41	100
GH (0–100)	129	45.7	17.1	0	45	87
VT (0–100)	129	48.4	22.3	0	50	100
SF (0–100)	128	68.5	26.2	0	75	100
RE (0–100)	129	68.1	31.3	0	75	100
MH (0–100)	129	60.9	23.9	5	60	100
PCS	127	34.9	16.5	−10.1	38.2	63.4
MCS	127	45.2	11.6	14.6	46.3	75.1

SD standard deviation, *NDI* Neck Disability Index, *ext* extremity, *JOACMEQ* Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire, *QOL* quality of life, *HADS* Hospital Anxiety and Depression Scale, *SF36* short form 36, *PF* physical functioning, *RP* role physical, *BP* bodily pain, *GH* general health, *VT* vitality, *SF* social role, *RE* role emotional, *MH* mental health, *PCS* Physical Component Score, *MCS* Mental Component Score

Reliability and responsiveness

The two versions of the NDI were evaluated by calculating the intraclass correlation coefficient (ICC) of first and second NDI in patients who reported being "unchanged" in the PGIC of the second survey. The ICC ranged from 0 to 1, and a higher value indicated higher repeatability. An ICC above 0.70 is accepted as good [11].

Responsiveness is the ability of an instrument to detect clinically relevant change over time. The responsiveness was evaluated from the data of patients who reported that they were "much better," "better" or "slightly better" in the PGIC of the second survey. We calculated the effect size and the standard response mean (SRM) from these data. The effect size was judged to be small if it was less than 0.2, moderate if it was around 0.5 and large if it was greater than 0.8 [10]. A higher SRM indicates higher responsiveness. We also calculated the correlation between change of the NDI and PGIC. Statistical analysis was performed by IBM SPSS 17.0 (IBM, Chicago, IL, USA).

Table 3 The Cronbach's α values of the original and modified NDIs

	Original NDI		Modified NDI	
	N	Cronbach α	*N*	Cronbach α
Neck pain	26	0.90	25	0.84
Radiculopathy	40	0.91	41	0.90
Myelopathy	52	0.94	52	0.92
Total	118	0.92	118	0.89

Results

The first survey was performed from March 2010 to October 2010, and 130 patients completed the first study. The mean patient age was 59.4 ± 13.8 years (range 22–88 years), and there were 88 male and 42 females. The patient characteristics are shown in Table 1. The pain duration averaged 50.3 ± 66.3 months. The interval between the two surveys averaged 56.9 ± 5.6 days. Thirty-four (26.2 %) patients had received no treatment before the first survey, and of the others who had previous or ongoing treatment, 89 (68.5 %) received therapeutic drugs, 59 (45.4 %) had surgery, and 11 (8.5 %) received physical therapy (% greater than 100 because of multiple choices). The symptom severity judged by surgeons was mild in 44 (33.9 %), moderate in 70 (53.9 %) and severe in 16 (12.3 %) patients.

Twenty-eight (21.5 %) patients were classified into the neck pain group, 45 (34.6 %) into the radiculopathy group and 57 (43.9 %) into the myelopathy group. The number of patients who underwent surgical treatment after the first survey was 1 (3.6 %) in the neck pain group, 7 (15.6 %) in the radiculopathy group and 6 (10.5 %) in the myelopathy group.

The original NDI and the modified NDI of the first survey were 26.9 ± 17.1 and 29.9 ± 15.5, respectively (Table 2). No response was frequently found (6.9 and 8.5 %, respectively) for the question about driving. The ceiling effect of individual questions was small (0 to 4.8 %), but the floor effect was found more frequently in the original NDI than in the modified NDI (5.1 vs. 0.9 %). In both NDIs, the floor effect was significant for question 5 (about headaches) and 9 (about sleep) (45.3–50.8 %). The results of the NRSs, JOACMEQ, HADS and SF-36 are shown in Table 2.

In the second survey, 118 patients responded. The response to the PGIC was "much better" in 7 (5.9 %) patients, "better" in 24 (20.3 %), "slightly better" in 21 (17.8 %), "unchanged" in 55 (46.6 %), "slightly worse" in 5 (4.2 %), "worse" in 5 (4.2 %) and "much worse" in 1 (0.9 %) patient.

Internal consistency, criterion-related validity and distinctive validity

The Cronbach α of the original NDI and the modified NDI were 0.92 and 0.89, respectively (Table 3). The subgroup analysis of the three groups showed good to excellent values for Cronbach's α.

The majority of parameters had a statistically significant correlation with the NDIs (Table 4). The original NDI had higher CCs for pain severity in the neck and back. The modified NDI had a higher correlation than the original NDI in some domains: numbness in the upper extremities, lower back and lower extremities; the upper/lower extremity function in the JOCMEQ; all mental health domains and the MCS in the SF36.

There was a statistically significant difference in the symptom severity for the modified NDI (ANOVA, $p = 0.020$), but not for the original NDI ($p = 0.142$).

