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Cut off value in each gender and decade of 10-s grip and release and 10-s step test: A comparative study between 454 patients with cervical spondylotic myelopathy and 818 healthy subjects

Masaaki Machino[a], Kei Ando[a], Kazuyoshi Kobayashi[a], Masayoshi Morozumi[a], Satoshi Tanaka[a], Keigo Ito[b], Fumihiko Kato[b], Naoki Ishiguro[a], Shiro Imagama[a,*]

[a] Department of Orthopedic Surgery, Nagoya University Graduate School of Medicine, Nagoya, Japan
[b] Department of Orthopedic Surgery, Chubu Rosai Hospital, Japan Organization of Occupational Health and Safety, Nagoya, Japan

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ABSTRACT

Objectives: The purpose of this study was to establish the clinical cut-off values of the 10-s grip and release (G&R) and 10-s step quantitative tests for the diagnosis of cervical spondylotic myelopathy (CSM) and to elucidate the aging variation and gender difference of those values in a large cohort of healthy subjects.
Patients and methods: Patients with CSM (n = 454) and asymptomatic subjects (n = 818) were included. Subjects were aged 40–70 years; according to their age, they were categorized by decades. The 10-s G&R and 10-s step tests were used to quantitatively assess performance. The receiver operating characteristic (ROC) curves were plotted to evaluate the cut-off value of the 10-s G&R and 10-s step tests for determining the presence or absence of CSM in each gender and decade.
Results: The cut-off values in the G&R test were 20 in 40 s, 19 in 50 s, 17 in 60 s, and 16 in 70 s groups respectively. The cut-off values in the 10-s step test were 19 in 40 s, 18 in 50 s, 16 in 60 s, and 15 in 70 s groups respectively. The cut-off value of the G&R test in females was lower than that in the males. The cut-off value of 10-s step test was lower in the females than in the males in 40 s and 50 s groups.
Conclusions: The cut-off values in the 10-s G&R test and 10-s step decreased with age. When these quantifiable tests are used as screening tests of CSM, age and gender difference should be considered.

1. Introduction

The increase in prevalence of degenerative cervical myelopathy (DCM) in an aging population is of concern [1,2]. DCM is one of the most common neurological disorders, whose symptoms include sensory disturbances of the extremities, clumsiness of hands, gait disturbance, and urinary dysfunction [3,4]. In cases of severe compression or a progressive course, the accepted treatment for DCM is usually surgical decompression [5,6]. However, in determining the severity of any disease process, it is essential to have objective and reproducible means of measuring patient disability prior to treatment [7].

Various clinical grading systems have been used to assess the severity of DCM. There are a few quantifiable and screening tests to assess neurological conditions in DCM, including the 10-s grip and release (G&R) test and 10-s step test [8,9]. The 10-s G&R test was introduced to evaluate myelopathy of the hand and correlates well with the degree of disability of the upper extremities [8]. The 10-s step test has been shown to be useful for assessing the severity of DCM [9]. The G&R and step tests have also been demonstrated to be highly reproducible. Particularly, the G&R and step tests are access friendly and easy to use in clinical practice.

However, the clinical usefulness of these quantitative performance tests has not been fully evaluated in patients with cervical spondylotic myelopathy (CSM) due to the inclusion of ossification of the posterior longitudinal ligament (OPLL) in previous studies and the relatively small sample sizes. Since clinical symptoms of CSM differ from that of OPLL, application of the G&R, and step tests produces some age- or sex – related bias [6,10]. Therefore, we hypothesized that cut-off values of these quantitative performance tests would vary by gender and decade in a population of patients with CSM and healthy subjects. Studies describing a cut-off value are lacking and the objective of this current study was to establish the clinical cut-off values of the 10-s G&R and 10-

* Corresponding author at: Department of Orthopaedic Surgery, Nagoya University Graduate School of Medicine, 65, Tsurumai, Showa-ku, Nagoya, Aichi, 466-8550, Japan.
E-mail address: imagama@med.nagoya-u.ac.jp (S. Imagama).

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s step quantitative tests for the diagnosis of CSM that reflects age and gender as variables in a large cohort of normal subjects.