Reliability and responsiveness

A total of 118 patients responded to the PGIC questionnaire, and 55 patients (46.6 %) answered "unchanged" in the PGC in the second survey. Their responses were analyzed for the test–retest repeatability. The ICC of the original and modified NDI was accepted as good (0.77 and 0.78, respectively).

Spearman's ρ between the two versions of the NDI and the PGIC was 0.47 ($p < 0.0001$) in the original NDI and 0.59 ($p < 0.0001$) in the modified NDI (Fig. 2).

Fifty-two patients (44.1 %) reported a positive change at the second survey ("much better," "better" and "slightly better"). The effect size of the original and modified NDI was judged to be moderate (0.55 and 0.64, respectively). The SRMs of the original and modified NDI were −0.52 and −0.66, respectively.

Discussions

Our study demonstrated that both of the Japanese NDIs had good to excellent validity, repeatability and responsiveness.

We compared the internal consistency and repeatability of the Japanese NDI with the NDIs in other languages (Table 5) and found that the internal consistency of the Japanese NDI was comparable to the NDI in other languages. The reliability was marginally acceptable, possibly

Table 4 Correlations between the two versions of the NDI and other outcomes

	N	Original NDI		Modified NDI	
		Spearman	*p* value	Spearman	*p* value
Pain (0–10)					
Head	118	0.374	<0.0001	0.370	<0.0001
Neck	118	0.635	<0.0001	0.486	<0.0001
Back	117	0.601	<0.0001	0.555	<0.0001
Upper ext	117	0.455	<0.0001	0.499	<0.0001
Lower back	117	0.221	0.017	0.219	0.018
Lower ext	117	0.271	0.003	0.319	0.001
Numbness (0–10)					
Head	118	0.306	0.001	0.347	<0.0001
Neck	118	0.435	<0.0001	0.443	<0.0001
Back	115	0.407	<0.0001	0.416	<0.0001
Upper ext	116	0.402	<0.0001	0.481	<0.0001
Lower back	117	0.256	0.001	0.327	<0.0001
Lower ext	117	0.286	<0.0001	0.371	<0.0001
JOACMEQ (0–100)					
Cervical	116	−0.397	<0.0001	−0.369	<0.0001
Upper ext	117	−0.385	<0.0001	−0.454	<0.0001
Lower ext	115	−0.363	<0.0001	−0.427	<0.0001
Bladder	118	−0.191	0.039	−0.206	0.026
QOL	115	−0.677	<0.0001	−0.686	<0.0001
HADS (0–21)					
Anxiety	116	0.415	<0.0001	0.414	<0.0001
Depression	117	0.426	<0.0001	0.455	<0.0001
SF36					
PF (0–100)	117	−0.526	<0.0001	−0.551	<0.0001
RP (0–100)	117	−0.599	<0.0001	−0.607	<0.0001
BP (0–100)	117	−0.64	<0.0001	−0.669	<0.0001
GH (0–100)	117	−0.501	<0.0001	−0.510	<0.0001
VT (0–100)	117	−0.518	<0.0001	−0.597	<0.0001
SF (0–100)	116	−0.422	<0.0001	−0.483	<0.0001
RE (0–100)	117	−0.523	<0.0001	−0.580	<0.0001
MH (0–100)	117	−0.413	<0.0001	−0.482	<0.0001
PCS	115	−0.602	<0.0001	−0.617	<0.0001
MCS	115	−0.336	<0.0001	−0.410	<0.0001

NDI Neck Disability Index, *Ext* extremity, *JOACMEQ* Japanese Orthopaedic Association Cervical Myelopathy Evaluation Questionnaire, *QOL* quality of life, *HADS* Hospital Anxiety and Depression Scale, *SF36* short form 36, *PF* physical functioning, *RP* role physical, *BP* bodily pain, *GH* general health, *VT* vitality, *SF* social role, *RE* role emotional, *MH* mental health, *PCS* Physical Component Score, *MCS* Mental Component Score

because of the long interval between the two surveys; the interval between the two surveys ranged from 1 day to 2 weeks in other studies except for one subgroup. We selected an 8-week interval between the two surveys because we had planned to evaluate both the repeatability and responsiveness by separating patients into two groups based on the PGIC of the second survey.

The majority of past reports demonstrated the validity of the NDI in the neck pain population. Few validation studies of the NDI were performed in patients with cervical radiculopathy/myelopathy, who do not always have neck pain, though many studies have adopted the NDI as an assessment following conservative or surgical treatment. With regard to the patients with radiculopathy, only Cleland et al. [13] reported a good test–retest reliability (ICC = 0.68) in 38 radiculopathy patients. The Korean NDI developed by Song et al. [21] demonstrated the validity and reliability in a mixed population that included radiculopathy and myelopathy patients.