2. Material and methods

2.1. Study population

2.1.1. Patients with CSM

Between January 2007 and March 2011, 701 consecutive Japanese patients with CSM were prospectively enrolled in this study conducted at Chubu Rosai Hospital. The following exclusion criteria were used: (1) OPLL; (2) history of rheumatoid arthritis, cerebral palsy, Parkinson's disease, stroke or tumors; (3) spinal injuries; (4) destructive spondyloarthritis caused by hemodialysis; (5) previous cervical surgery; (6) severe kyphotic deformity, spinal fusion with instrumentation; (7) thoracic spondylotic myelopathy; and (8) lumbar spinal canal stenosis. Of the 701 patients, 528 patients with CSM excluding other locomotor disorders, such as hip or knee osteoarthritis, were eligible for participation. Moreover, of the 528 patients, 454 patients, excluding those in the third, fourth, and ninth decades of life, were finally included as patients with CSM. The patients with CSM were aged between 40 and 70 years (289 males and 165 females, mean age: 64.8 years) were classified according to their age by decade (Table 1).

All patients presented with symptoms of myelopathy. Magnetic resonance imaging and myelographic findings were consistent with myelopathy secondary to multisegmental cervical spondylotic stenosis. Each patient had myelopathy confirmed with a physical examination, and cord compression was present only between the C2/C3 and C7/T1 disc levels.

2.1.2. Asymptomatic subjects (Controls)

Between February 2006 and February 2008, 1230 healthy Japanese volunteers were prospectively enrolled as asymptomatic subjects in this study conducted at Chubu Rosai Hospital. Subjects with a history of brain or spinal surgery; comorbid neurological diseases, such as cerebral infarction or neuropathy; symptoms related to sensory or motor disorders (e.g., numbness, clumsiness, motor weakness, and gait disturbances) or the presence of severe neck pain were excluded. Pregnant women and individuals who received worker's compensation or presented with symptoms after a motor vehicle accident were also excluded. Excluding those in the third and fourth decade of life, 818 healthy volunteers (408 males and 410 females) were included as asymptomatic subjects. There were at least 100 males and 100 females in each decade from their 40 s to 70 s. Table 1 shows the age and sex of the subjects.

The institutional review board approved this project, and we obtained written informed consent from the patients with CSM and asymptomatic subjects prior to the examination.

2.2. Performance tests

After the study population were provided with information regarding 10-s G&R and 10-s step tests, the performance tests were conducted to quantitatively assess performance [8,9,11,12]. In the 10-s G&R test, data were collected from the left or right side, depending on which side was weaker.

Table 1
Demographics of CSM patients and Asymptomatic subjects in each gender and each decade.

	40 s	50 s	60 s	70 s	ALL
CSM patients					
Male	29	64	112	84	289
Female	4	29	58	74	165
Total	33	93	170	158	454
Asymptomatic subjects					
Male	100	105	101	102	408
Female	100	102	106	102	410
Total	200	207	207	204	818

2.2.1. Ten-second G&R test (10-s G&R test)

The test subject had to grip and release the fingers as rapidly as possible with the forearm kept in pronation and the wrist in mild extension. The number of completed cycles of movement within 10 s was separately counted on each arm [8]. Individuals who were unable to perform complete grip and/or extension of fingers were asked to do as much as they could.

2.2.2. Ten-second step test (10-s step test)

The subject had to take high steps by bending knees to 90° such that the thigh was parallel to the floor. The number of steps taken without holding onto anything for balance for 10 s was determined. If the subject was at risk of falling, the test was performed in proximity to a hand bar [9,12].

2.3. Statistical analysis

Data were analyzed using SPSS statistical software (version 24.0; SPSS, Inc., Chicago, IL, USA). All values were expressed as the mean ± standard deviation. The threshold value for the cut-off value of the 10-s G&R and 10-s step tests for the presence of CSM was determined using the receiver operating characteristics (ROC) analysis and Youden's index [13]. $P < 0.05$ was considered to indicate statistical significance.

3. Results

The ROC curve for the cut-off value of the 10-s G&R test for the presence or absence of CSM showed an area under the curve (AUC) of 0.744 in all participants in the study (Fig. 1). The cut-off value of the 10-s G&R test was determined to be 18 for diagnosis of CSM, for which the sensitivity and specificity were 77.3% and 58.8% respectively. Decade-wise cut-off values in the 10-s G&R test were 20 (AUC 0.771) in the 40 s, 19 (AUC 0.654) in the 50 s, 17 (AUC0.717) in 60 s, and 16

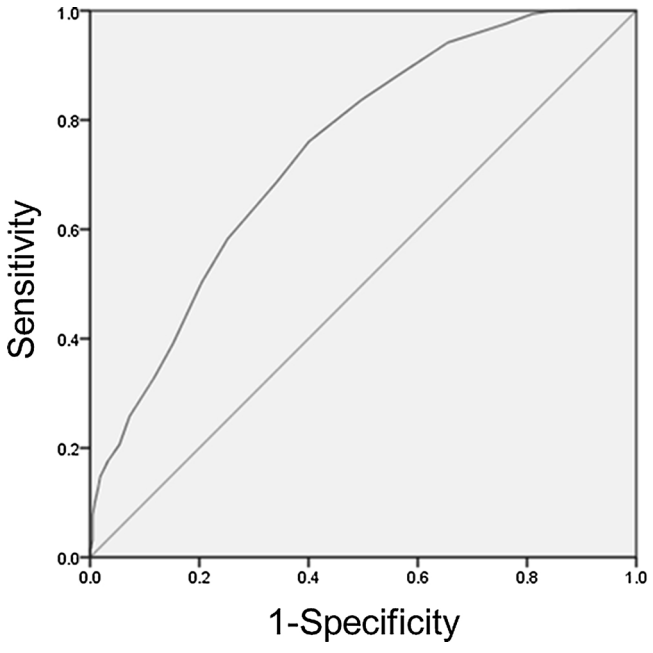

Fig. 1. The receiver operating characteristic (ROC) curve of the 10-s G&R test in all patients and subjects. The area under the ROC curve was 0.744.

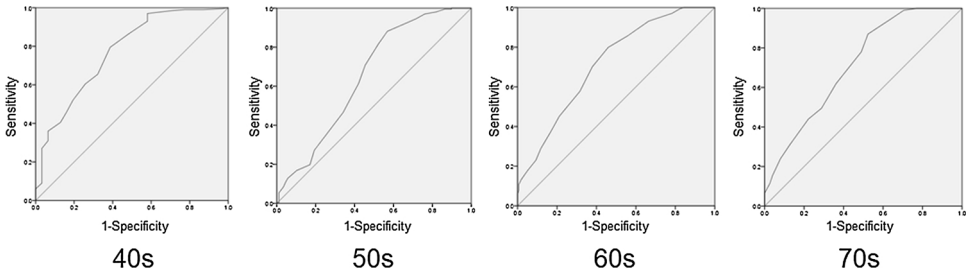

Fig. 2. The receiver operating characteristic (ROC) curve of the 10-s G&R test in each decade for the presence or absence of CSM.

Table 2
Cut-off values, AUC, and sensitivity and specificity of the 10-s grip and release test in each gender and decade for the presence or absence of cervical spondylotic myelopathy.

	40 s	50 s	60 s	70 s
Total				
Cut-off value	20	19	17	16
AUC	0.771	0.654	0.717	0.713
95% CI	0.677–0.865	0.580–0.729	0.664–0.770	0.658–0.768
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sensitivity (%)	72.7	71.0	70.6	73.4
Specificity (%)	65.5	62.3	58.5	51.5
Male				
Cut-off value	22	21	18	17
AUC	0.804	0.660	0.786	0.763
95% CI	0.707–0.901	0.569–0.750	0.725–0.847	0.694–0.833
p-value	< 0.0001	0.001	< 0.0001	< 0.0001
Sensitivity (%)	77.8	70.3	82.1	81.0
Specificity (%)	63.0	42.9	60.4	52.0
Female				
Cut-off value	19	18	16	15
AUC	0.890	0.733	0.653	0.647
95% CI	0.792–0.988	0.620–0.846	0.554–0.752	0.559–0.735
p-value	0.008	< 0.0001	0.002	0.001
Sensitivity (%)	75.0	72.4	70.7	70.3
Specificity (%)	74.0	66.7	59.4	53.9

AUC indicates area under curve; CI, confidence interval.