Patients who have neurological symptoms often complain not only of pain but also variable symptoms: tingling, burning, numbness, etc. Patients with spinal disorders often complain of numbness and insist that it is different from pain, although numbness is usually regarded as one of the symptoms of neuropathic pain [23]. In a study of 892 patients with cervical ossification of the posterior

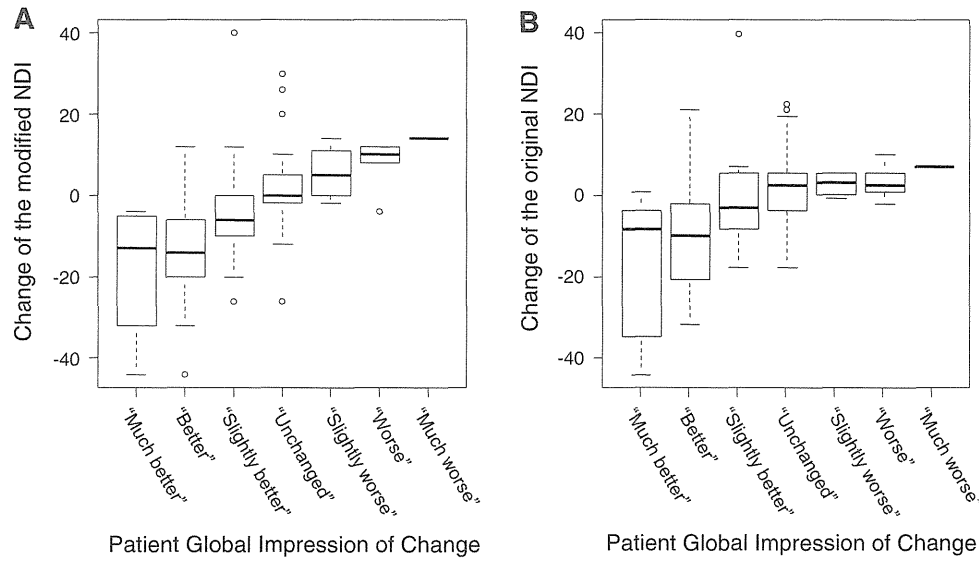

Fig. 2 The relationship between the change in the NDI and the patient global impression of change (PGIC). **a** The modified NDI: Spearman's $\rho = 0.588$ ($p < 0.0001$, $n = 106$). **b** The original NDI: Spearman's $\rho = 0.467$ ($p < 0.0001$, $n = 106$)

Table 5 The internal consistency and reliability of the NDI in various languages

	N	Condition	Cronbach α	ICC/interval
English [1]	52	Neck pain	0.8	0.89/2 days
French [12]	101	Neck pain	na	0.93/1 day
Swedish [13]	59	Neck pain	na	0.97/2 days (chronic)
				0.94/3 months (chronic)
				0.89/2 days (acute)
Dutch [14]	187	Acute neck pain	na	0.90/1 week
Brazilian Portuguese [15]	203	Trauma, OA	0.74	0.92/1 day
				0.48/1 week
Greek [16]	65	Neck pain	0.85	0.93/1–2 weeks
Iranian [17]	185	Neck pain	0.88	0.90/2 days
Catalan [18]	150	Whiplash	0.87	na
Spanish [19]	221	Neck pain	0.89	0.88/2 weeks
Turkish [20]	88	Chronic neck pain	na	0.979
Korean [21]	78	Radiculopathy (50)	0.82	0.93/2 days
		Myelopathy (28)		
Chinese [22]	125	Neck pain	0.89	0.95/1 day
Japanese (present study)	130	Neck pain (28)	0.92 (original)	0.77/8 weeks (original)
		Radiculopathy (45)	0.89 (modified)	0.78/8 weeks (modified)
		Myelopathy (57)		

NDI Neck Disability Index, *na* not available, *OA* osteoarthritis

longitudinal ligament [24], the researchers had asked, "Which is more troublesome, pain or numbness?" Of these patients, 45.0 % responded "both pain and numbness," 25.0 % responded "numbness" and 22.2 % responded "pain." Their result indicates the clinical importance of numbness, which is often regarded by patients as another entity different from pain. In the present study, the modified NDI had a higher criterion-related validity in numbness and mental health-related QOL, while the original NDI had a higher criterion-related validity in neck pain. In other words, the inclusion of numbness in the questionnaire enhanced the validity of the NDI in the assessment of

patients with cervical disorders. In addition, the modified NDI had a higher correlation with the assessment by both physicians and patients and had a higher effect size and SRM than the original NDI. Accordingly, the modified NDI may be a better choice for studies of patients with cervical disorders. On the other hand, the original NDI is still useful for epidemiological studies of nonspecific neck pain.

In summary, we demonstrated the validity, reliability and responsiveness of both versions of the Japanese NDI, and the modified NDI more accurately reflected the numbness and mental health-related QOL, while the original NDI better reflected the neck pain.

Conflict of interest The authors declare that K. Takeshita received payment for lectures that had no direct relationship with the submitted work from Pfeizer Japan Inc., Tokyo, Japan.

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