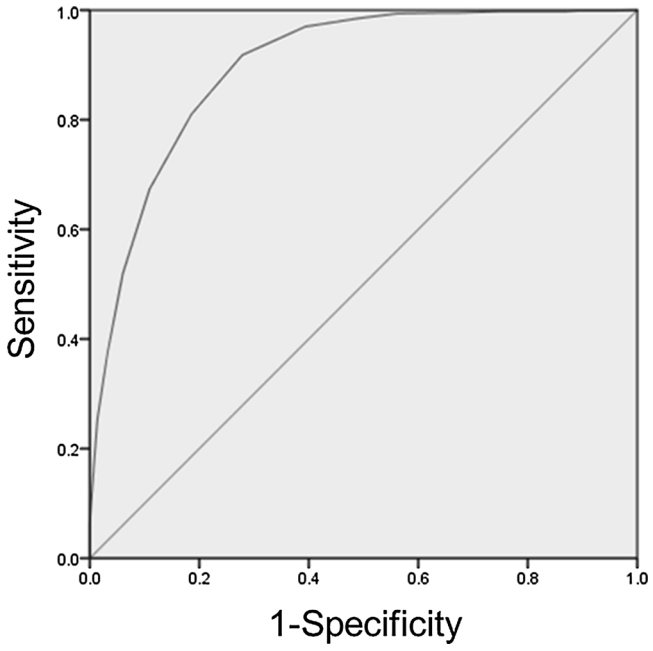

Fig. 4. The receiver operating characteristic (ROC) curve of the 10-s step test in all patients and subjects. The area under the ROC curve was 0.897.

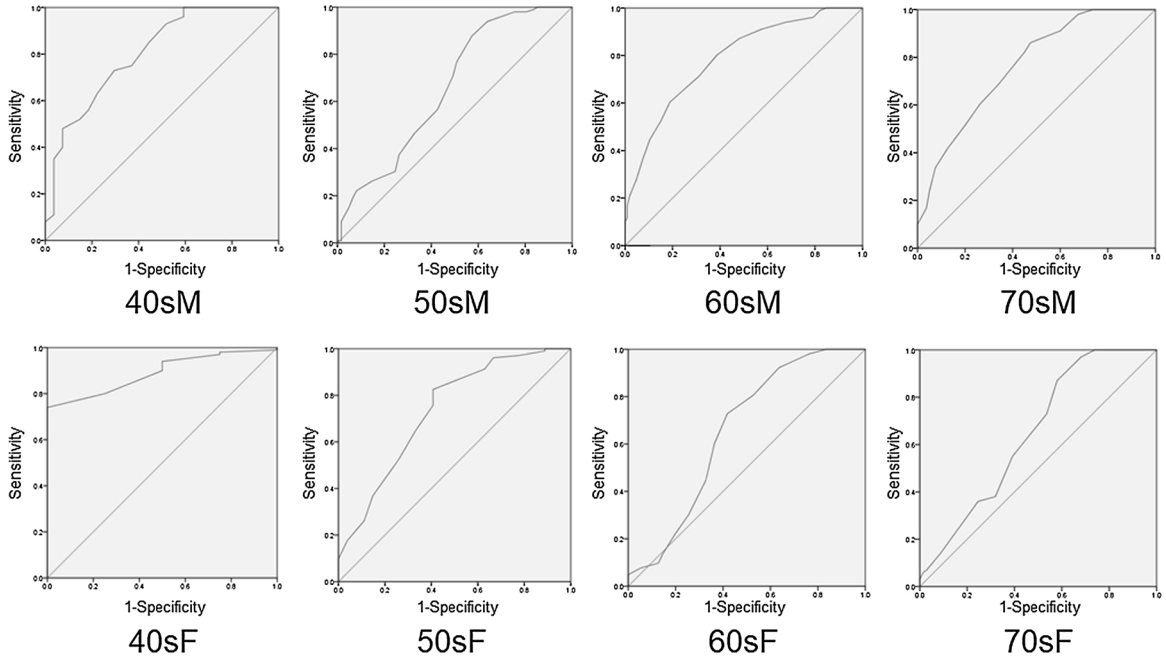

Fig. 3. The receiver operating characteristic (ROC) curve of the 10-s G&R test in each gender and decade for the presence or absence of CSM.

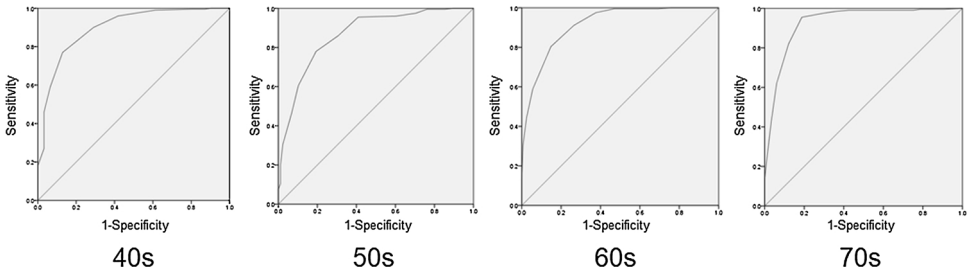

Fig. 5. The receiver operating characteristic (ROC) curve of the 10-s step test in each decade for the presence or absence of CSM.

(AUC0.713) in the 70 s group respectively (Fig. 2). The cut-off value in the 10-s G&R test decreased with age (Table 2). Males and females in all decade categories showed a significant difference in the 10-s G&R test results (Fig. 3). The cut-off value of the 10-s G&R test in females was significantly lower than that in the males (Table 2).

The ROC curve for the cut-off value of the 10-s step test for the presence or absence of CSM showed an AUC of 0.897 in all participants in the study (Fig. 4). The cut-off value of the 10-s step test was determined to be 17 for diagnosis of CSM, for which the sensitivity and specificity were 92.3% and 67.8% respectively. Decade-wise cut-off values in the 10-s step test were 19 (AUC 0.897) in the 40 s, 18 (AUC 0.867) in 50 s, 16 (AUC 0.915) in 60 s, and 15 (AUC 0.929) in 70 s age groups respectively (Fig. 5)

The cut-off value in the 10-s step test decreased with age (Table 3) and showed high sensitivity in all decades analyzed. Males and females in the 40 s and 50 s decades showed a significant difference in the 10-s step test results (Fig. 6). The cut-off value of 10-s step test in females was significantly lower than that in the males, except in the 60 s and 70 s groups (Table 3).

4. Discussion

The objective of the current study was to establish the clinical cut-off values of the 10-s G&R and 10-s step quantitative tests for the diagnosis of CSM that reflects age and gender as variables in a large cohort of patients and normal subjects. Data analyses of results obtained from the performance tests showed that the cut-off values in females were lower than those in the males, except those in the 60 s and 70 s groups, in the 10-s step test. As well, the cut-off values in the both tests decreased with age. Therefore, age- and sex-related differences should be considered when administering the 10-s G&R and 10-s step tests as a screening examination for CSM [12].

Table 3
Cut-off values, AUC, and sensitivity and specificity of the 10-s step test in each gender and decade for the presence or absence of cervical spondylotic myelopathy.

	40 s	50 s	60 s	70 s
Total				
Cut-off value	19	18	16	15
AUC	0.897	0.867	0.915	0.929
95% CI	0.834–0.959	0.820–0.913	0.887–0.943	0.900–0.958
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sensitivity (%)	93.9	90.3	85.9	89.2
Specificity (%)	59.0	61.8	80.1	81.7
Male				
Cut-off value	19	18	16	15
AUC	0.895	0.885	0.922	0.936
95% CI	0.830–0.961	0.831–0.939	0.887–0.957	0.899–0.973
p-value	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Sensitivity (%)	93.1	92.2	88.4	89.3
Specificity (%)	67.0	62.9	82.2	82.4
Female				
Cut-off value	18	17	16	15
AUC	0.995	0.834	0.902	0.931
95% CI	0.982–0.999	0.745–0.923	0.852–0.952	0.889–0.972
p-value	0.001	< 0.0001	< 0.0001	< 0.0001
Sensitivity (%)	100	82.8	84.5	89.2
Specificity (%)	74.0	77.5	76.4	78.4

AUC indicates area under curve; CI, confidence interval.

Clinical variables that are prone to reporting biases include patient symptoms, physical findings, and laboratory investigations; therefore, necessitating a variety of traditional functional measures for evaluating the severity of CSM [14–17]. The most commonly used types are the Ranawat classification [14], Nurick classification [15], and Japanese Orthopaedic Association (JOA) score [16,17]. The Ranawat classification scale was originally devised to evaluate the neurological function of patients undergoing cervical spine arthrodesis for rheumatoid involvement of the cervical spine [14]. Nurick proposed a grading scheme to measure the degree of walking difficulty in patients with myelopathy secondary to cervical spondylosis [15]. The JOA clinical score is the most comprehensive of the traditional and available measures for quantifying the degree of impairment secondary to myelopathy [16,17]. However, JOA score alone is insufficient for effectively quantifying the severity of myelopathy [16]. The abovementioned functional measures obtain scores derived by questioning the patients and therefore, lack the objectivity of a clinical neurological examination. These measures are also poorly quantifiable, with very few and largely arbitrary categories. The sensitivity to change is likely to be poor because one category covers a wide range of clinical severity [16].

Thus, quantitative physical tests may provide a confidential objective assessment of CSM severity, whose utility for the evaluation of CSM may be enhanced when they are combined with clinical tests, such as the JOA score. A preferable assessment of neurological impairment would be objective, quantitative, and easy to use. Three quantitative tests for DCM have been reported: the 30-m walking test [18], 10-s G&R test [8], and 10-s step test [9,12].

The 10-s G&R test was introduced to evaluate myelopathy of the hand. The G&R test can quantitatively reflect motor disability of the upper extremities and distinguish the laterality of the symptom and can be easily performed in clinics and wards [8]. The current study demonstrated that the 10-s G&R test was useful in diagnosis of CSM. In the previous study, the number of completed cycles in the 10-s G&R test significantly correlated with the motor function grading of the upper extremities by JOA score. Therefore, the previous study demonstrated that the 10-s G&R test can reflect and quantify the severity of CSM [11].

The 30-m walking test is a quantitative, reproducible, and reliable functional measure to determine the severity of DCM [18]. However, this test is fairly difficult to perform in an outpatient clinic and usually requires a relatively wide space in addition to an examiner. The 10-s step test quantifies the severity of DCM and has the added advantage of being easier to evaluate lower limb dysfunction than the 10-s G&R and 30-m walking tests [9,19]. The 10-s step test can be easily performed anywhere and at any time without the need for specialized equipment and can be repeated if necessary because it is sensitive to neurological impairment, particularly of locomotor function of the lower extremities [20]. The previous study showed that the number of steps significantly correlated with the motor function grading of the lower extremities

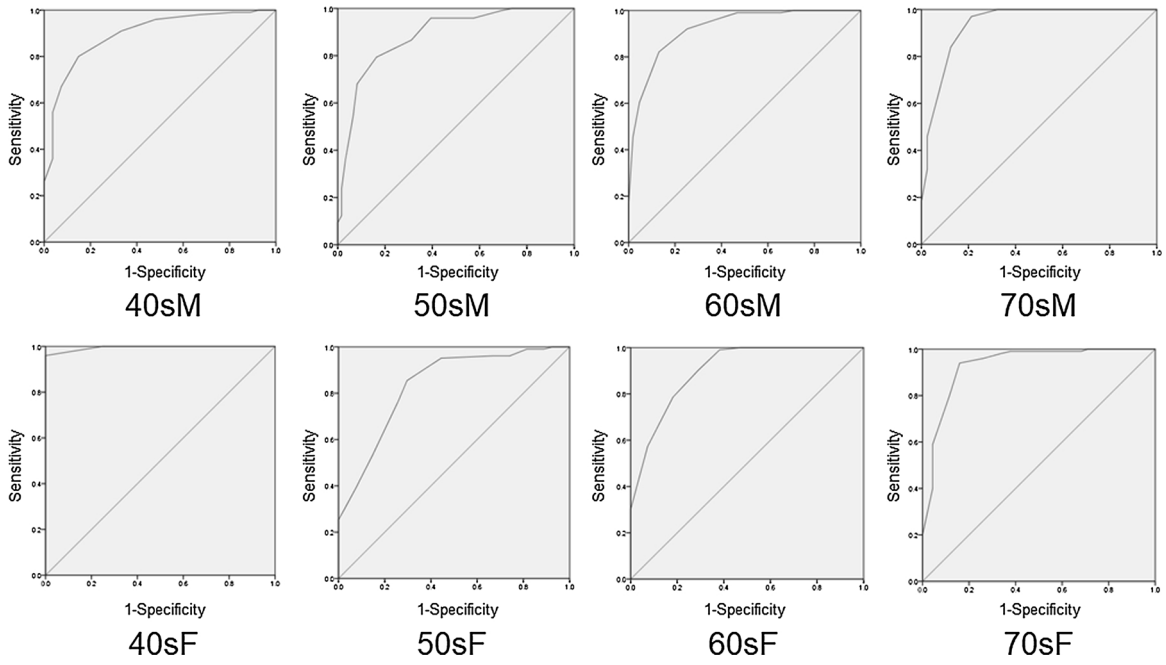

Fig. 6. The receiver operating characteristic (ROC) curve of the 10-s step test in each gender and decade for the presence or absence of CSM.

assessed based on JOA score. Thus, the previous study also demonstrated that the 10-s step test can reflect and quantify the severity of CSM [11].

We used the 10-s G&R and 10-s step tests to quantitatively measure symptoms of myelopathy in this study and demonstrated that though the 10-s G&R test was useful in the diagnosis of CSM, the 10-s step test had higher sensitivity in the presence or absence of CSM. Nevertheless, these tests are accessible, easy to use in clinical practice, provide reproducible results, and are comprehensively performed worldwide without being affected by language and life style [8,9,12]. As well, their accessibility for screening improves the potential to reveal undiagnosed patients who do not recognize their own symptoms. In light of these advantages, the diagnostic accuracy of early myelopathy can be improved by combining the two tests.

Usually, these functional tests are affected not only by the severity of locomotor disability but also due to age-related decline in performance. There were some differences in the 10-s G&R and 10-s step test results in their 40 s and 70 s. A score of < 20 in the 10-s G&R test is considered to be pathologic without considering aging [8]. A previous study showed a difference in the results of 10-s G&R and 10-s step tests between the sexes [11]. Because the age variation was quite large, it was difficult to set up standardized border values between the patients and healthy subjects [11].

From the results of this study, the cut-off values in the G&R test in the females was less than that in the males. We speculated that males had a greater physical ability for these tests than females. As for the reason why age-related difference in the results of both tests was observed, there may be differences in the severity of CSM. Although these tests could potentially be used as a screening examination for CSM, age- and sex-related differences should be considered at the evaluation [12].

A possible criticism of this study may be that data were derived only from Japanese subjects, the majority of who belonged to a single race. Therefore, it may be difficult to extrapolate these findings to a racially diverse population. Nevertheless, Japan is the most aged society in the whole world; therefore, data obtained in this study may help understand age-related changes in other nations with an aging population [21]. All CSM patients included in present study underwent decompression surgery. Therefore, we could not investigate the cut-off values between non-operative and operative treatment for CSM in current study. However, because this will aid physicians and surgeons in clinical decision making, further study is needed to clarify the cut-offs for deciding conservative or surgical treatment. The strength of this study is the largest number of patients with CSM and asymptomatic subjects included in a prospective trial till date. The information obtained from this study may be helpful for the diagnosis of CSM.

In conclusion, the cut-off values of the 10-s G&R test and 10-s step test in females were lower than those in the males. The cut-off values in the both tests also decreased with age. Therefore, age- and sex-related differences should be considered when administering these tests as a screening tool for CSM.

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